ERAVANT

NEXT GENERATION MILLIMETERWAVE COMPONENTS

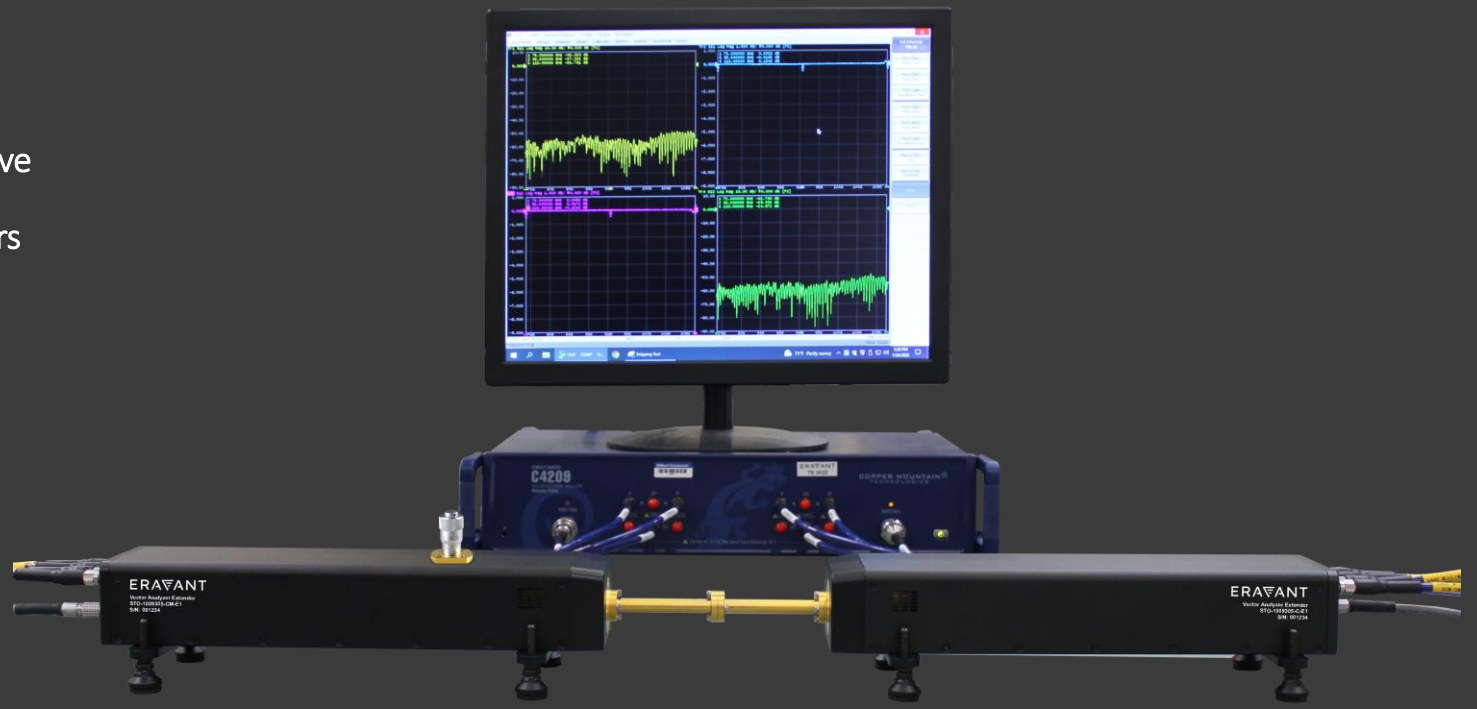
# Contactless Flanges Reaching 325 GHz


11 to 16 June 2023, IMS 2023 MicroApps

# CONTENTS

# mmW and THz Test Challenges

- mmW band: 30 to 300 GHz;
- THz band: 100 GHz to 3 THz and above
- Equipment setup: VNA with extenders

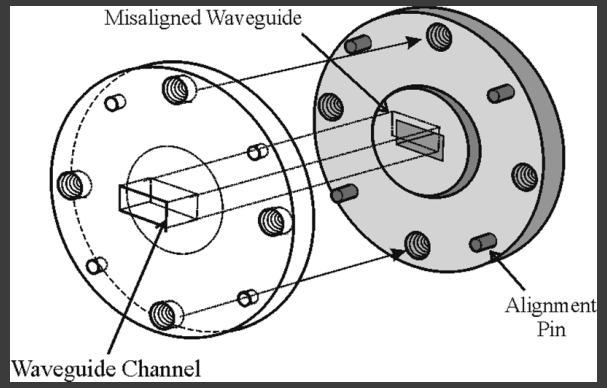



Model STO-03203N05-CMC-S1 from Eravant, covering 220 to 330 GHz, 110 dB Dynamic Range, 12.22 to 18.33 GHz Input, WR-03 Waveguide

Reliable waveguide connection between two extenders are critical for accurate mmW and THz measurements.

# mmW and THz Test Challenges

- Small rectangular waveguide sizes:
  - WR-10, 75-110 GHz, 0.1'' X 0.05" (2.54 mm X 1.27 mm)
  - WR-03, 220 to 330 GHz, 0.034" X 0.017" ( 0.8636 mm X 0.4318 mm)




Waveguide misalignment [1]
- Tolerance in fabrication
- Flange misalignment in test

Waveguide cocking [2] the flange screws have pulled the mating faces apart

Waveguide fasten [3]
Waveguide quick connect provided by Eravant

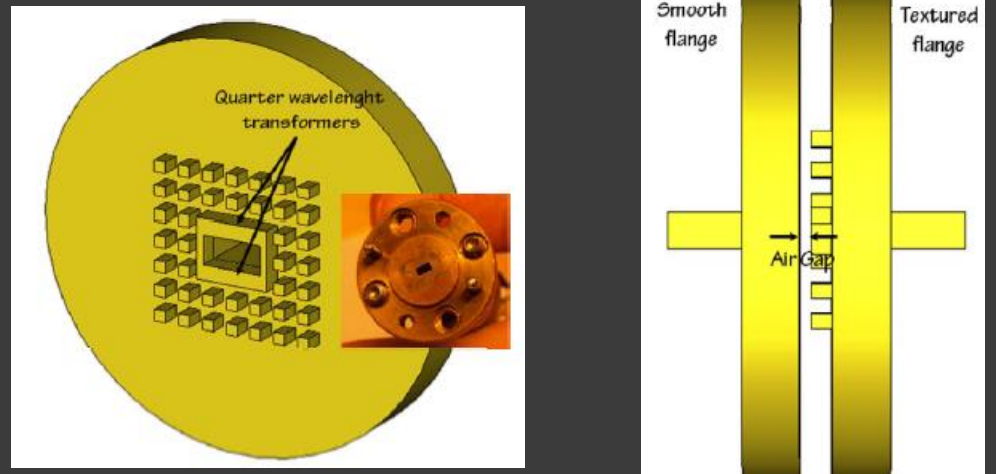
1. Z. Liu and R. M. Weikle II, "A reflectometer calibration method resistant to waveguide flange misalignment," IEEE Trans. Microw. Theory Tech., vol. 54, no. 6, pp. 2447–2452.
2. https://flann.com/comment/why-cots-makes-no-sense/
3. https://coppermountaintech.com/calibration-kits/waveguide-quick-connect/

# mmW and THz Test Challenges

Some other challenges

- Waveguide connection leakage due to flange wear out, deform
- Experienced technician needed for reliable and accurate measurement

To avoid the waveguide flange cocking, fastening and wear out, **contactless waveguide flange** has been proposed by researchers for mmW and THz measurements.



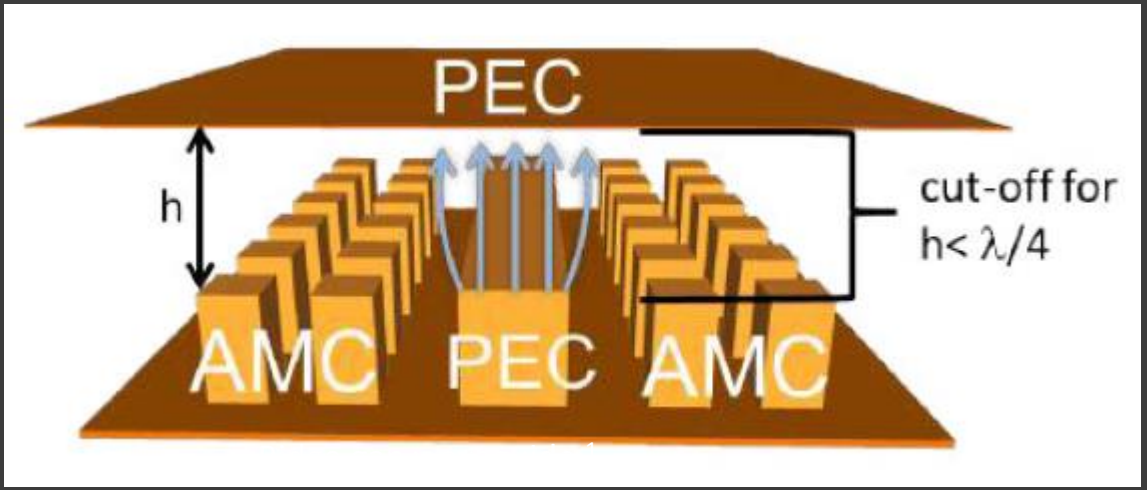




One contactless flange design [1]

1. E. Pucci and Per-Simon Kildal, "Contactless non-leaking waveguide flange realized by bed of nails for millimeter wave applications," 6th Eur. Conf. Antennas Propag (EUCAP), March 2012.

# Contactless Flange Design




- The pins generates an array of open circuits, so tangential magnetic field is zero at the surface. So the pin-surface realizes the artificial magnetically conductive (AMC) surface.
- A perfect electrically conductive surface has zero tangential electrical field at the surface.
- When the distance between PEC and AMC is less than $\lambda_0/4$, a stopband is created.

1. S Rahiminejad, E Pucci, S Haasl and P Enoksson, “Micromachined contactless pin-flange adapter for robust high-frequency measurements,” J. Micromech. Microeng., vol. 24, no. 8, p. 084004, 2014.

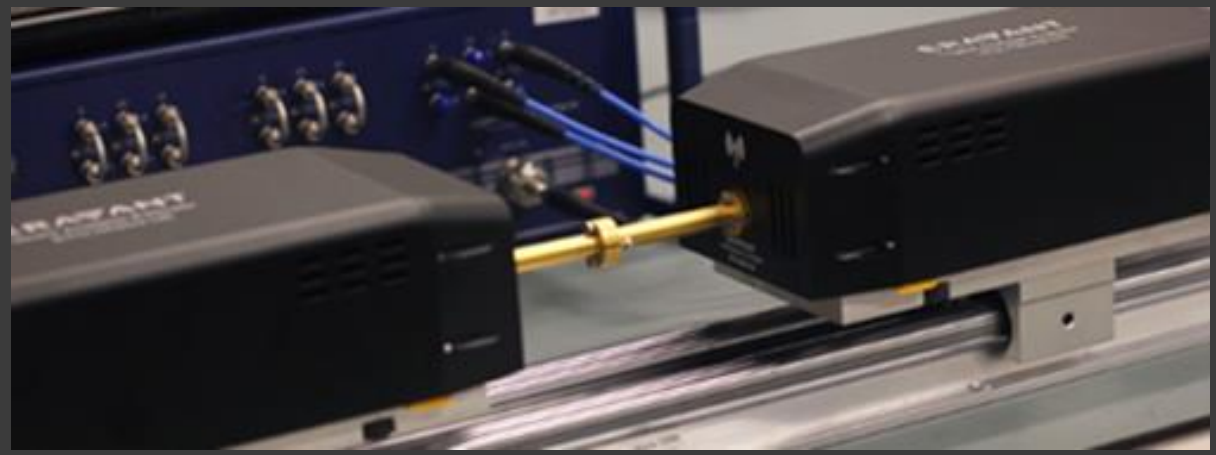
# Proposed Contactless Flange Design

- The difference between the proposed contactless flange and other designs: the pin array is engraved on a choke flange on the surface.
- The proposed contactless flange can mate with standard waveguide flanges using screws
- Choke ring depth:  quarter wavelength
- Choke ring inner diameter:  quarter wavelength to the waveguide broadside

Example:
WR-3 contactless flange with transformer

- WR-3 waveguide size 0.034”X0.017”
- Inner diameter of choke 0.068”
- Outer diameter of choke 0.212”
- Choke depth 0.012”
- Pin array height 0.012”
- Four rows of pins along concentric circles
- Pin thickness 0.008”
- Spacing between pin circles 0.008”
- 9 group of pins with central angle of 24 degrees
- Central angle of 16 degrees between two adjacent groups

# VNA Calibration Using Contactless Flanges



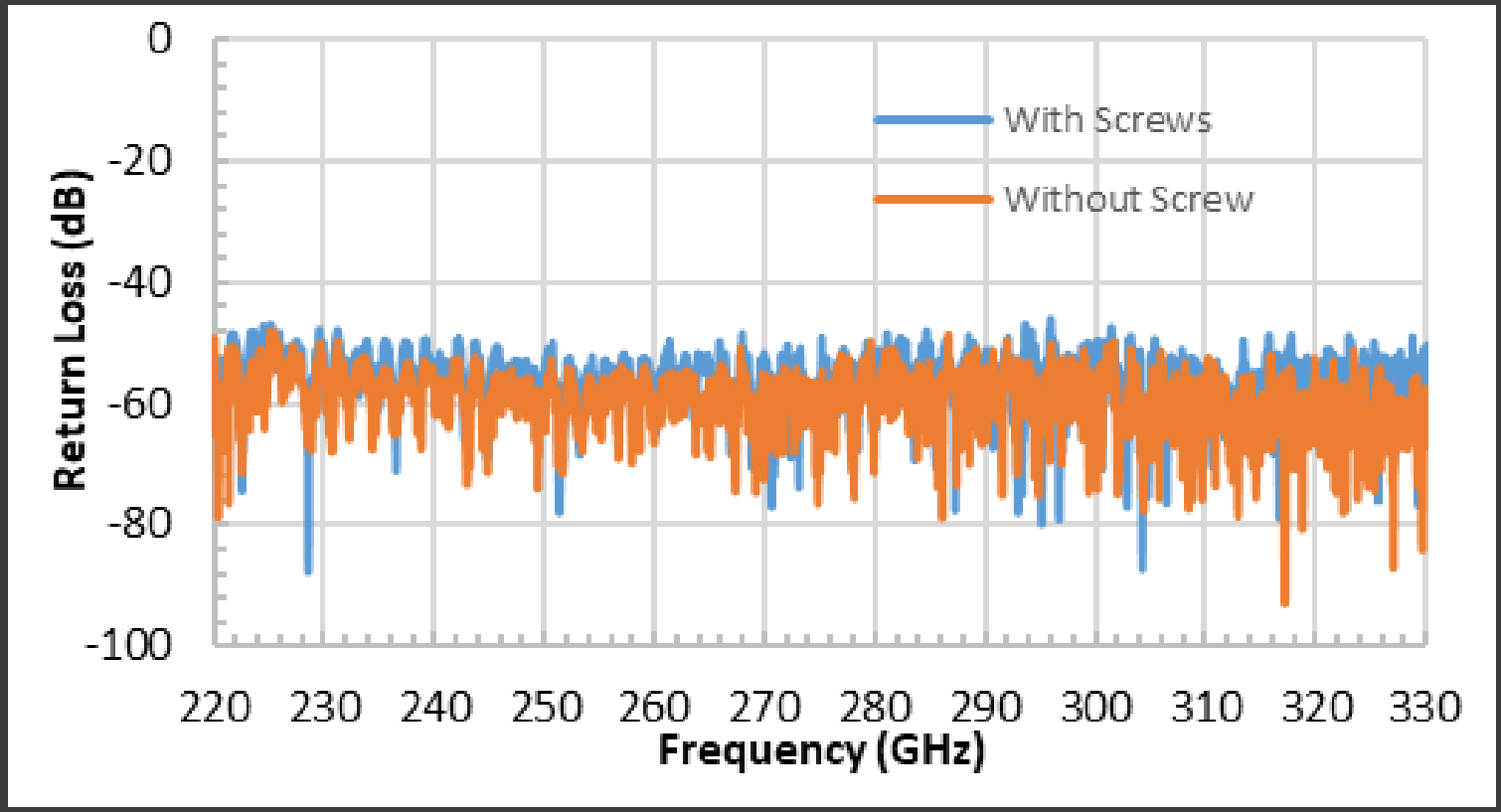
- Each extender is equipped with a straight waveguide using contactless flanges.
- SOLT (short, open, load, through) and TRL (through, reflect, line) calibrations performed on the VNA
- TRL Calibration performed on WR-3 VNA
- Both SOLT and TRL calibrations performance on WR-10 VNA
- The proposed contactless flange can be used with or without screws
- Calibration results between tightening up screws or not are compared

# VNA Calibration Using Contactless Flanges

Time recorded to perform calibrations on VNA

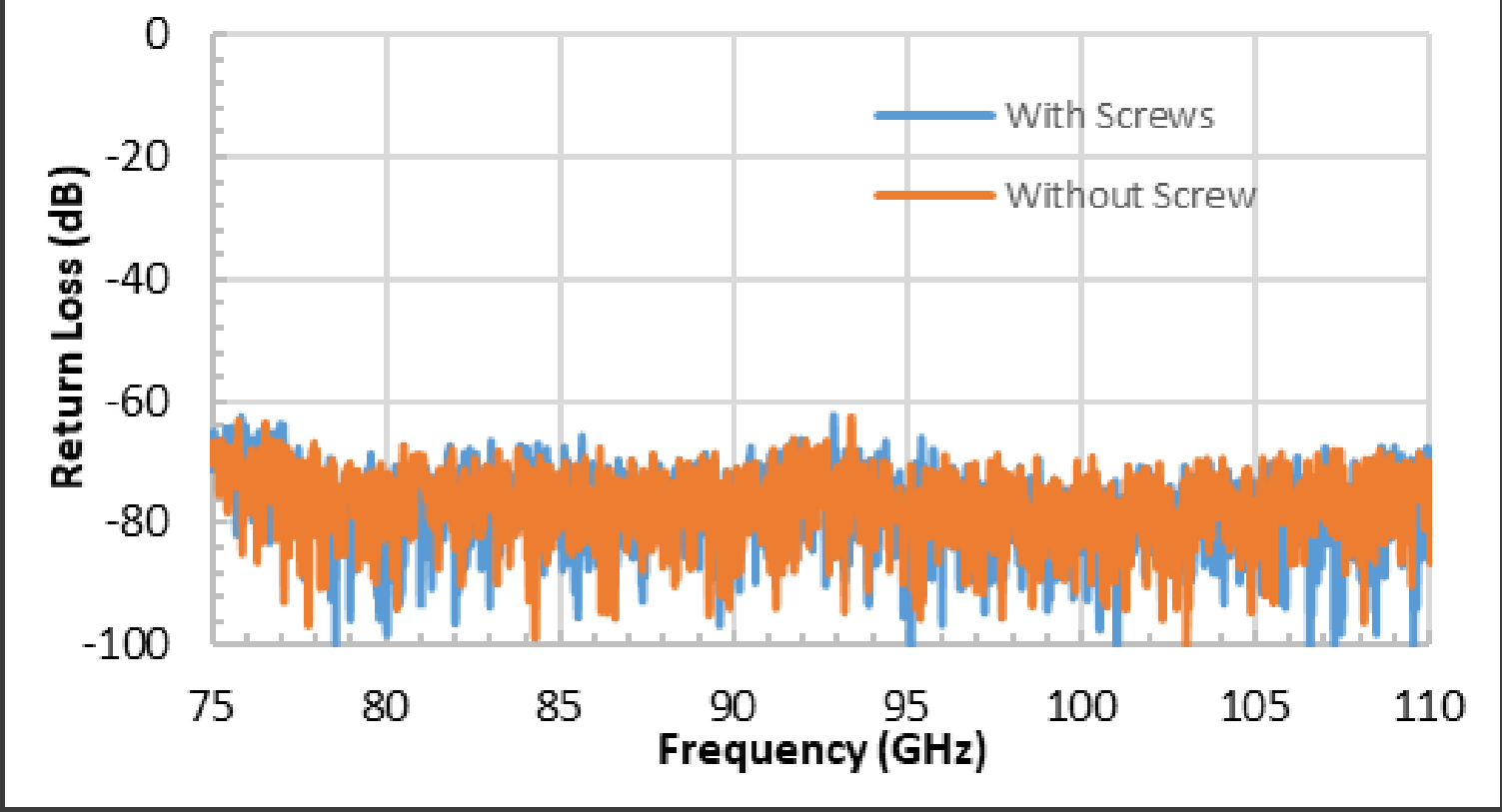
| | SOLT Calibration | TRL Calibration |
|---|---|---|
| WR-3 VNA with screws | - | 3 minutes 15 seconds |
| WR-3 VNA without screws | - | 44 seconds |
| WR-10 VNA with screws | 3 minutes 15 seconds | 1 minute 57 seconds |
| WR-10 VNA without screws | 1 minute 3 seconds | 42 seconds |

# VNA Calibration Using Contactless Flanges



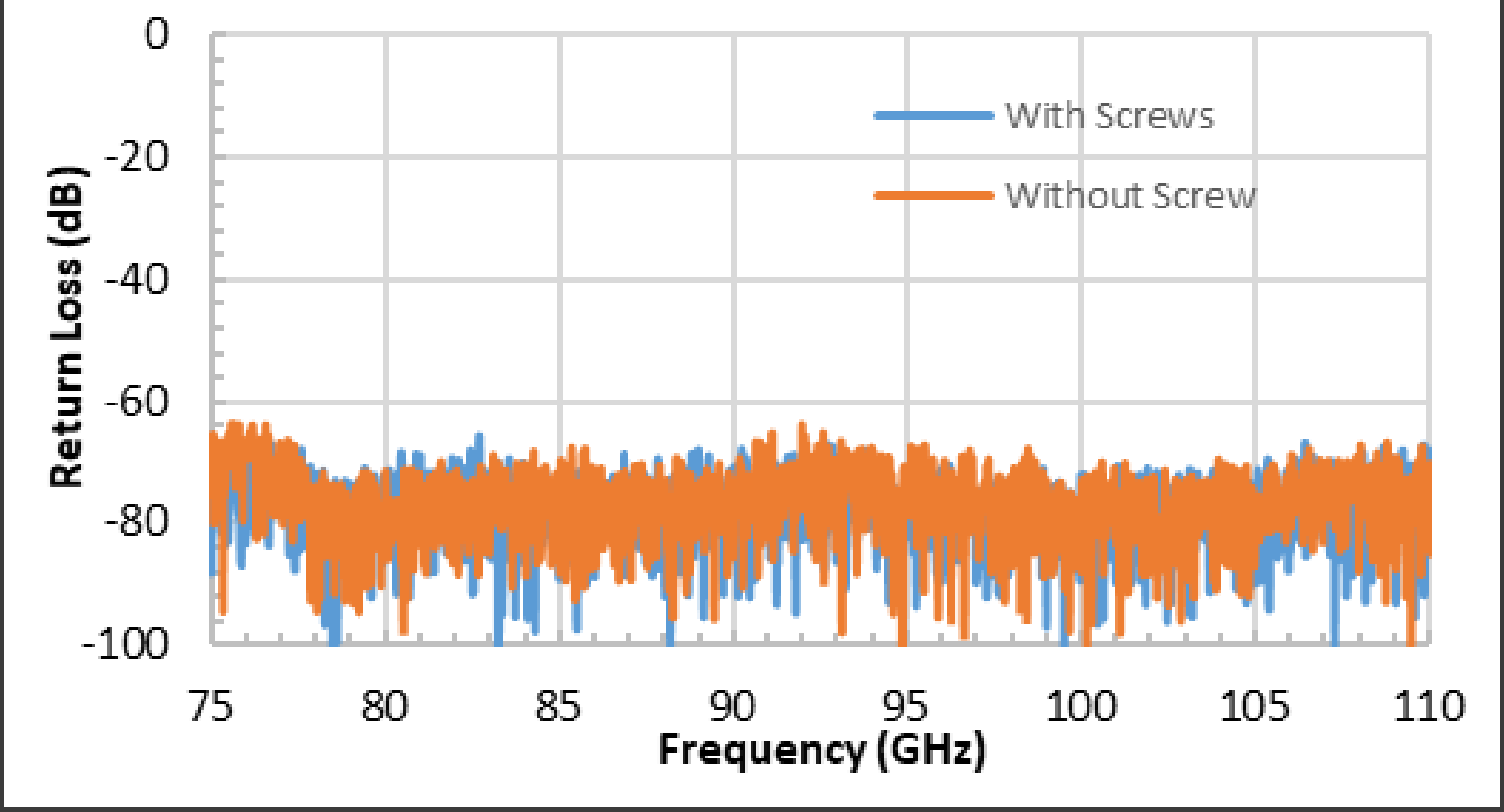

Return loss of WR-3 VNA after TRL calibration

# VNA Calibration Using Contactless Flanges



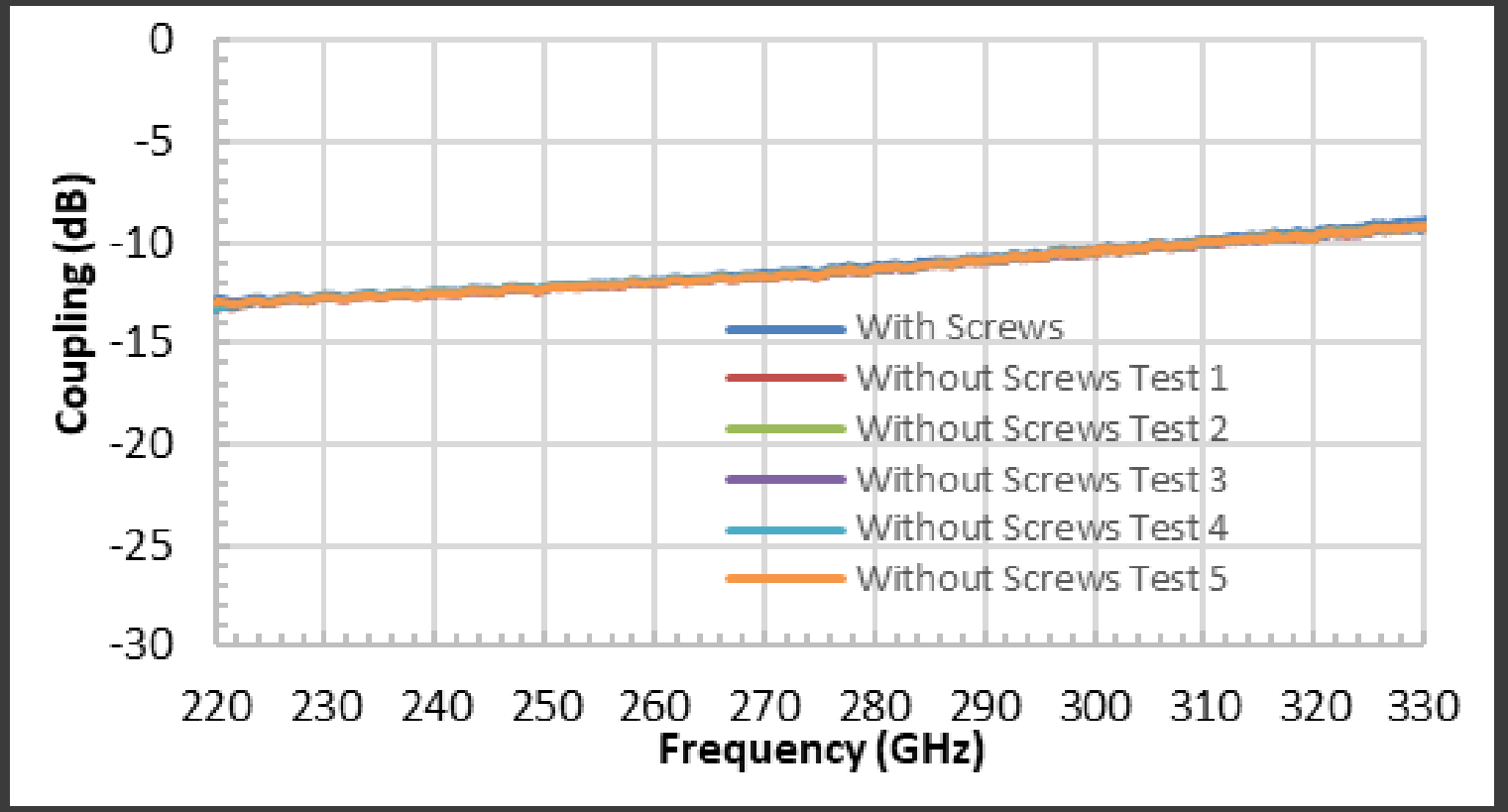

Return loss of WR-10 VNA after SOLT calibration

# VNA Calibration Using Contactless Flanges



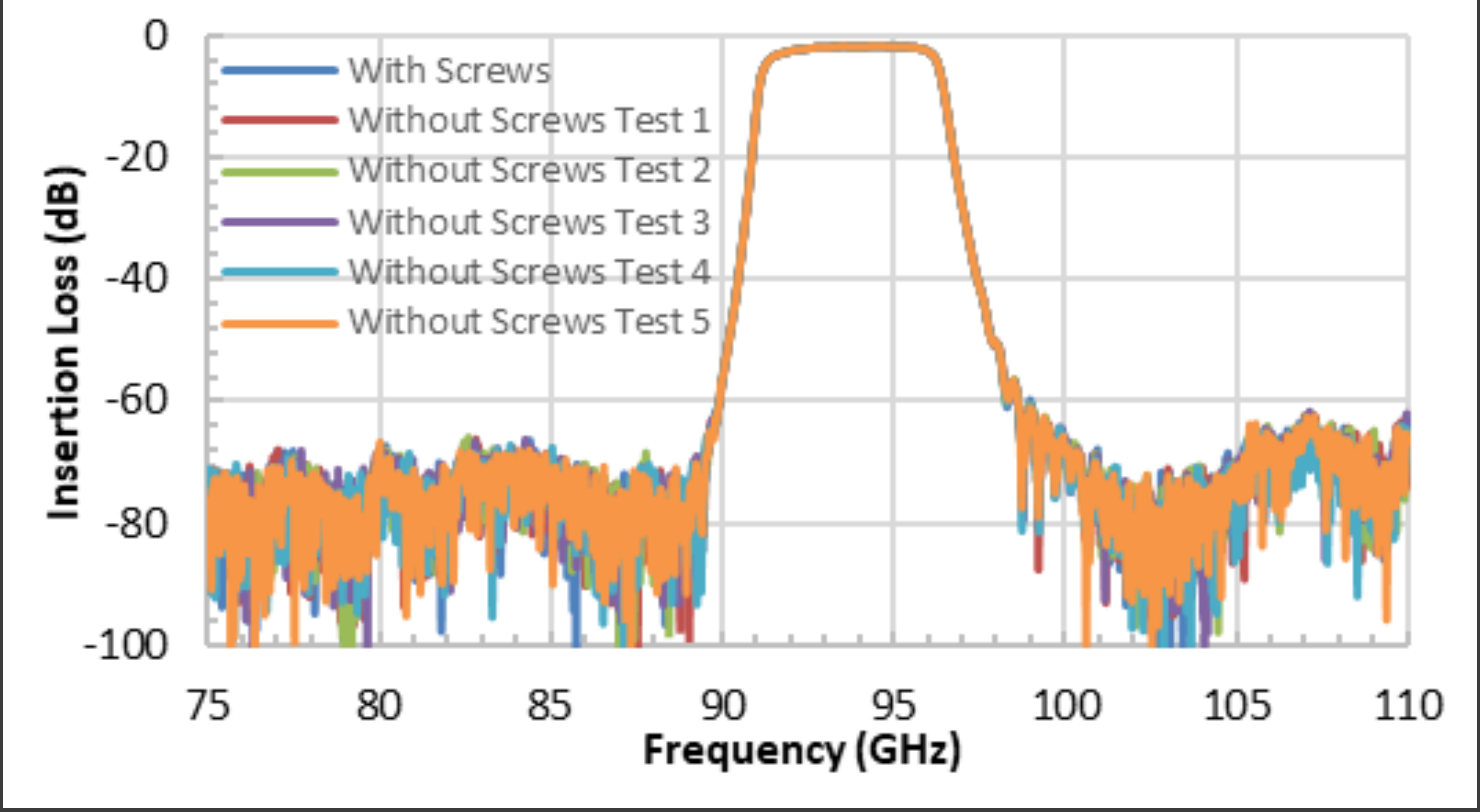

Return loss of WR-10 VNA after TRL calibration

# Sub-THz Component Measurement Using Contactless Flange




Comparison of coupling of one WR-3 coupler when screws of contactless flanges were tightened up and when no screws used.

# Sub-THz Component Measurement Using Contactless Flange




Comparison of insertion loss of one WR-10 E-plane filter when screws of contactless flanges were tightened up and when no screws used.

# CONCLUSION

- Contactless flanges show advantages in mmW and THz measurements.
- Contactless flanges which can mate with standard waveguide flange have been proposed. The contactless flange can be used with VNA extenders and make VNA calibration much faster.
- Contactless flanges can provide reliable VNA calibrations.
- Tests of sub-THz components using VNAs with contactless flanges have demonstrated consistent and reliable results.