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Challenges of HVM OTA Testing for mmWave Devices

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TestConX中国 China

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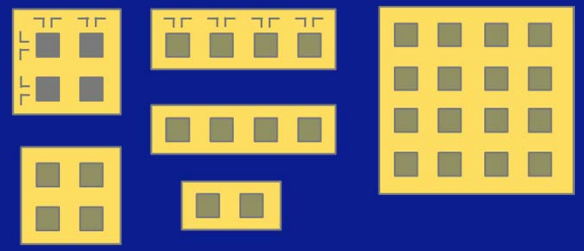
- Introduction
- HVM OTA
- OTA Test Challenges

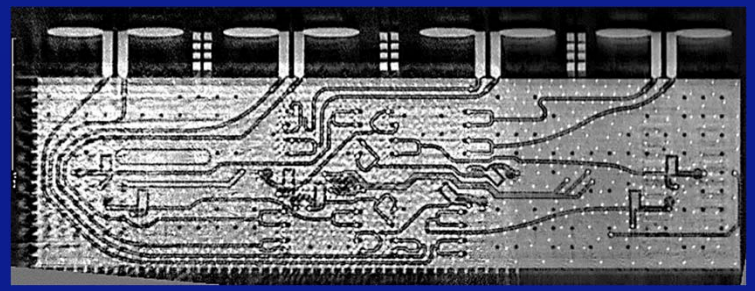
Why OTA Testing?

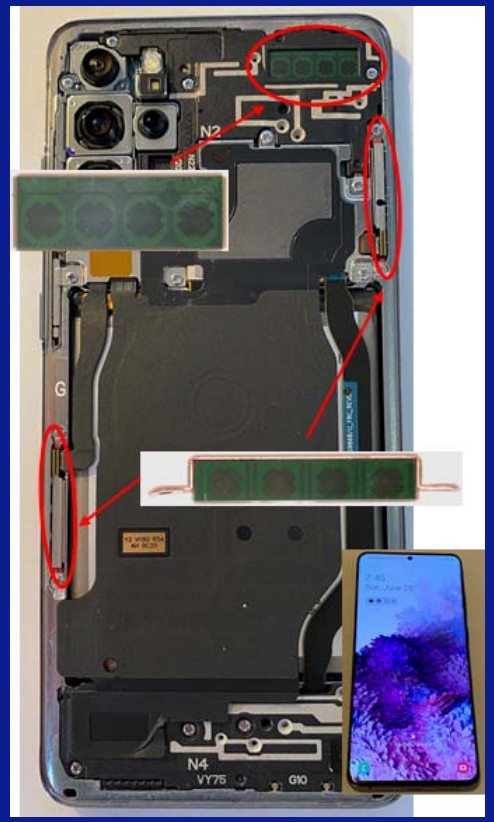
Antenna-in-Package(AIP)

- No contact access for mmWave ports
  - Antennas are built-in.
  - Antenna is the only access for mmWave.

- AiP package substrates can be very complex:
  - Multiple layers.
  - Complex routing and via interconnect.







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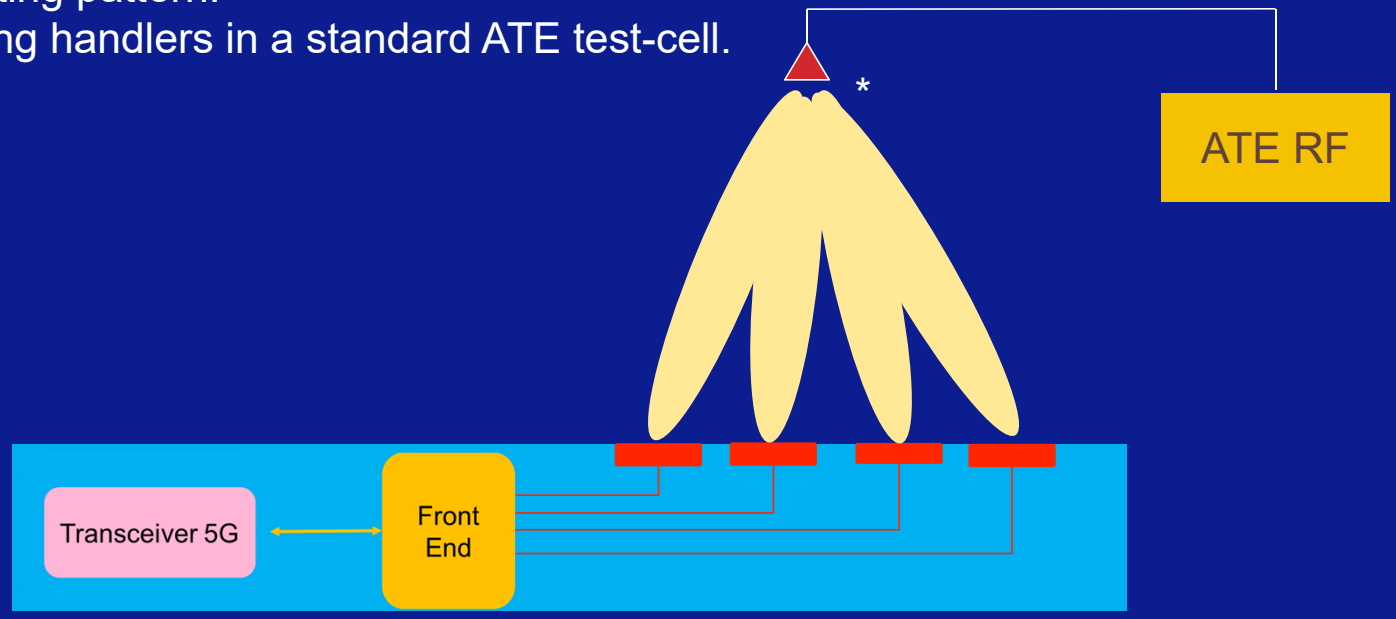
HVM OTA Testing

HVM AiP OTA testing: Testing the silicon using the antenna

- Measures the silicon performance.
- Validate antenna's functionality – MIMO.
- Not measuring radiating pattern.
- Mass production using handlers in a standard ATE test-cell.

Types of OTA :

- Far-field.
- Radiating near-field.
- Reactive near-field.



*Note: Radiating pattern is not correct but act as an illustration of effects of each antenna

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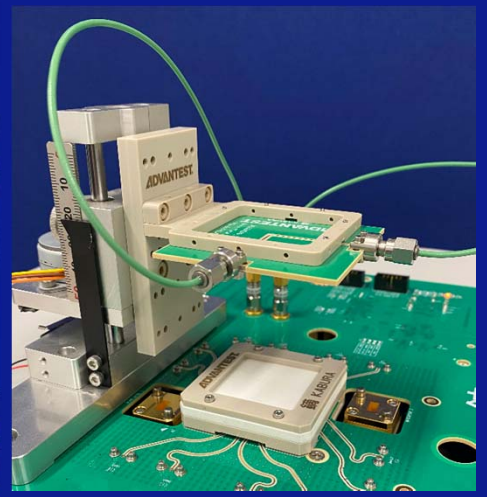
OTA Manual Test

OTA Manual test setup for characterization and test program development:

- Setup to be similar to handler.
- Special socket that does not impact radiating signal.
- Custom antenna that fits in socket.

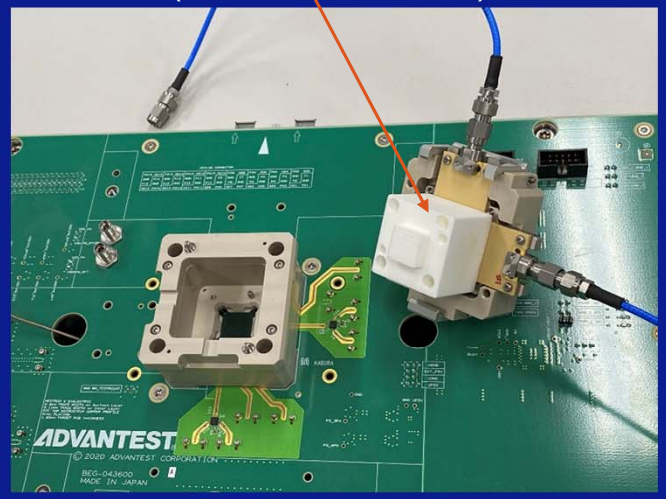
Custom socket lid made with electromagnetic transparent material

Far-field OTA setup



Precision adjustable height OTA setup controllable by software

Manual engineering socket with DUT pusher (antenna behind it)



Radiating near-field OTA setup

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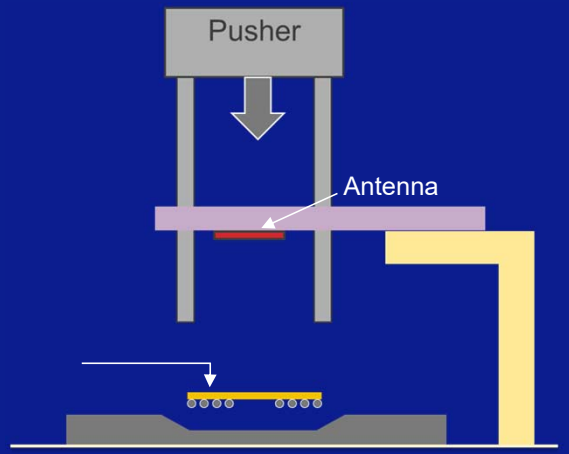
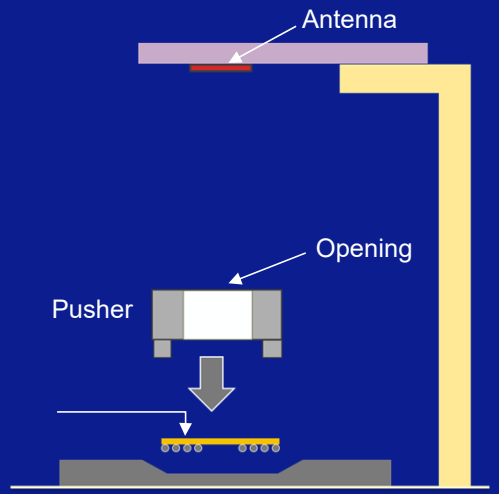
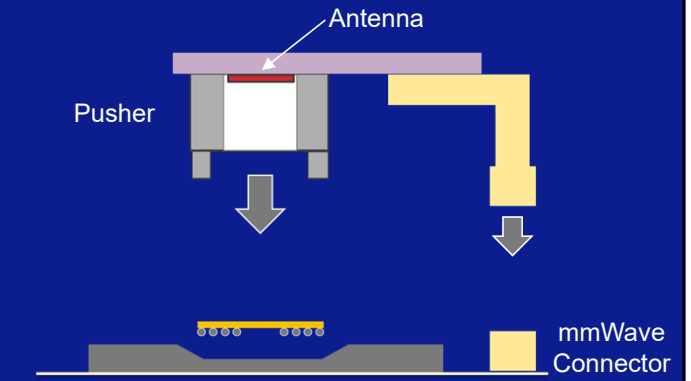
Examples of Handling OTA AIP



Fix Antenna



Fix Antenna
Far Field



Antenna in Arm

*Illustrations not to scale

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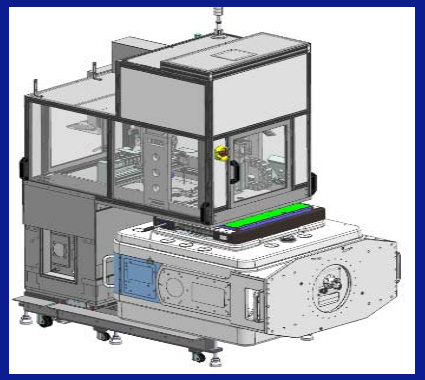
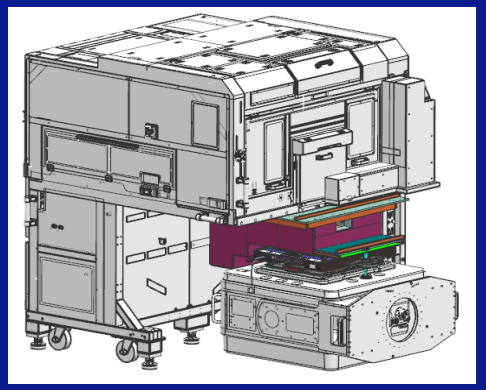
HVM OTA Test Cell



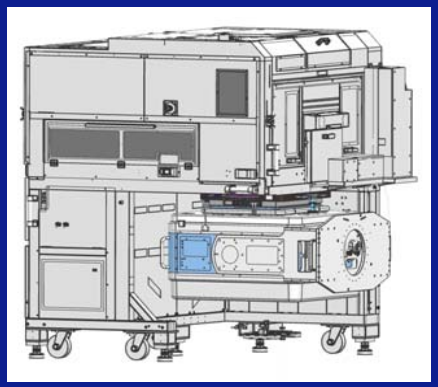
Far-Field/Near-Field Engineering OTA Handler

- Limited to 1-site possible.
- Allows for easy change between far-field and near-field for correlation.
- Tri-temp.



OTA Test Module

- Independent OTA module provides OTA testing using a separate feeding arm approach.
- No handler modifications required.
- Near-field - up to 8 sites.
- Far-field - up to 2 sites.
- Tri-temp.



Near-Field OTA Handler

- Requires OTA change kit with mmWave blind mating interconnect.
- Only near-field OTA testing possible.
- Up to 8 sites possible.
- Tri-temp.

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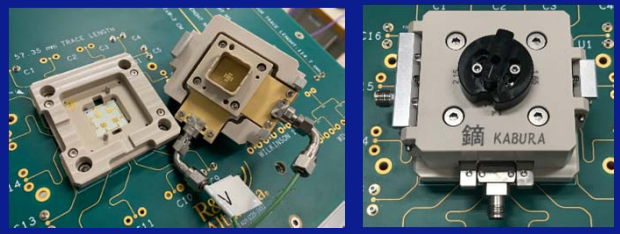
Antennas for HVM OTA

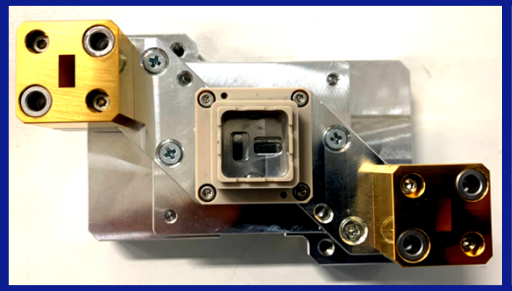
Antenna for HVM testing requirements:

- Gain is not critical, bandwidth is more important.
- Customised to fit in handler/arm.
- Required to cover all frequency bands in the test program.
- Able to withstand production environment.



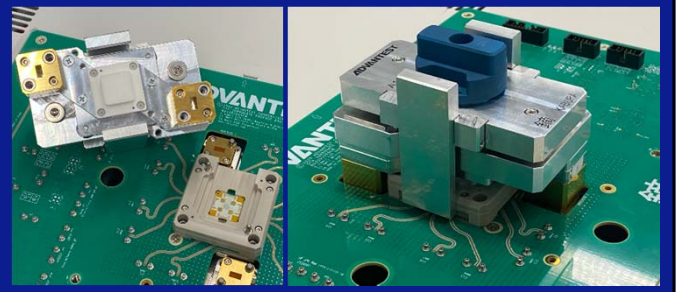
Manual socket with coaxial interconnect

Dual polarized PCB antenna With blind mating interconnect



Dual polarized waveguide antenna with blind mating interconnect

Dual polarized PCB antenna with coaxial interconnect



Manual socket with blind mating interconnect

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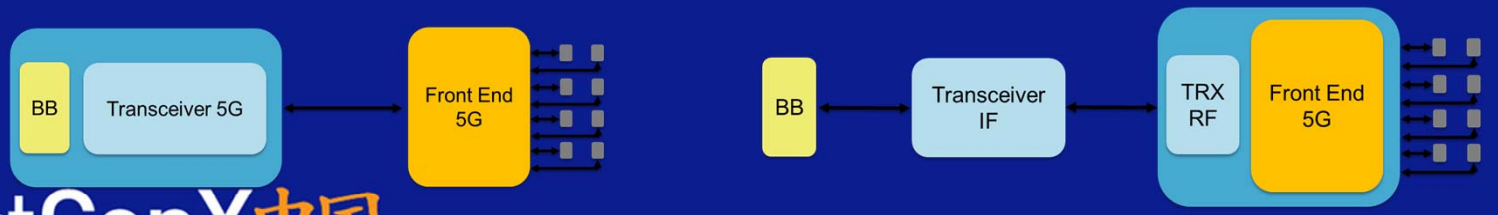
OTA Tests

TX	RX
Gain, Gain Steps	Gain, Gain Steps
P1db	IP3
Phase Shift (Beamforming)	Phase Shift (Beamforming)
Flatness	Flatness
EVM	EVM
ACPR	Isolation
Spurs	Noise Figure
Isolation	



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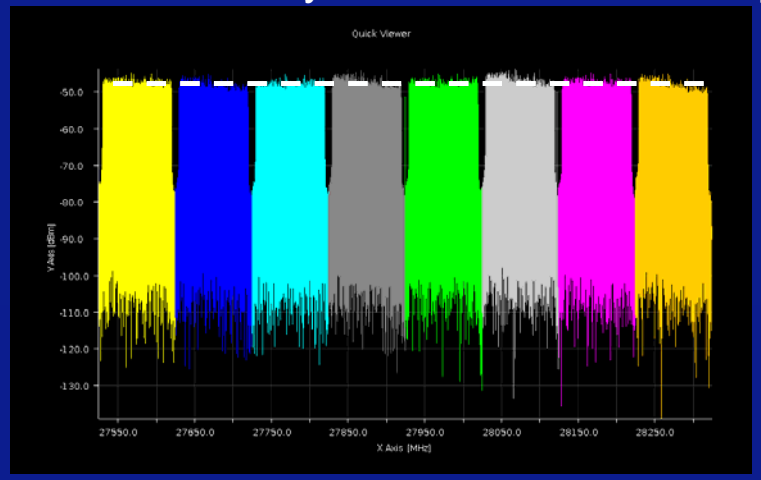
Differences between OTA & Contact Test

OTA	Contact
Per radiator/port, polarization & antenna array	Per port
High path/air loss	Path loss mainly due to cables & trace
No direct access to “port” for debug	Direct contact
Polarization Isolation is limited by measurement antenna	Very high isolation possible
Focus calibration needed	Focus calibration may not be necessary
Socket cover/pusher can affect performance	Performance is not affected by socket cover
Test cell customization needed	Standard HVM test cell

Gain, P1db and Flatness

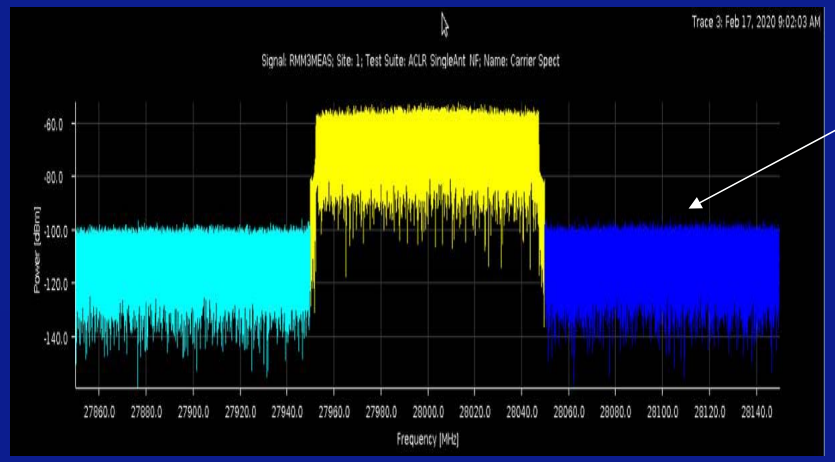
- Path loss:
  - Air & dielectric loss, cables and connectors are tricky to compensate in the near-field.
- OTA key difference:
  - Combine port array as well per port measurements.
  - Phase shift of each port is important when combining ports.
  - Per port path loss is different from array loss. Needs to be compensated separately.



800MHz Power Spectrum

Adjacent Channel Power Ratio (ACPR)

- High path loss can cause the adjacent power measured to be even lower.
- Instrument with low noise floor and low phase noise required.
- OTA key differences:
  - Combine port array instead of just per port.
  - Phase shift of each port is important during test.

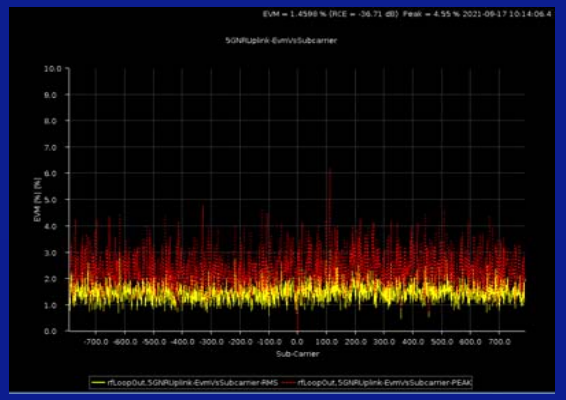


ACPR Plot

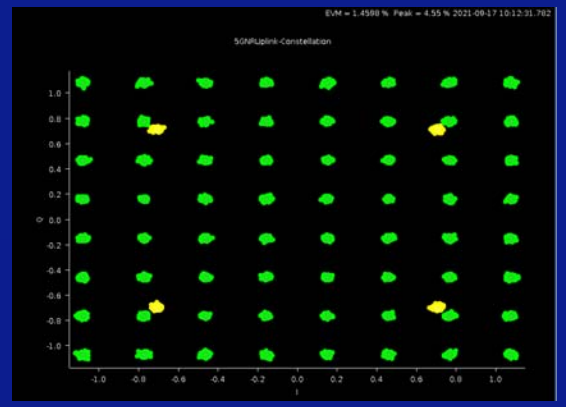
High path loss makes low adjacent channel power even lower.

EVM Measurement

- Wide Bandwidth (100M-800MHz) means signal power per carrier are lower for same total rms power.
- High path loss can reduce the measured signal power, and stim power needs to be increased.
- Measurement instrument with low noise floor and low phase noise needed.
- Source instrument with high P1db power is required.
- OTA Key differences:
  - Combine port array EVM instead of just per port.
  - Phase shift of each port is important during test.



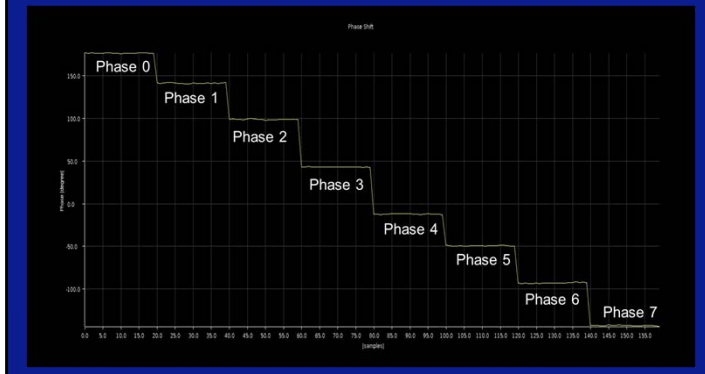
EVM vs Sub-carrier



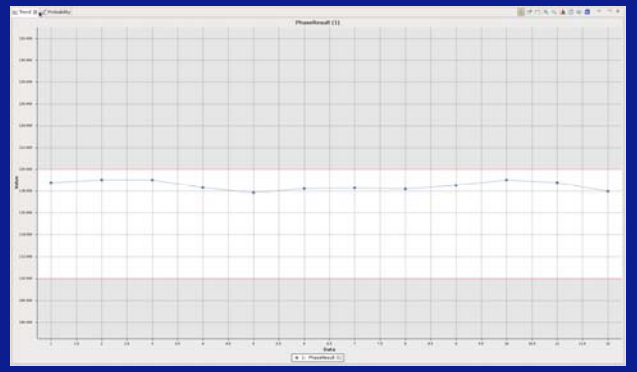
Constellation

Phase Measurement

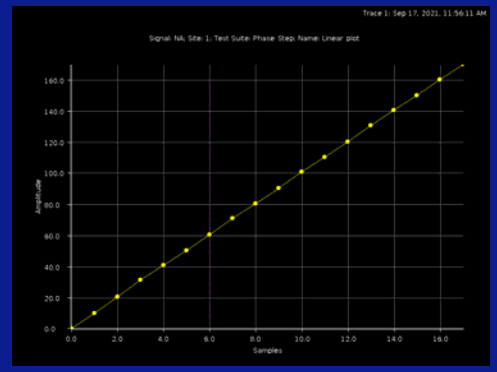
- Key measurement for MIMO.
- Accurate phase measurement at mmWave frequency.
- Absolute Phase very sensitive to path/antenna distance.
- Requires phase compensation due to path.
- Instrument with low phase noise is required



Phase vs Time



Phase Repeatability (<0.5 deg)



Phase Linearity

Relative Phase Measurements

Summary

- OTA testing presents new challenges for Test Engineers.
- Careful design is required for the OTA socket and antenna.
- Integration of OTA in standard production test cell requires special considerations.
- It is important to have a clear strategy for HVM OTA testing.

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