

Microapps 2023

Broadband On-wafer Differential VNA Measurements to 220 GHz: Concepts and Solutions

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Lecture content:

Industry needs

Broadband 2-port and 4-port VNA configurations

4-port single-ended and differential measurements

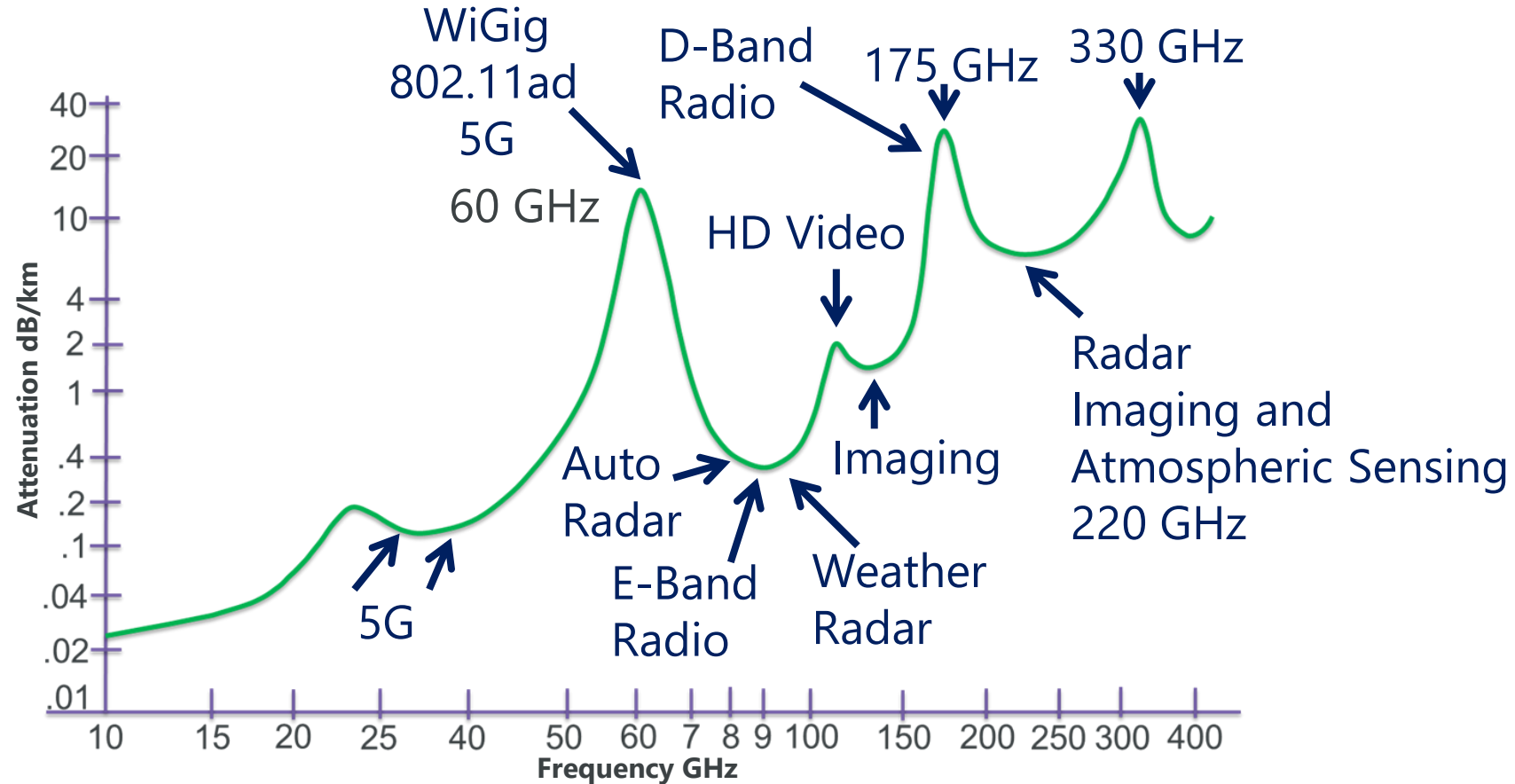
True mode differential measurements to 220 GHz

VectorStar ME7838G4 4-port 220 GHz system installation

4-port differential calibrations to 220 GHz

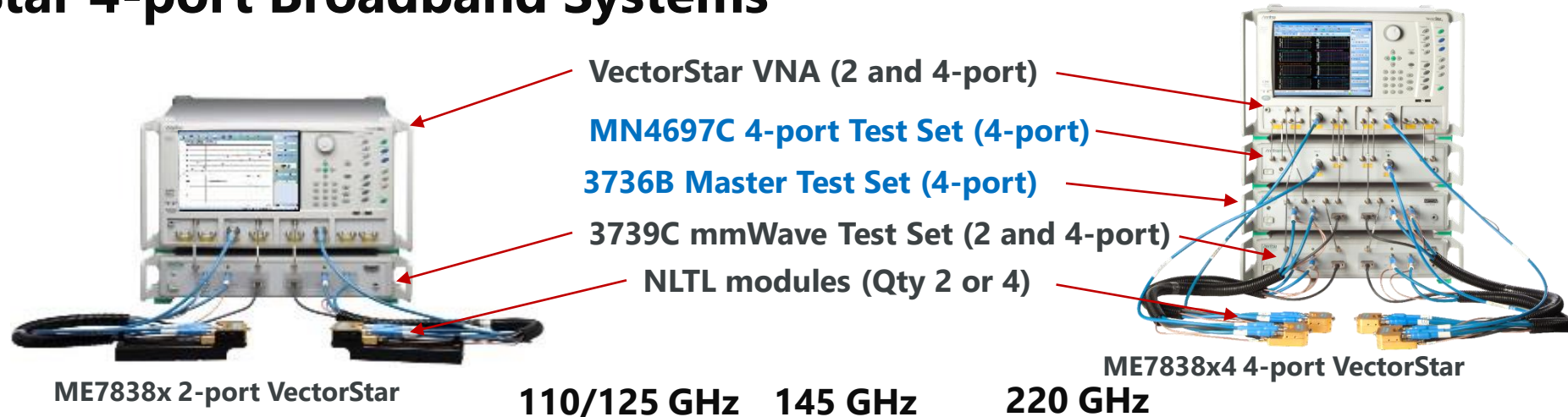
Summary

VectorStar 4-port Broadband Systems



- Microwave and mmWave communication systems optimize radio performance through the use of differential front-end receivers. As operating frequencies for communication systems continue to rise, the requirement for on-wafer differential mmWave measurements continues to increase.
- An example is the current development of 170 GHz D band radios to support the backhaul needs of 5G and upcoming 6G traffic. Differential front end receivers optimize sensitivity and overall radio performance.

VectorStar 4-port Broadband Systems

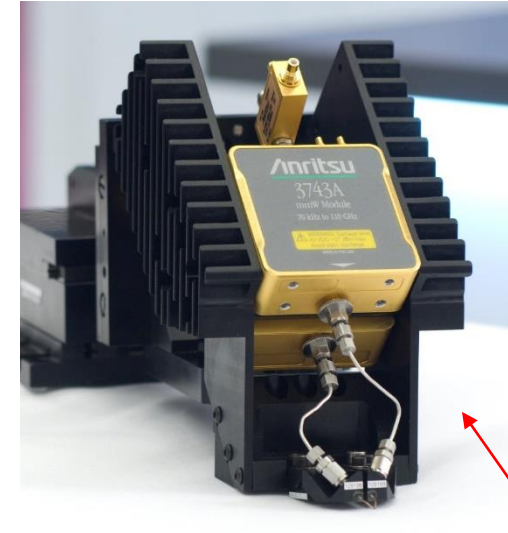


NLTL Frequency extension modules

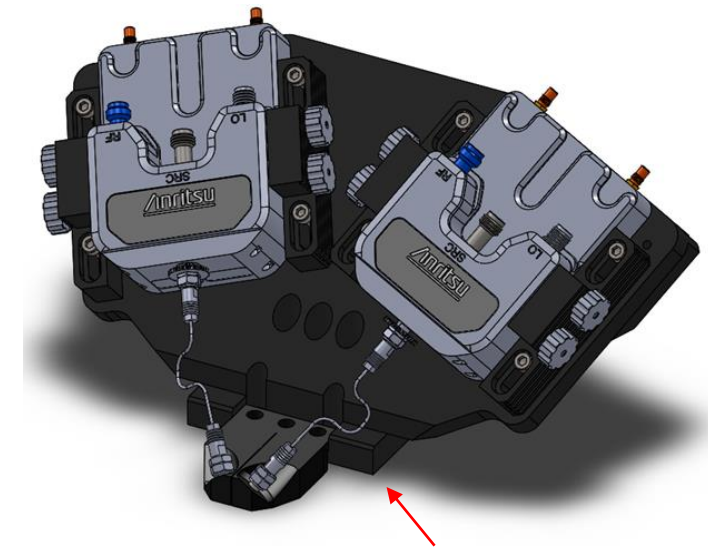
- VectorStar broadband systems extend the baseband VNA frequencies by incorporating non-linear transmission line (NLTL) modules and mmWave test sets.
- The modular architecture of the ME7838x VectorStar broadband systems offer upgrade opportunities for higher frequencies and higher port count. A two-port broadband VectorStar can be upgraded to 4 ports by adding two test sets and two NLTL modules. 4-port VectorStar broadband systems are available in 110, 125, 145 and 220 GHz.

VectorStar 4-port Broadband Systems

- Differential on-wafer measurements require a 4-port VNA, 4 mmWave modules and differential probes.
- Differential GSGSG probes require two signal sources (i.e. two separate mmwave modules per differential port). Since direct connection between modules and GSGSG probes is difficult, cables are often used. At mmwave frequencies cables need to be as short as possible.
- Small compact NLTL modules offer multiple mounting solutions for configuring on-wafer mmwave differential measurements.

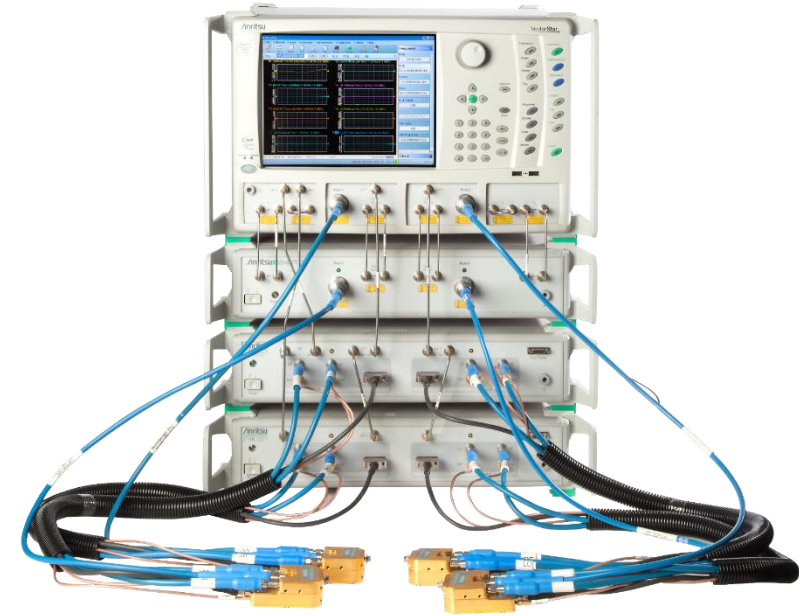
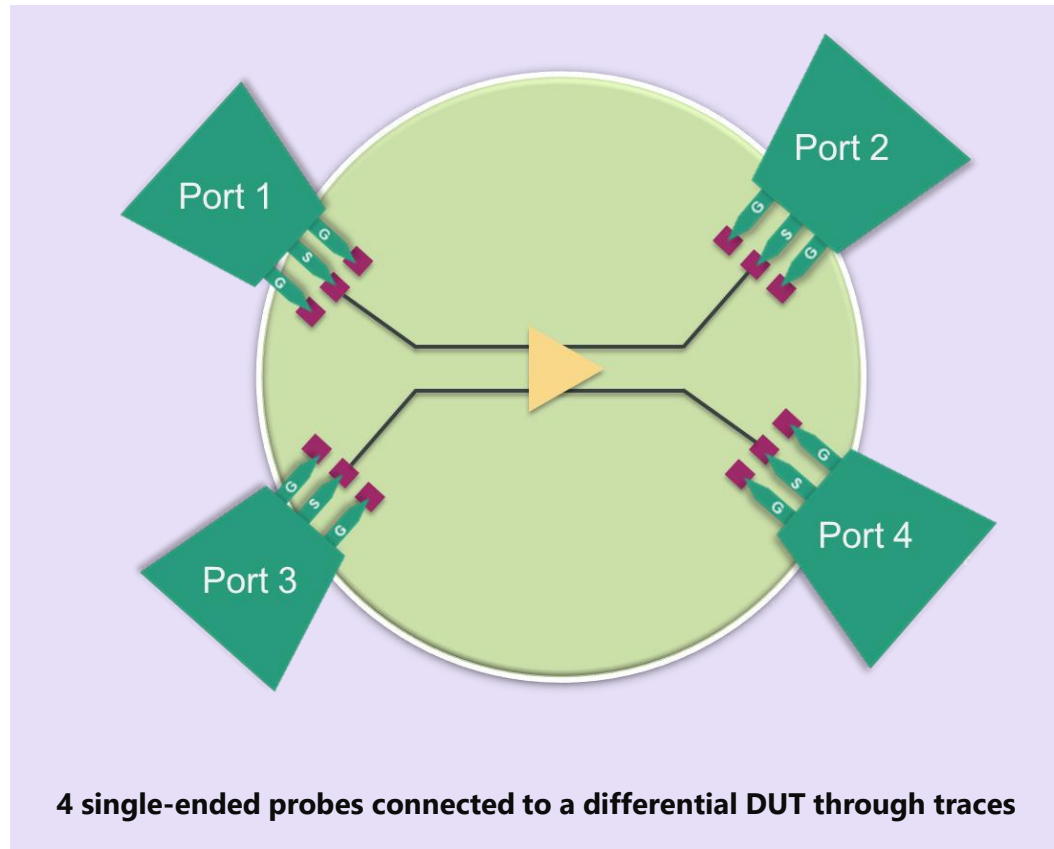


- 110 GHz differential assembly



- 145 GHz differential assembly

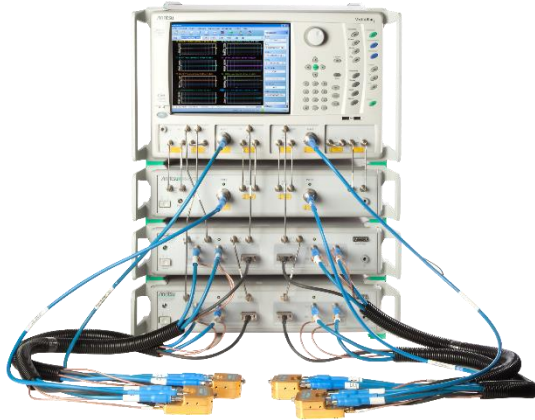
VectorStar 4-port Broadband Systems



VectorStar ME7838G4 4-port 220 GHz VNA

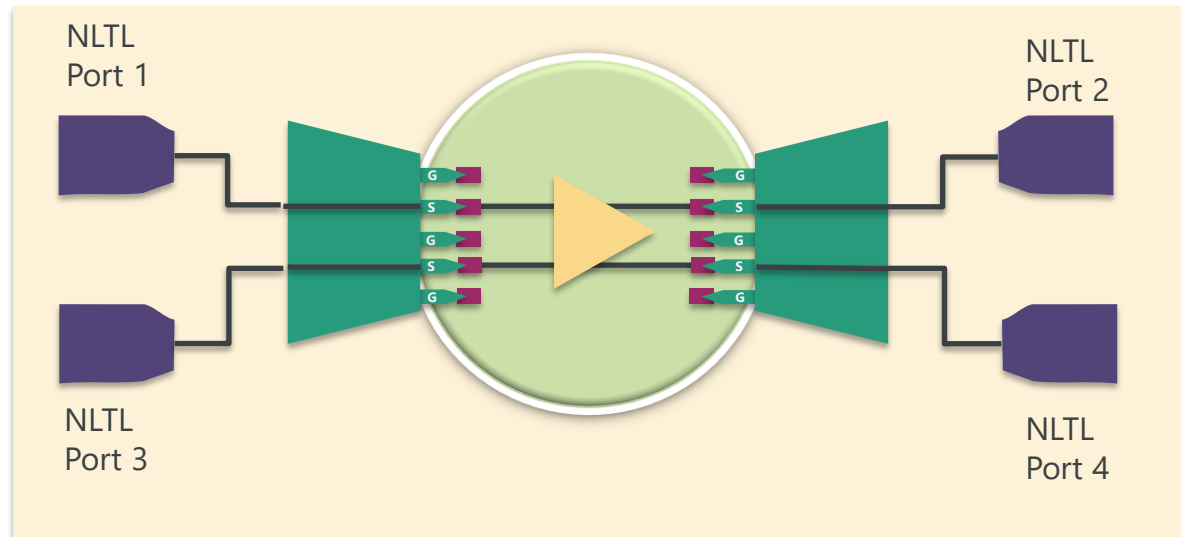
- Four NLTL modules supply the four signal sources plus receivers for differential measurements.
- Until recently, 220 GHz differential probes have not been available to measure D-band differential circuits. When differential probes are not available, signal lines connecting to the DUT are laid out to accommodate single-ended probes.
- The complexity and challenge of de-embedding multiple single-ended lines result in a less than desirable arrangement compared to a true differential trace layout.

VectorStar 4-port Broadband Systems



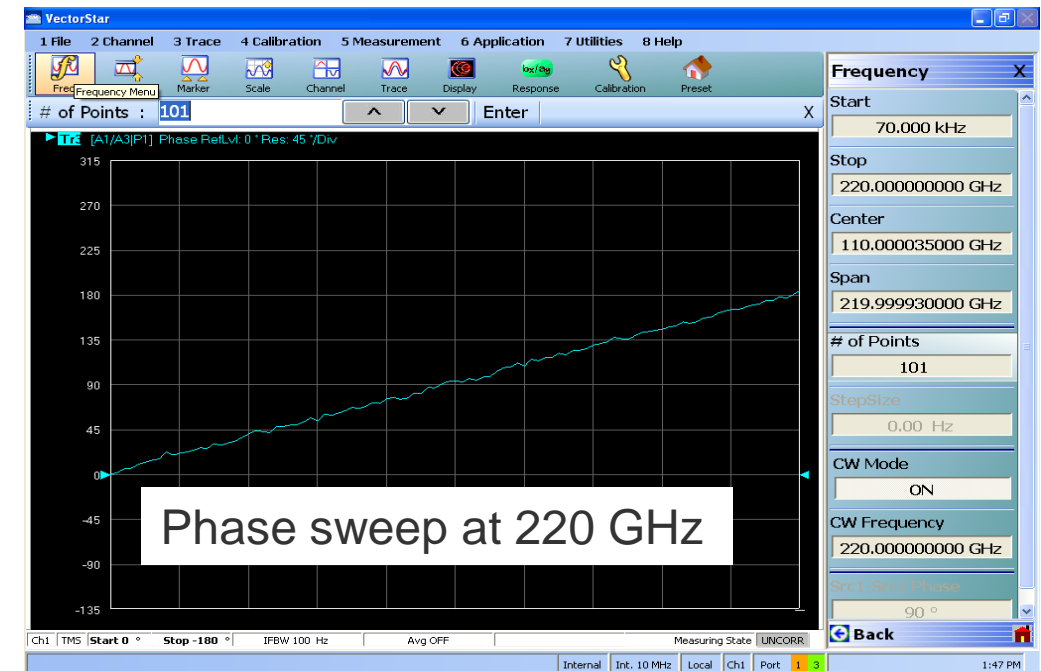
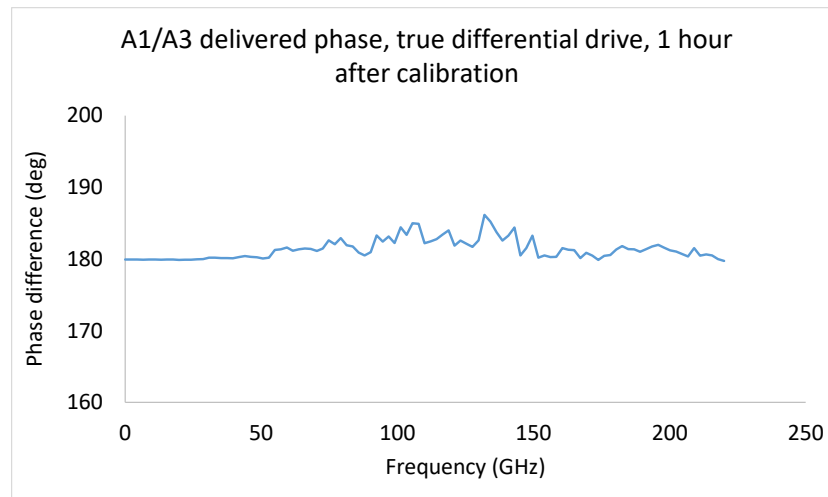
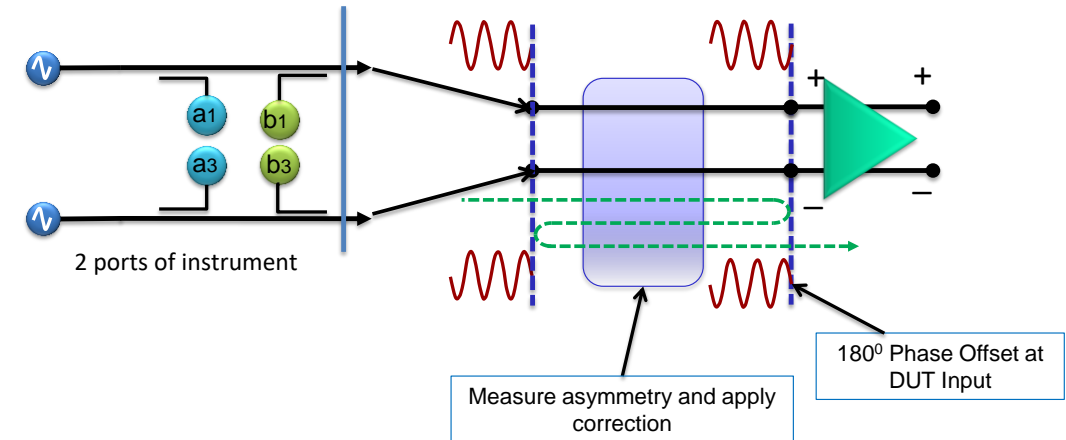
VectorStar ME7838G4 4-port 220 GHz VNA

- The Anritsu ME7838D4 4-port 145 GHz and ME7838G4 4-port 220 GHz VNA systems are the only VNAs able to measure differential devices above 110 GHz.
- Four NLTL modules supply the four signal sources plus receivers for a complete differential measurement.
- The MPI TITAN 220 GHz differential probes offer the first capabilities for differential measurements of D-band radios and other circuits above 145 GHz.

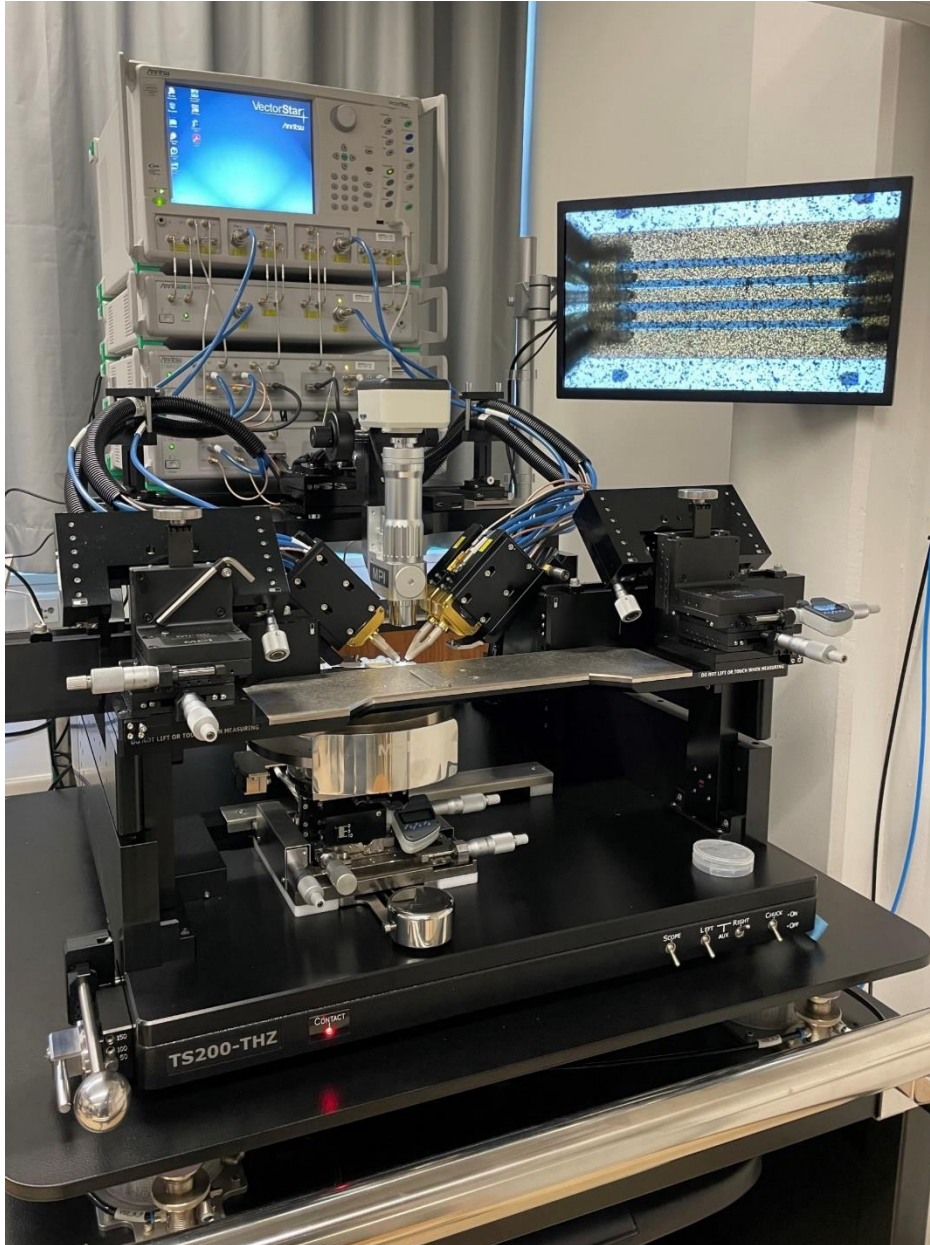


VectorStar 4-port Broadband Systems

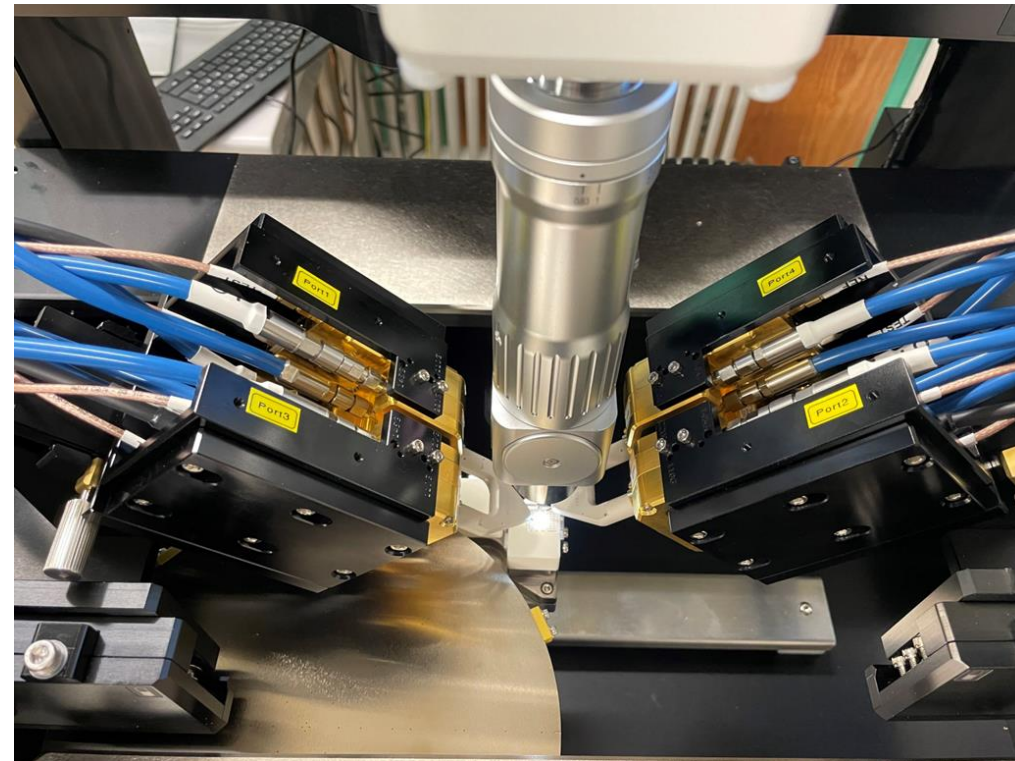
- For some differential active devices, true mode stimulus (both input ports being driven at 180 degree phase offset) is required for accurate measurements. This is particularly true for gain compression and distortion measurements for certain active devices. All VectorStar configurations can be equipped with true mode, including the 220 GHz systems, with phase delivery stability on the order of a few degrees. Combining the on-wafer calibration with true mode results in phase delivery accuracy referenced to the probe tip.



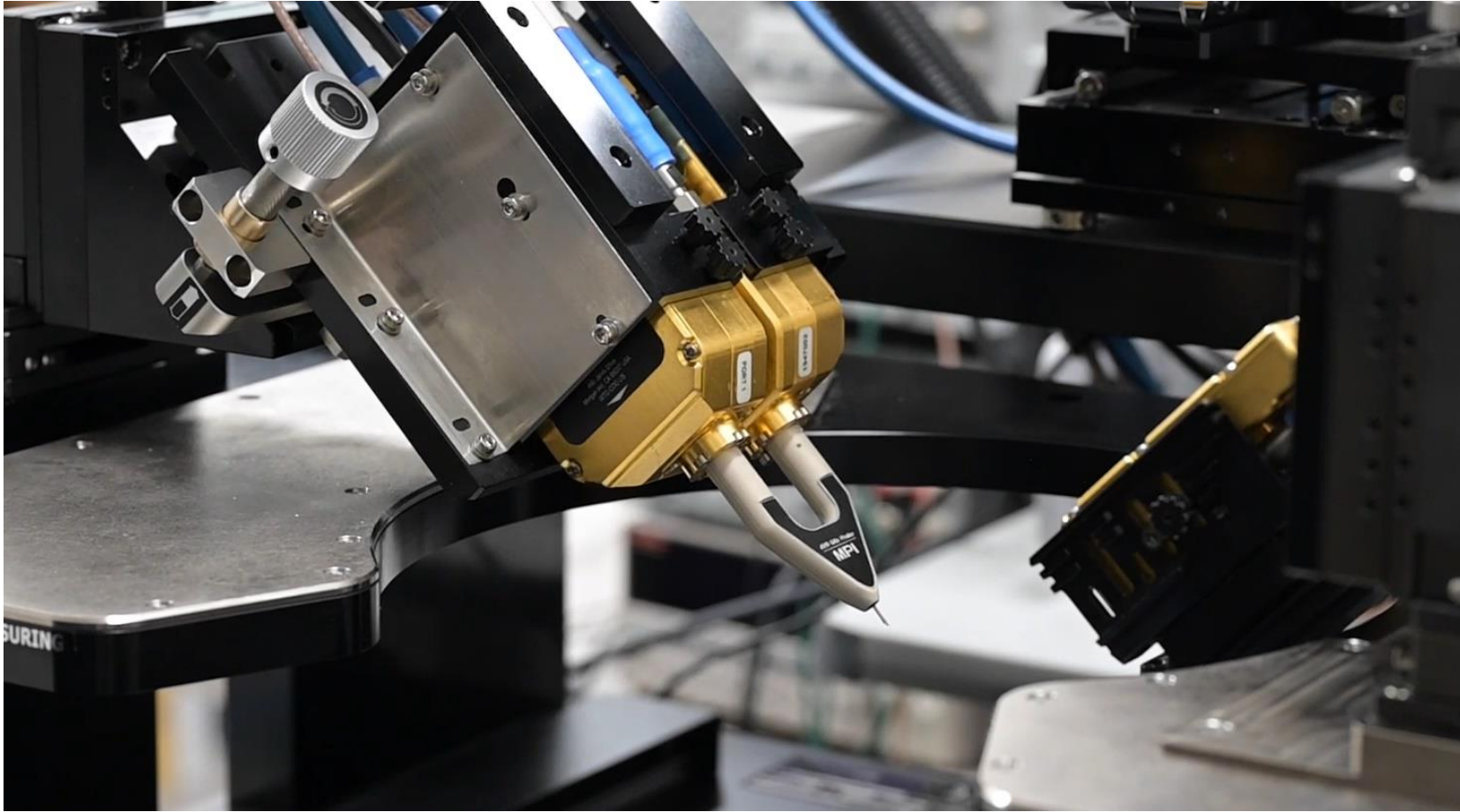
VectorStar 4-port Broadband Systems



- The Anritsu ME7838G4 4-port 220 GHz VNA system performs true mode differential measurements up to 220 GHz.
- The four NLTL modules are mounted on the MPI positioners and supply the four signal sources with receivers for full differential measurements.
- The compact modules and installation capabilities can be mounted on a manual or semi-automatic MPI probe station.

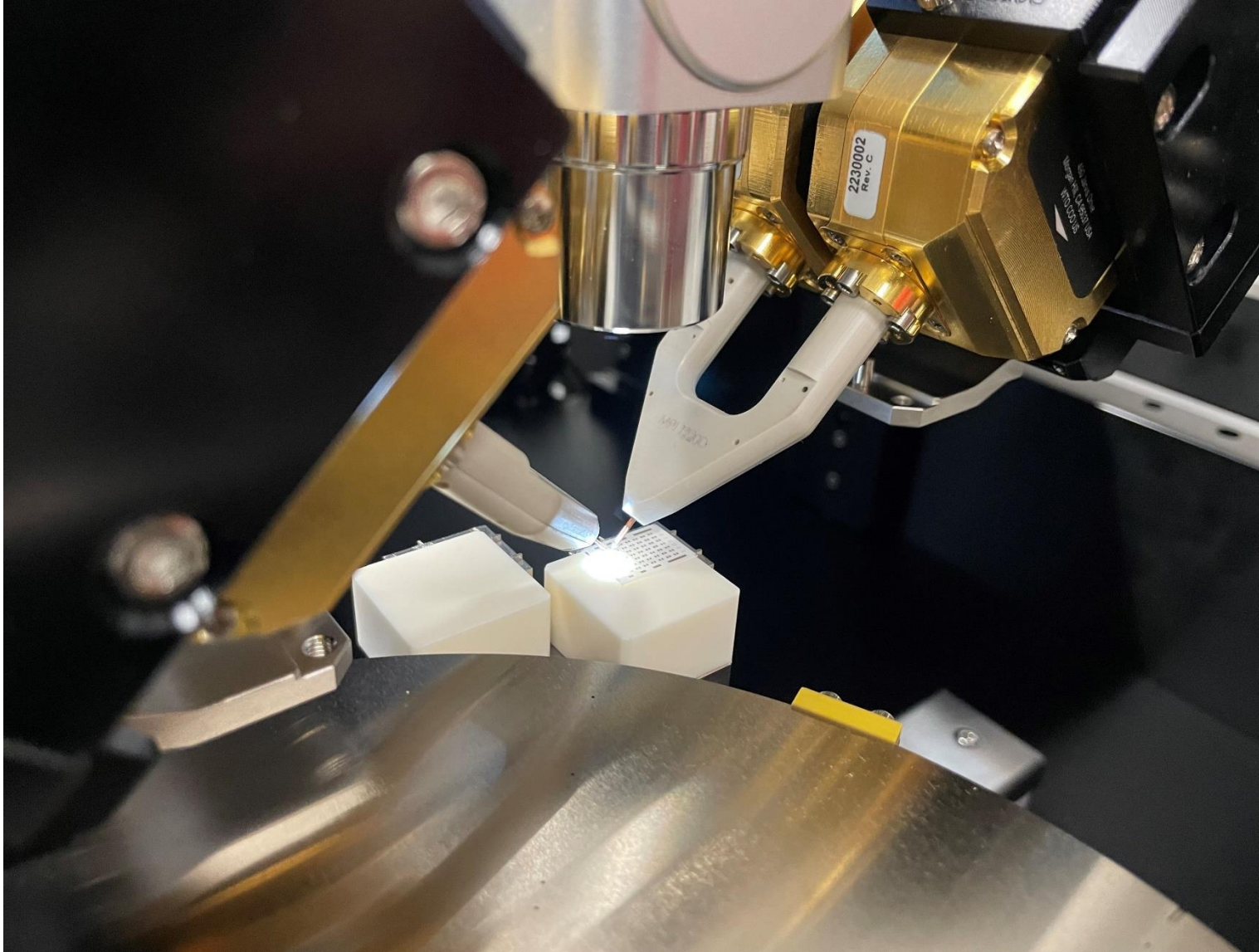


VectorStar 4-port Broadband Systems



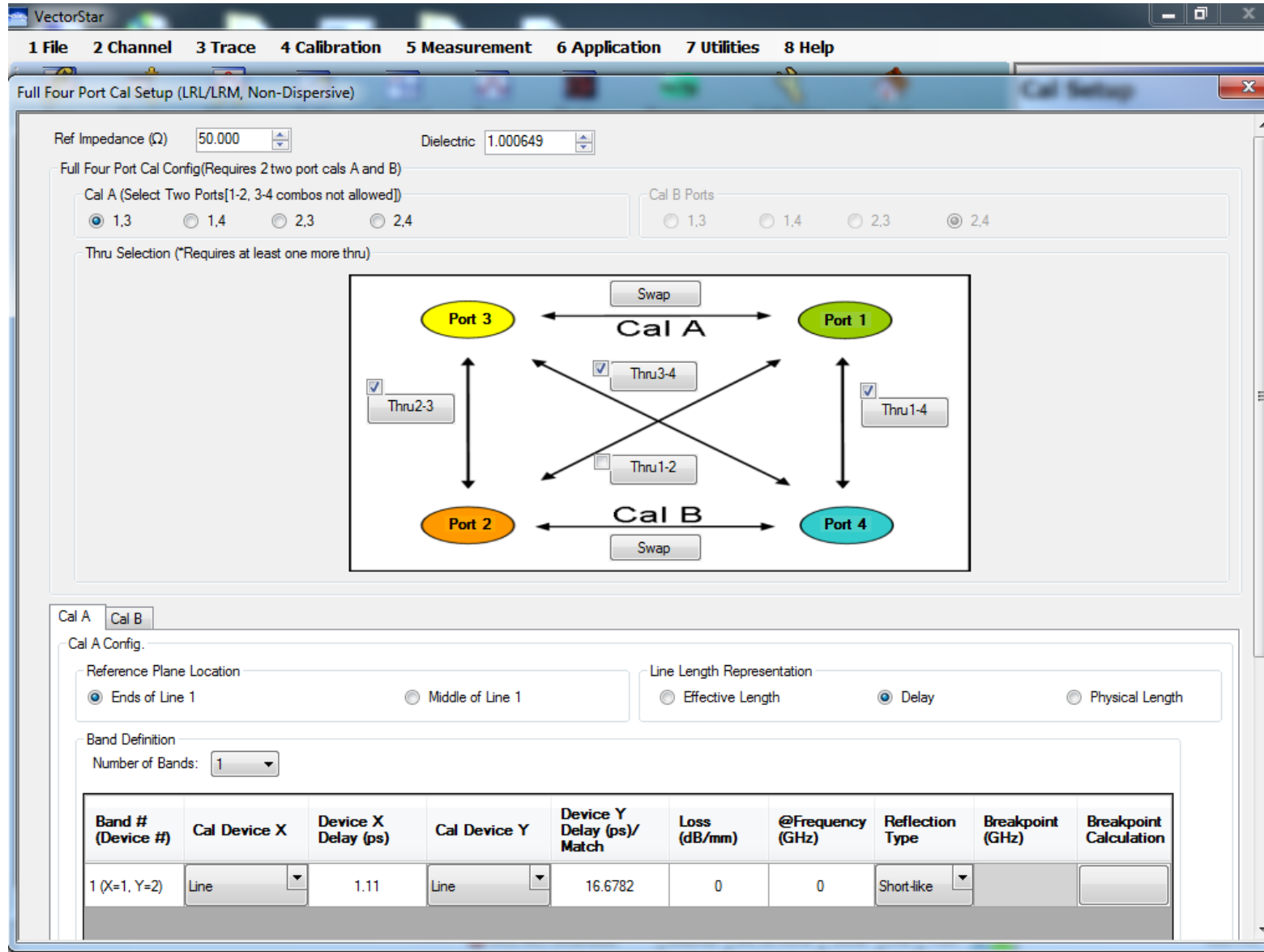
- The ME7838G4 4-port 220 GHz broadband VectorStar system performs true mode measurements from 70 kHz to 220 GHz.
- The NLTL modules connect directly to the MPI differential GSGSG probes with no cables for maximum performance.

VectorStar 4-port Broadband Systems

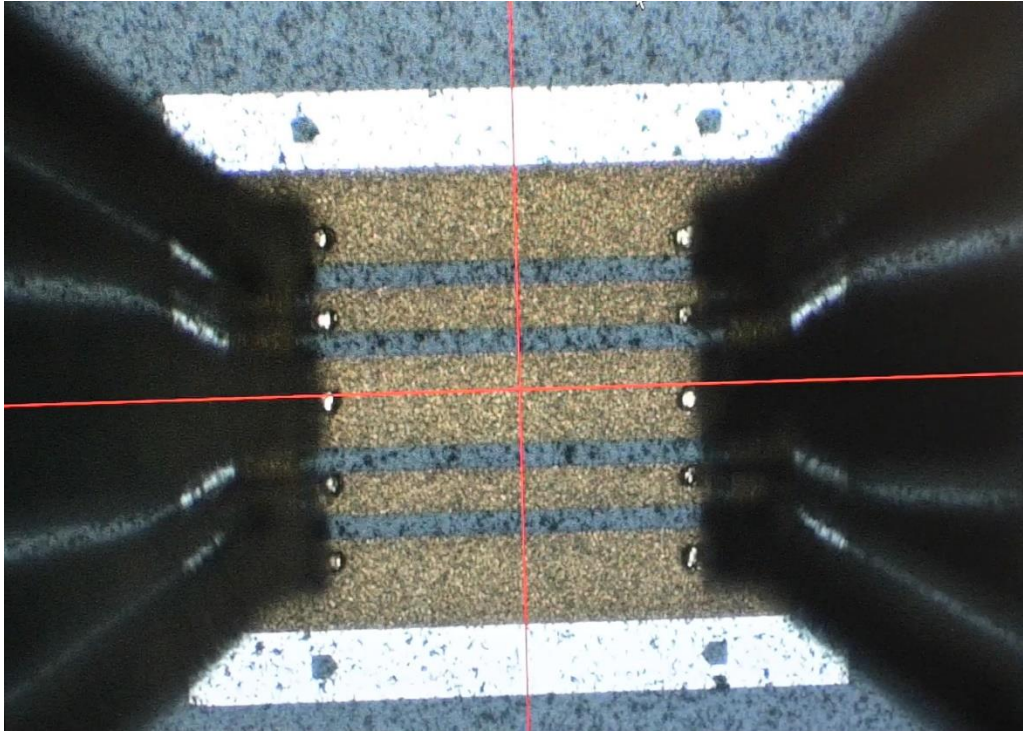


- The MPI GSGSG calibration substrate provides the on-wafer calibration standards necessary to provide accurate LRM, ALRM and variations using the VectorStar internal calibrations or when using MPI QAlibria calibration software.

VectorStar 4-port Broadband Systems

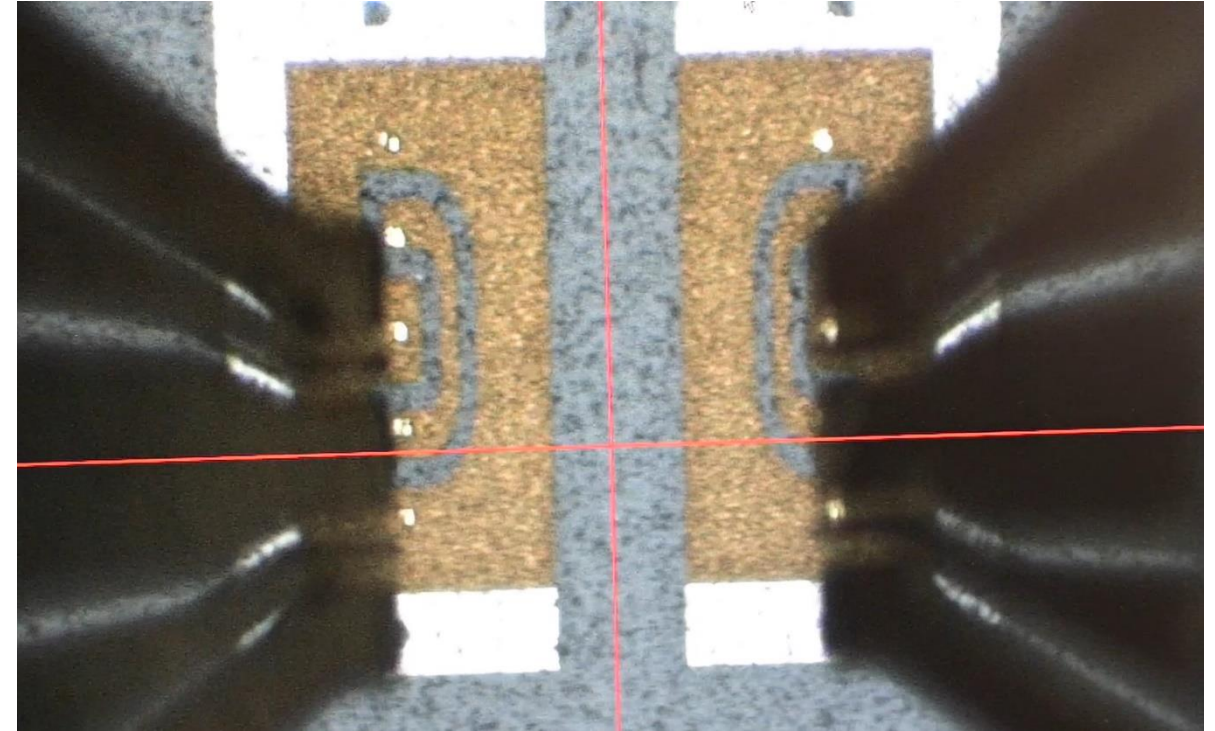


- The VectorStar 4-port LRM calibration configuration panel provides entries for thru path definitions.
- Setup is similar to 2-port LRM except for the additional lines.
- Single reflection standards (open or short) setup the standard LRM calibration.
- Adding both short and open reflections plus load models extends the calibration capabilities to ALRM.



Differential Thru

Port 1 to Port 4
Port 3 to Port 2



Differential loop-back

Port 1 to Port 3
Port 4 to Port 2

- A difference in the calibration substrates for differential measurements is the need for additional thrus and loop-back thrus in some cases. Since configuring the 4-port VNA system for calibration requires thrus in addition to the Port 1 to Port 4 and Port 3 to Port 2 straight thrus, it is helpful for the substrate to include loop-backs for the additional thru connections.
- For alternative thru choices such as Port 1 to Port 4 the differential probes may be offset during their landings.

VectorStar 4-port 220 GHz Broadband VNA Summary

- Broadband frequency coverage for VectorStar 4-port systems start at 70 kHz and operates to 110, 125, 145 and 220 GHz.
- mmWave modules with electronic power leveling provides low power level control to -50 dBm. Typical on-wafer measurements need power levels in the -30 dBm and lower levels.
- Compact, lightweight mmWave modules offer easy, precise, and economical positioning on the wafer probe station.
- The combined Anritsu 220 GHz NLTL modules with MPI TITAN 220 GHz differential probes provide direct connection with no RF cables for optimum performance and measurement stability.

