ERAVANT

NEXT GENERATION MILLIMETERWAVE COMPONENTS

YONGHUI SHU

MILLIMETERWAVE TO THz TEST & MEASUREMENT FREQUENCY EXTENSION STRATEGIES

(MAKE THE MILLIMETERWAVE AND SUB-THZ TECHNOLOGY ACCESSIBLE – PART II)

EDICON BEIJING 2024

CONTENTS

MAKE MMW AND SUB-THZ TECHNOLOGY ACCESSIBLE

(COMMERCIAL OFF THE SHELF COMPONENTS, EDI CON 2022)

OPTIONS FOR MMW AND SUB-THZ TEST SYSTEMS

Purchase test equipment with the necessary frequency range?

- Many measurement functions maybe be supported with various options (i.e. one instrument can replace a rack)
- Often the most expensive choice
- Concentrated test equipment limits its availability for different users and applications
- Not viable for higher frequencies

Purchase extendable test equipment and frequency extenders?

- Measurement functions may be limited
- Typically, more economical for addressing specific testing needs
- Test systems can be split, reconfigured or upgraded to address changing needs
- Viable for frequencies up to THz

TEST & MEASUREMENT LANDSCAPE @ MM & SUB-THZ

Equipment Availability

Many options up to 50 GHz

Fewer options reaching 67 and 85 GHz

Emerging options reach 110 GHz

Frequency extension is required for frequencies above 67 GHz in general.

PNA-X: Combined Extension of VNA, Signal Generator, and Other Signal Analyzing Functions

SIGNAL GENERATOR OPTIONS

Purchase signal generators with the necessary frequency range?

- Major equipment manufacturers offer solutions up to 50 GHz, and some up to 67 and even 85 GHz
- Newer models support vector signal generation for the latest communication standards
- Often necessary to develop advanced wireless and radar systems

Purchase lower-frequency signal generators and frequency extenders?

- Existing in-house signal generators may be suitable for frequency extension
- Many signal generators provide hardware and software support for frequency extenders
- Extended signal generators are suitable for many applications

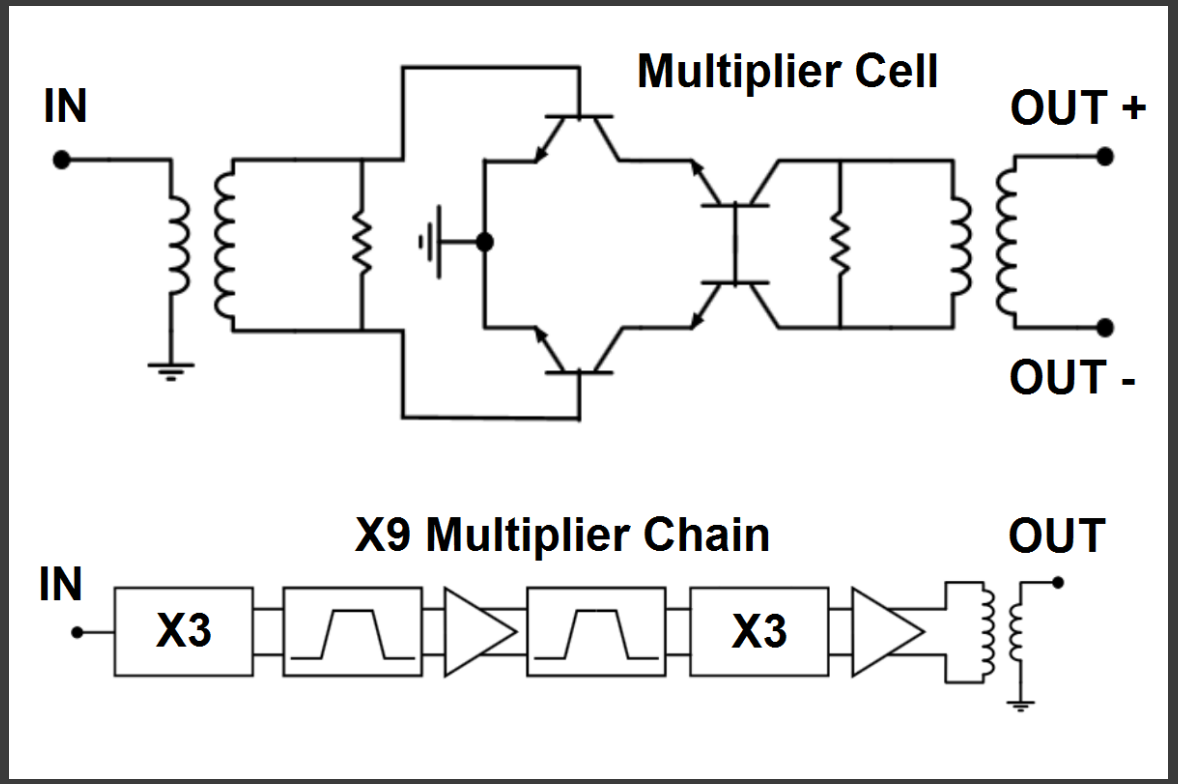
FREQUENCY EXTENSION OF SIGNAL GENERATORS

Frequency Multipliers

Typically used with synthesized signal sources and sweepers

Nonlinear devices generate 2nd and 3rd harmonics

Doublers and triplers are combined with inter-stage amplifiers and filters



FREQUENCY EXTENSION OF SIGNAL SOURCES

Frequency Multipliers

Most suitable for generating Continuous-Wave signals

Modulated input signals can be severely distorted

Phase noise levels increase by 20log(N) for a given offset

Eravant STE-KF1803-S1 to extend Anapico APUASYN20 20 GHz Synthesizer to 330 GHz

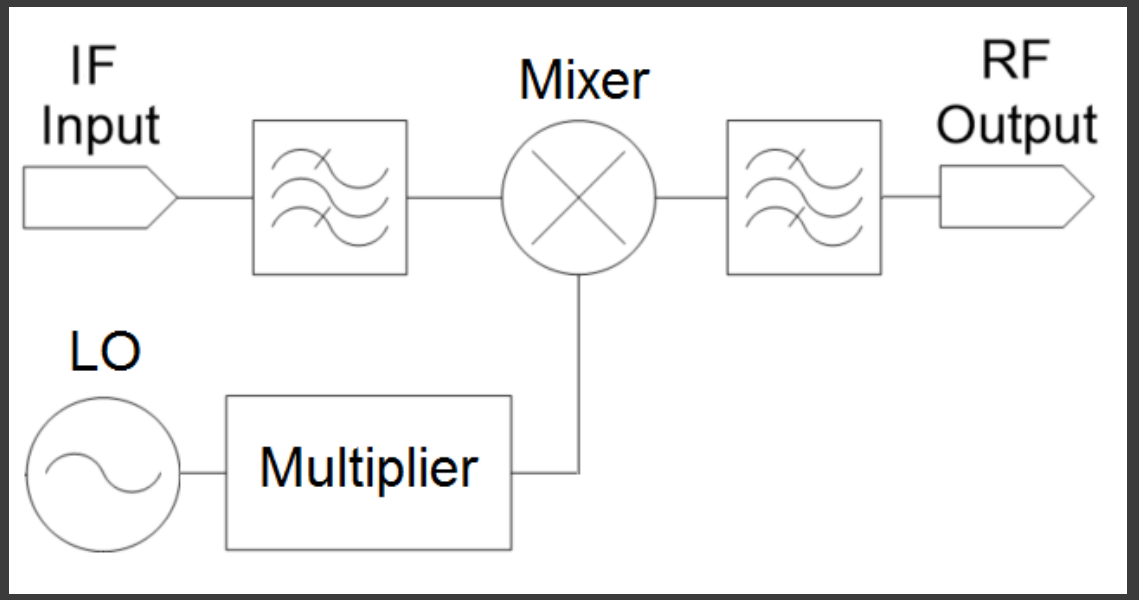
FREQUENCY EXTENSION OF SIGNAL SOURCES

Up-Converters

A mixer translates input signals to higher frequencies

An LO signal source is required, possibly from the signal generator

A multiplier is often included to enable lower LO frequencies



FREQUENCY EXTENSION OF SIGNAL SOURCES

Up-Converters

Suitable for wide-band modulated input signals

Conversion gain flatness is typically within +/- 2 dB over an entire waveguide band

Can extend an Arbitrary Waveform Generator (AWG) to higher frequencies

Eravant STV-00-06-S1 to cover 110 to 170 GHz with -3 dBm output and x12 LO

FREQUENCY EXTENSION OF SIGNAL SOURCES

Vector Signal Generator Extender

Newer signal generators are more commonly configured to work with optional frequency extenders

Keysight V3080A Signal Generator Extender to cover 0.01 to 110 GHz Frequency Range , 2.5 GHz Modulation Bandwidth Accessory for M9484C Vector Signal Generator

SIGNAL (SPECTRUM) ANALYZER OPTIONS

Purchase spectrum analyzers with the necessary frequency range?

- Major equipment manufacturers offer solutions up to 110 GHz
- Some newer models support advanced capabilities such as high-speed (real-time) spectral analysis and event capture
- Often necessary to develop advanced wireless systems

Purchase lower-frequency signal analyzers and frequency extenders?

- Existing in-house signal analyzers may be suitable for frequency extension
- Many signal analyzers provide hardware and software support for frequency extenders
- Extended signal analyzers are suitable for many applications

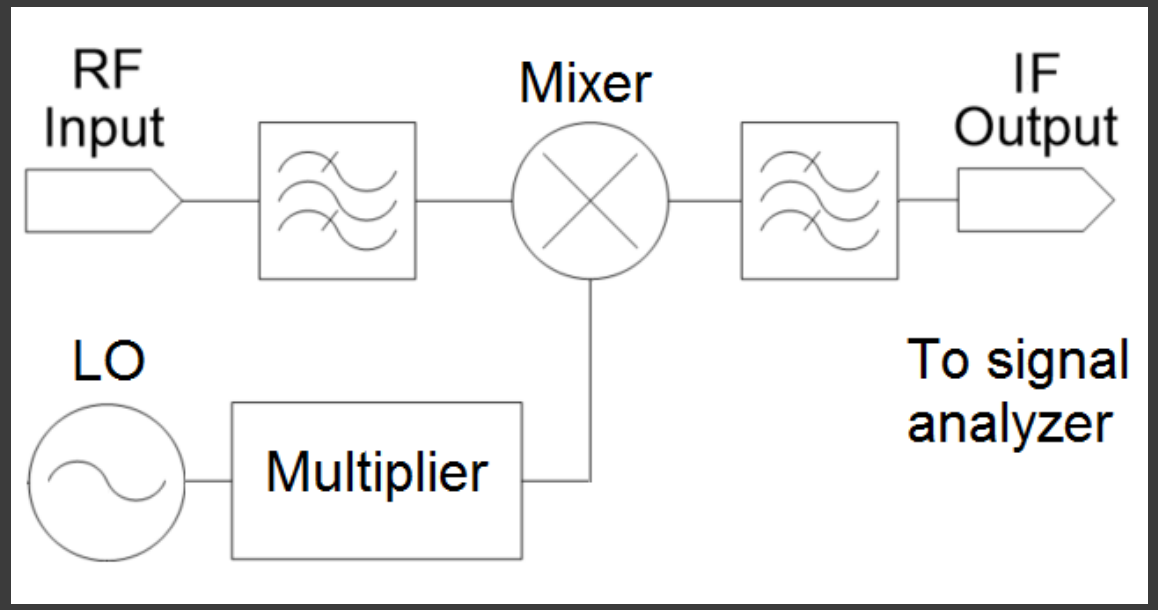
FREQUENCY EXTENSION OF SIGNAL ANALYZERS

Down-Converters

A mixer translates input signals to lower frequencies

An LO signal source is required, possibly from the signal analyzer

A multiplier is often included to enable lower LO frequencies



FREQUENCY EXTENSION OF SIGNAL (SPECTRUM) ANALYZERS

Harmonic Mixer

Suitable for wide-band modulated input signals

Capable of noise and power measurements

Lower cost

SFH-06SFSF-A3 to extend older 26.5 GHz Spectrum Analyzers to 110 to 170 GHz by using 32nd Harmonic

FREQUENCY EXTENSION OF SIGNAL (SPECTRUM) ANALYZERS

Down-Converters

Suitable for wide-band modulated input signals

Special configurations are available for phase noise and power measurements

STC-20-06-S1 and SOT-02220313200-SF-B6
to offer 110 to 170 GHz Spectrum Analysis Capability

FREQUENCY EXTENSION OF VECTOR SIGNAL ANALYZERS

Vector Signal Analyzer Down-Converters

Newer signal analyzers are more commonly configured to work with optional frequency extenders

Expensive

Keysight V3050A Signal Analyzer Extender
50 to 110 GHz, 40 GHz Analysis Bandwidth
Accessory for N9042B Vector Signal Analyzer

FREQUENCY EXTENSION OF NFA FOR MMW & SUB-THZ NOISE FIGURE & GAIN MEASUREMENT

Down-Converters and Noise Source

Gain and NF measurements are supported by down-converters and noise sources developed by Eravant to extend the standard 26.5 or 40 GHz Noise Figure Analyzer

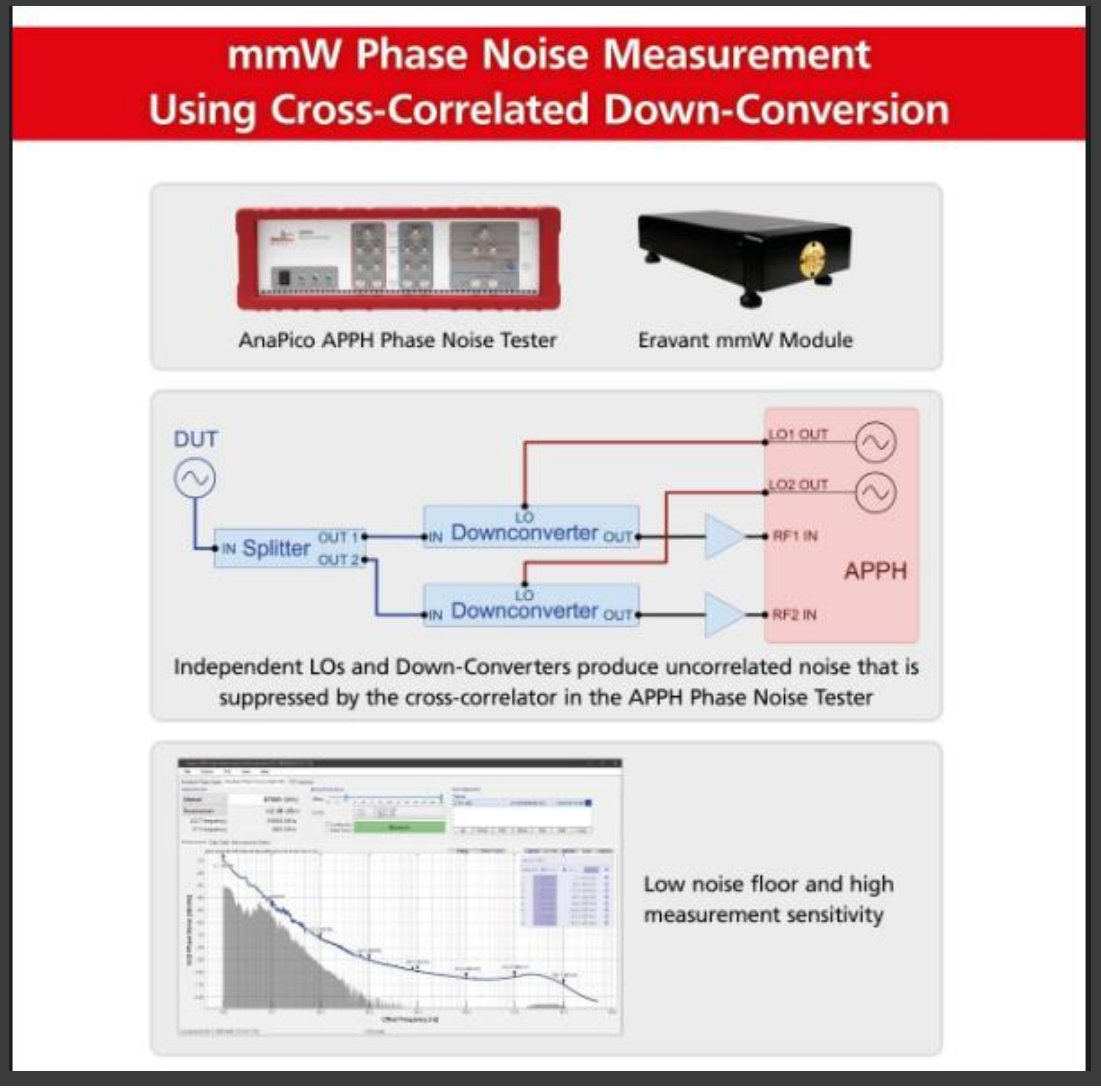
STG-06-S1 to offer 110 to 170 GHz Noise Figure and Gain Measurement

FREQUENCY EXTENSION OF SIGNAL ANALYZERS

Phase Noise Analyzer Down-Converters

Phase Noise Analyzer measurements are enabled by two-channel down-converters that support Anapico and Holzworth phase noise analyzers, extending cross-correlation phase noise measurement to Sub-THz.

Eravant STI-05-12-S1 to extend Anapico 40 GHz PNA to cover 60 to 90 GHz



VECTOR NETWORK ANALYZER OPTIONS

Purchase network analyzers with the necessary frequency range?

- Major equipment manufacturers offer solutions up to 110 GHz without frequency extension
- Some newer models support advanced capabilities such as cold-source noise figure measurements
- Often necessary to develop highly advanced wireless systems

Purchase lower-frequency network analyzers and frequency extenders?

- Most existing in-house network analyzers are not suitable for frequency extension
- Some network analyzers provide hardware and software support for frequency extension
- VNA vendor support is required to achieve good results

FREQUENCY EXTENSION OF NETWORK ANALYZERS

VNA Hardware Requirements

Frequency extenders require VNA hardware support!

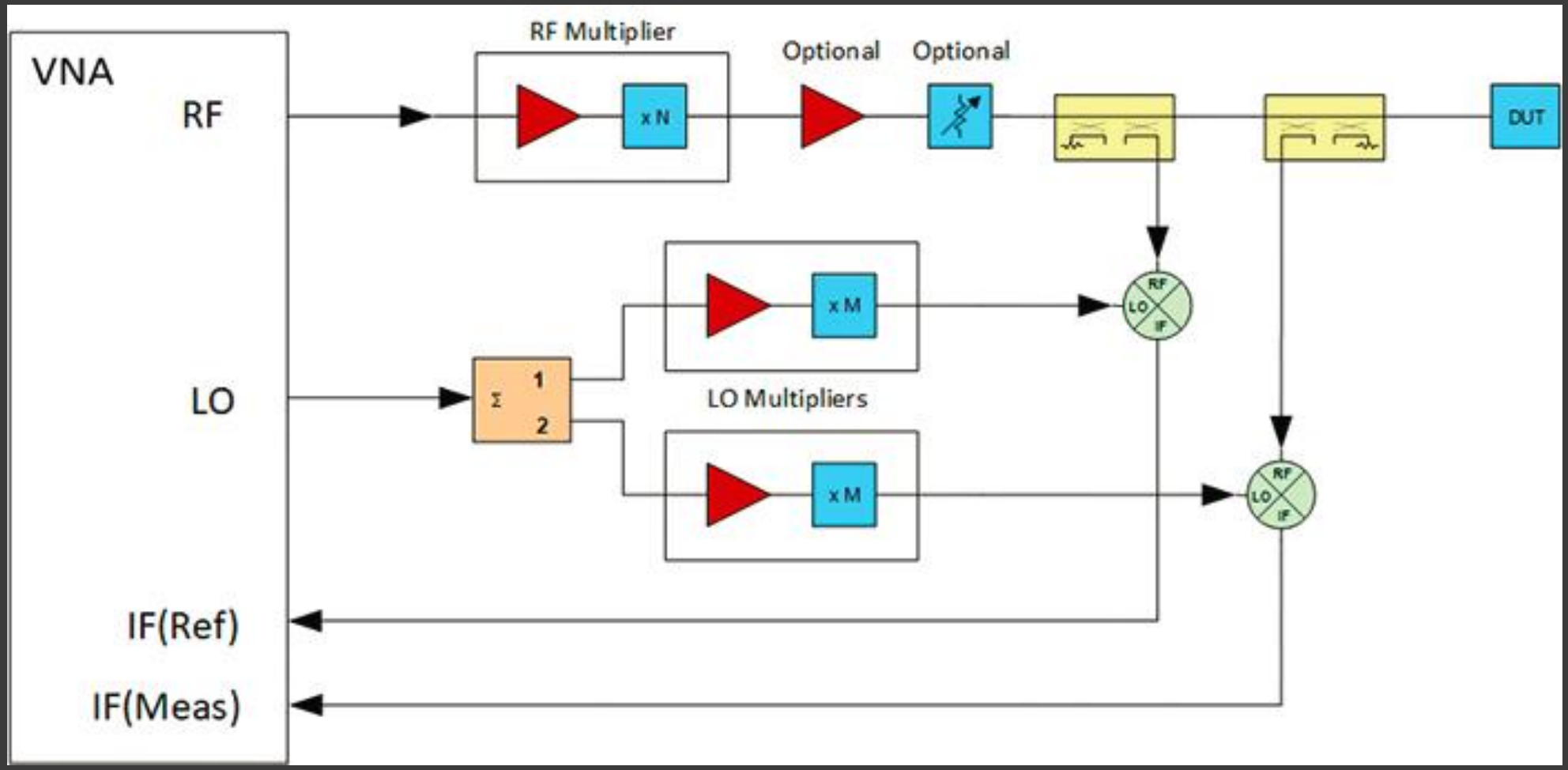
The VNA must provide independently controlled RF and LO signals

The RF and LO signals must be synthesized from the same reference

The VNA must provide access to its IF receiver channels

Eravant VNA extenders are compatible with all OEM VNAs.

VNA FREQUENCY EXTENDER ARCHITECTURE



FREQUENCY EXTENSION OF NETWORK ANALYZERS

VNA Software Functions

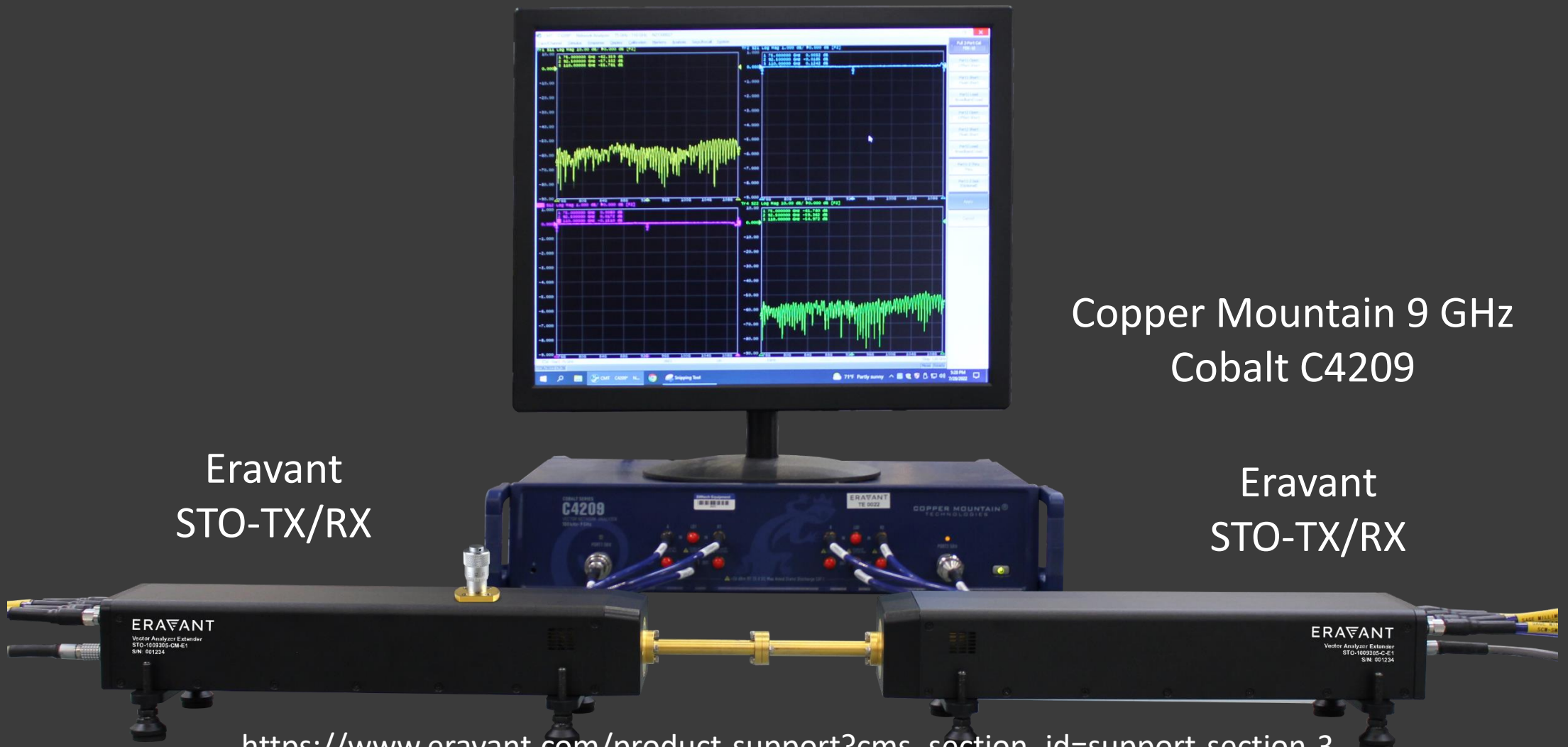
The VNA uses the RF and LO multiplication factors to generate the correct RF and LO frequencies fed to the frequency extender

The VNA controls the amplitude of the RF and LO signals

The VNA uses waveguide calibration standards and definitions

The VNA displays and records measurements using the extended test frequency values

VNA FREQUENCY EXTENDER SETUP



Copper Mountain 9 GHz
Cobalt C4209

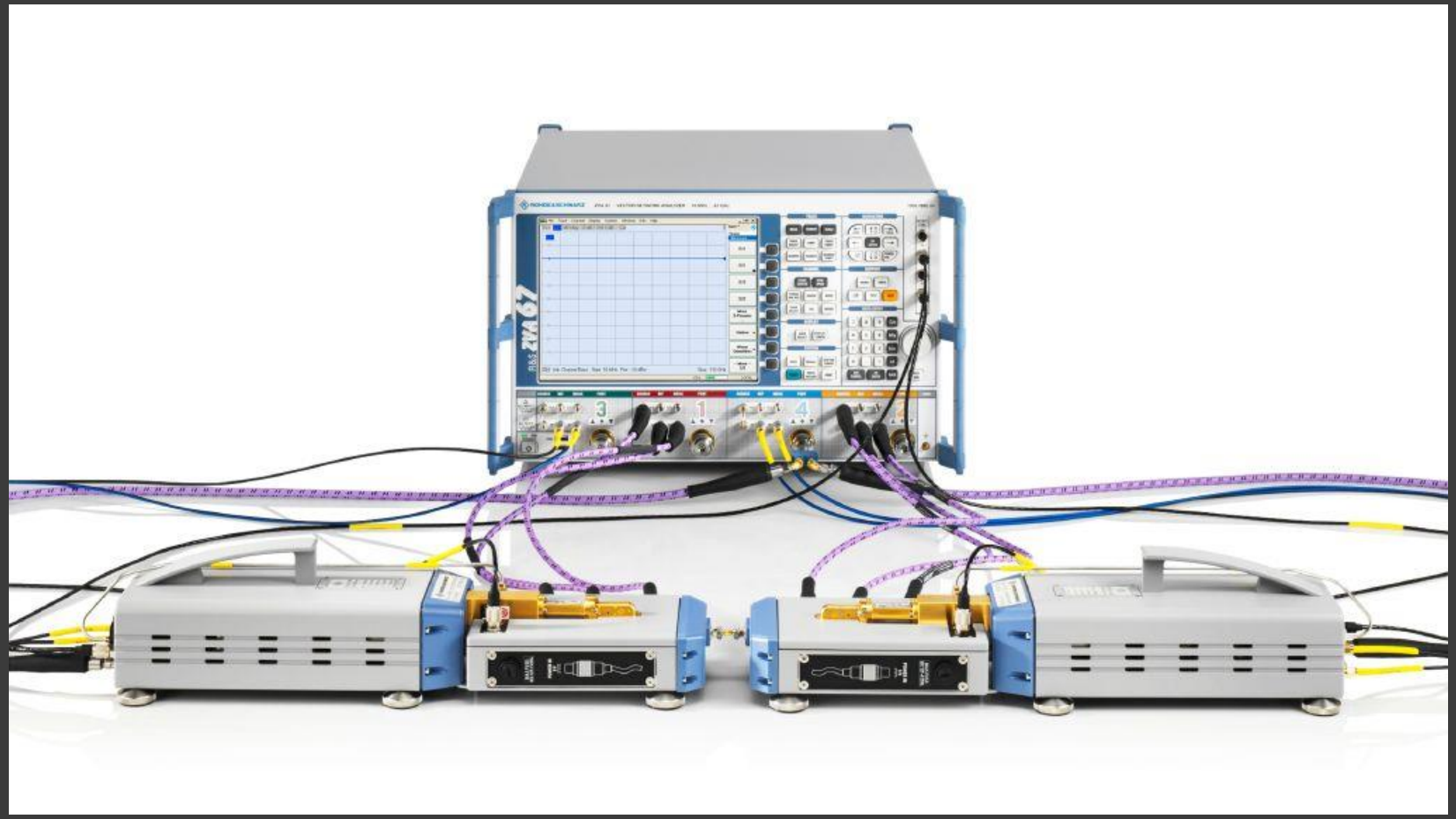
Eravant
STO-TX/RX

Eravant
STO-TX/RX

https://www.eravant.com/product-support?cms_section_id=support-section-3

VNA FREQUENCY EXTENDER SETUP

Rohde & Schwarz
ZVA-110
10 MHz to 110 GHz
Continuous Sweep



FAR FIELD ANTENNA RANGE EXTENDER SETUP

OTA – FAR FIELD

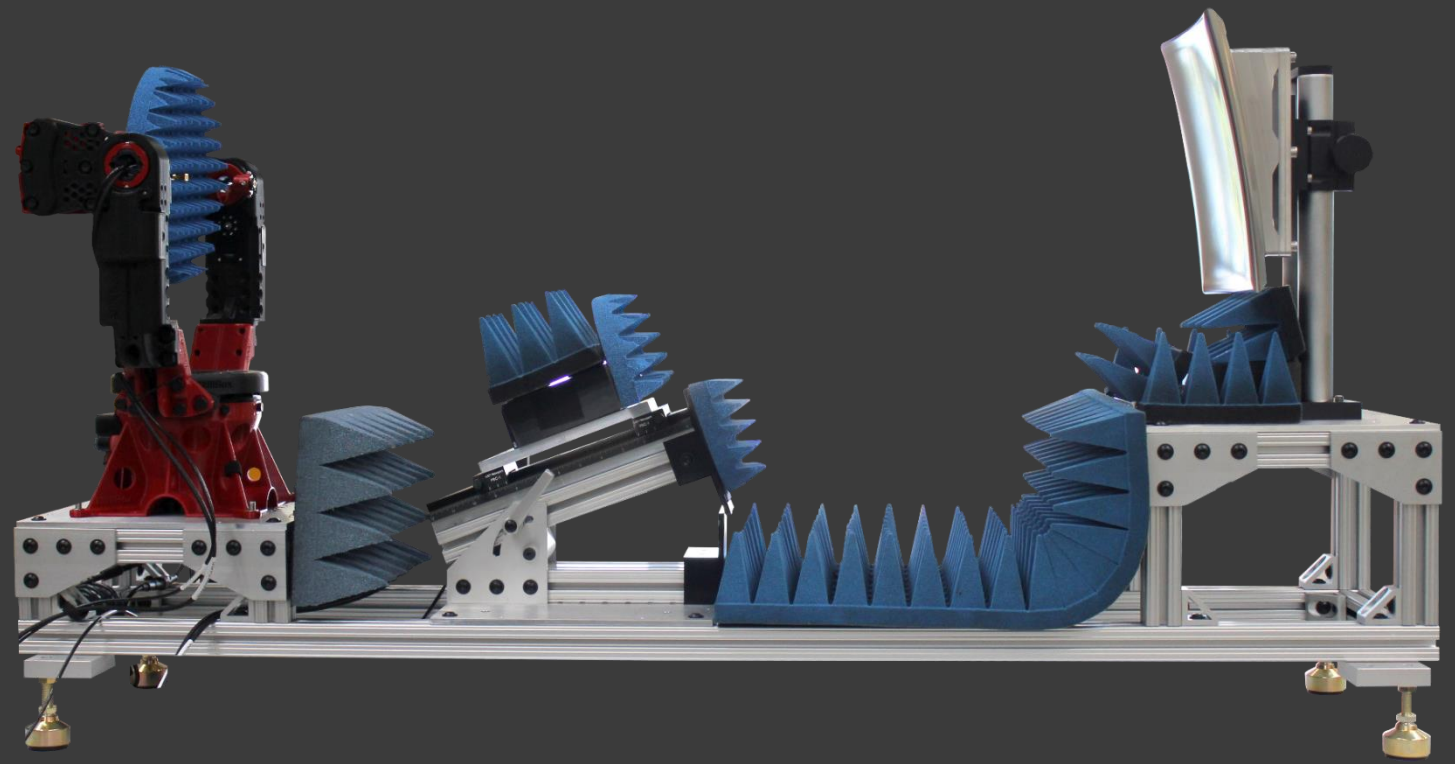
MilliBox gimbals with Copper Mountain VNAs and Eravant extender solutions offer low cost & high performance 3D pattern measurements up to 330 GHz for measuring phased arrays and many other antennas

COMPACT ANTENNA RANGE EXTENDER SETUP

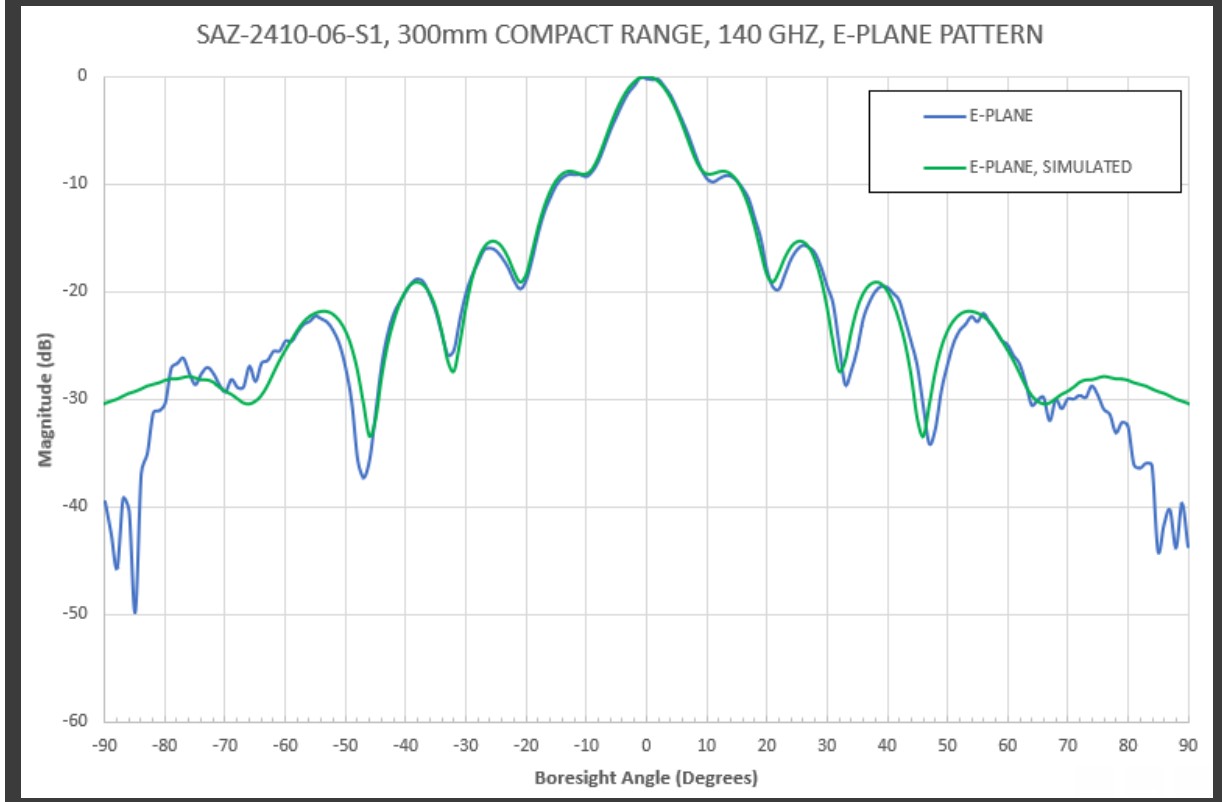
OTA-COMPACT RANGE

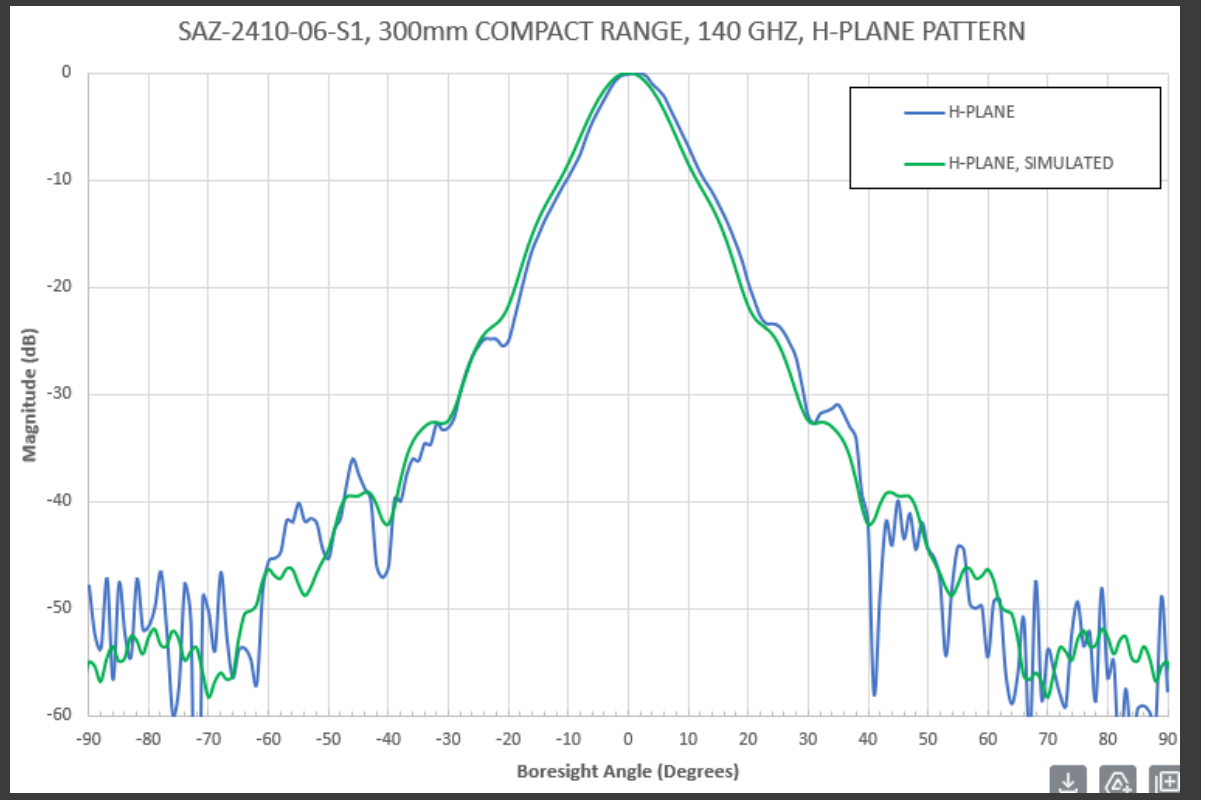
Eravant open bed compact ranges with Copper Mountain VNAs and Eravant extender solutions offer low cost and high performance up to 170 GHz using a 300 x 300 mm parabolic reflector

900 mm x 900 mm version is under development.



PATTERNS FROM COMPACT ANTENNA RANGE EXTENDER SETUP





CONCLUSION

- Frequency extension is a common strategy to achieve Test & Measurement capabilities at millimeter-wave and THz frequencies
- Above 100 GHz frequency extension is required generally
- Big Box can cover the most frequency extension measurement requirements but is very expensive.
- Single Function Equipment can be extended in frequency using multipliers, up-converters and down-converters: signal generators, arbitrary waveform generators, spectrum analyzers, noise figure and gain measurement systems, phase noise analyzers, and antenna measurement systems in a very cost-effective way.
- VNAs must have built-in hardware and software functions to support frequency extension: IF receiver access, independent RF and LO sources, and specialized calibration and measurement functions

ERAVANT

NEXT GENERATION MILLIMETERWAVE COMPONENTS

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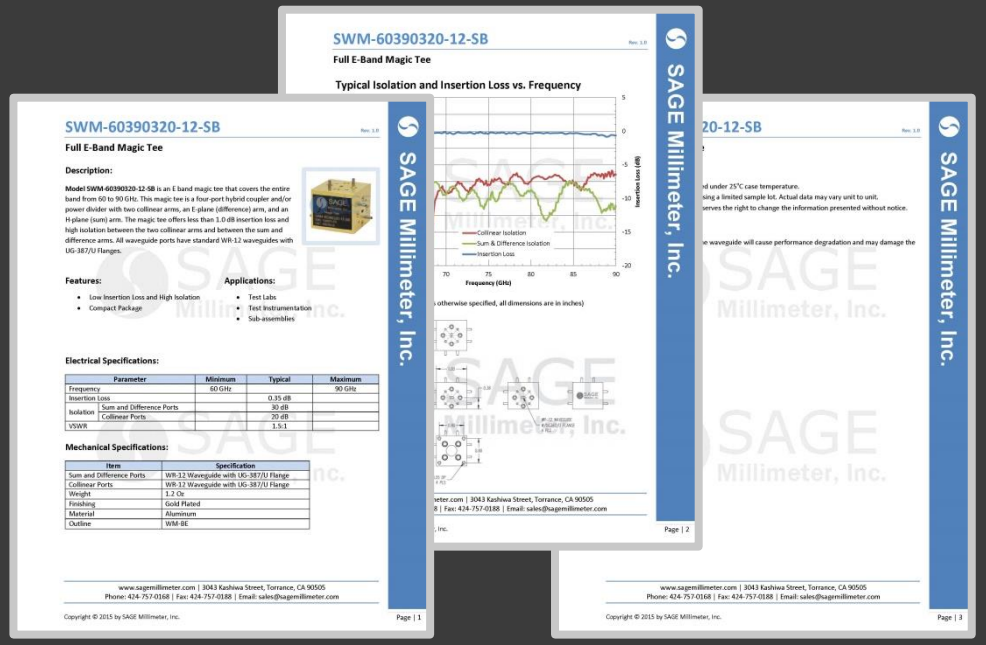

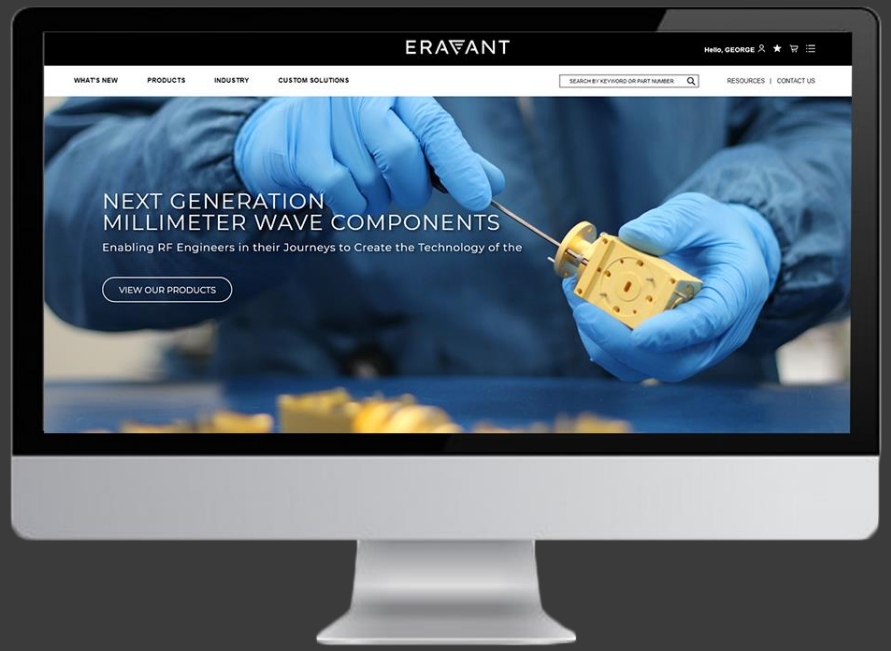

PASSIVE FREQUENCY MULTIPLIERS — GRID | TABLE — 28 RESULTS

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	56.67 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-283SF-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-2734033N05-28SF-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-223SF-S1	33 GHz	50 GHz	+3 dBm	11 GHz	16.67 GHz	+20 dBm	WR-22 Waveguide	SMA (F)	Datasheet STEP File	View
SFP-222KF-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-363673303-19SF-N1	57 GHz	86 GHz	+3 dBm	12 GHz	19 GHz	+20 dBm	WR-19 Waveguide	SMA (F)	Datasheet STEP File	View
SFP-192KF-S1	40 GHz	60 GHz	+6 dBm	20 GHz	30 GHz	+20 dBm	WR-19 Waveguide	2.92 mm (F)	Datasheet STEP File	View