April 2024

4D顯像雷達系統OTA量測及分析

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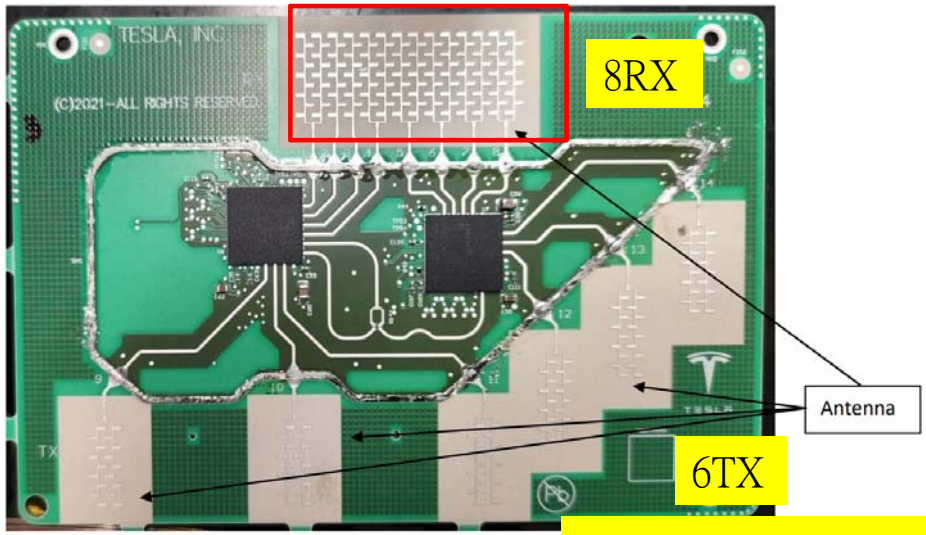
Outline

- Challenges of 4D Radar OTA Measure
- Introduction to Imaging Radar OTA Measure
  -Passive、EIRP、Group delay、Imaging Analysis and MP
- EIRP & Image Issues Analysis
- Conclusion

Tesla Radar!!

Tesla FCC ID: 2AEIM-1541584 (released in 2023.03)



TX Gain: 14.3 dBi

4.2 Antenna Description

External/Internal/Integral	Total Antenna Gain (dBi)	Antenna Type
Integral	20.32	PCB Trace Antenna

The antenna is factory-installed and is not modifiable by users.

Device has 6 Tx antennas, but only 4 can transmit at the same time. The maximum individual antenna gain is 14.3 dBi. Total antenna gain = individual antenna gain + 10log(number of antenna that transmit at the same time) = 14.3 dBi + 10log(4) = 20.32 dBi

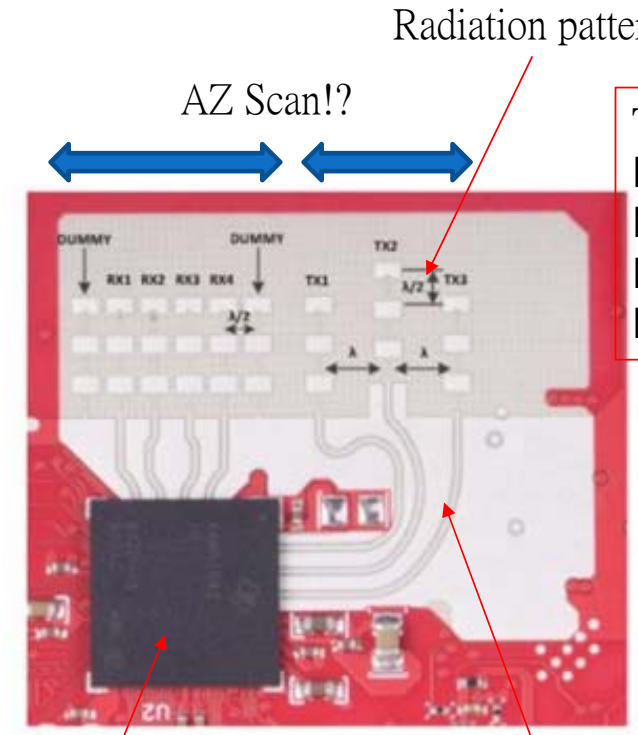
The antenna gain is information provided by the customer.

Antenna boresight direction(s) and 3 dB beamwidth in both horizontal and vertical planes:

- Azimuth:
  - Boresight – 0 degrees
  - 3dB beam width – 48 degrees
- Elevation:
  - Boresight – 0 degrees
  - 3dB beam width – 14 degrees

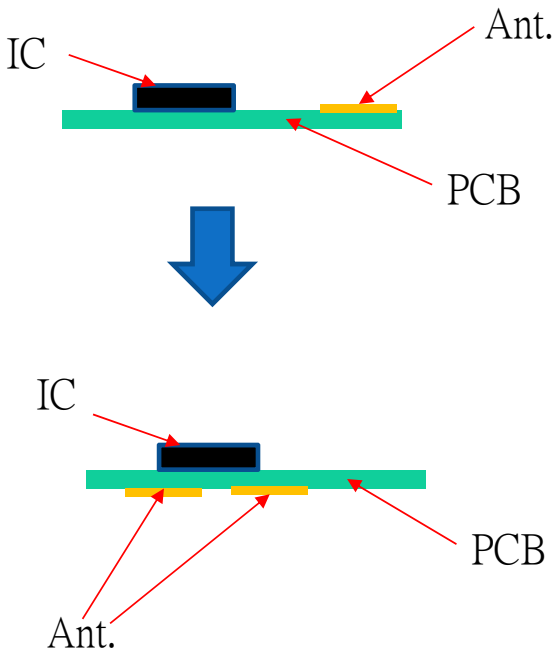
AZ + EL

4D Image Radar



Tech. key :

- ☐ EL scan : 1*n ➔ n*n
- ☐ Distance enhance : low loss & high gain
- ☐ High sensitive : SLL & XPL
- ☐ Algorithm : Channel emulation

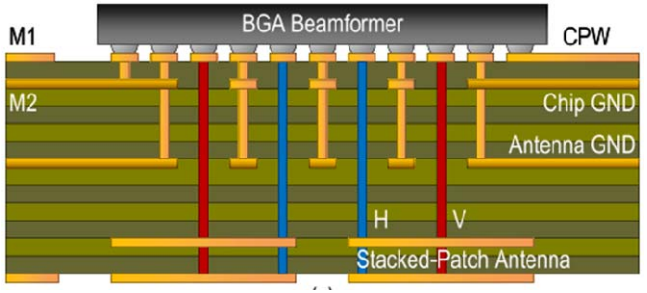


Phase error

- increased sidelobe
- wider 3D coverage
- lower EIRP

(2). PCB with inhomogeneous Dk ➔ phase error

(3). PCB via hole/pad ➔ phase error

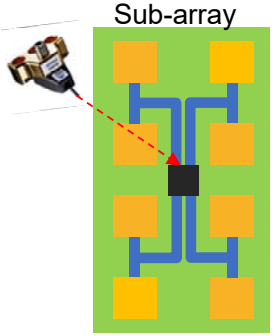


Measure items :

- ☐ S-para. (matching) & OTA(SNR)
- ☐ EIRP pattern
- ☐ Field OTA : Multi objects、Doppler、coverage

Antennas Measurement - OTA

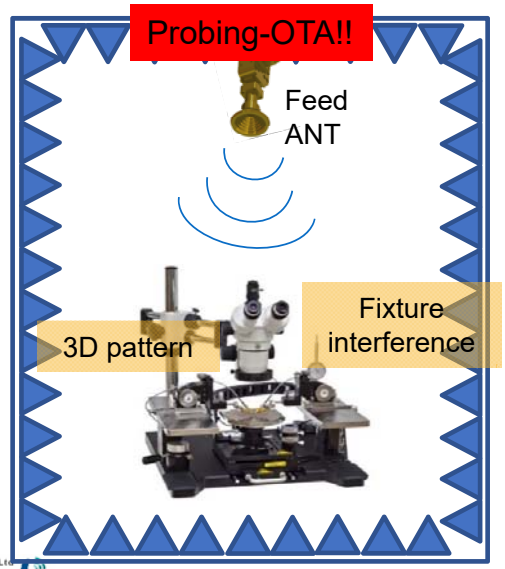
Probing OTA



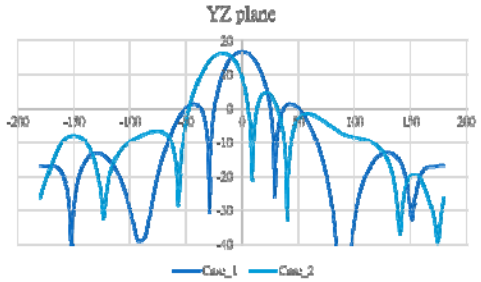
Inhomogeneous material parameters (D_k / D_f)

Different antenna characteristics

Insertion Loss & phase



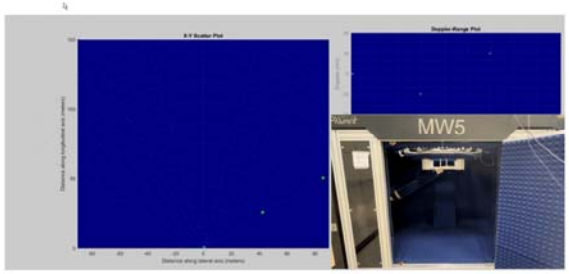
System OTA



- Large quiet zone (QZ)
- Path loss & beam scan
- EIRP
- Group delay

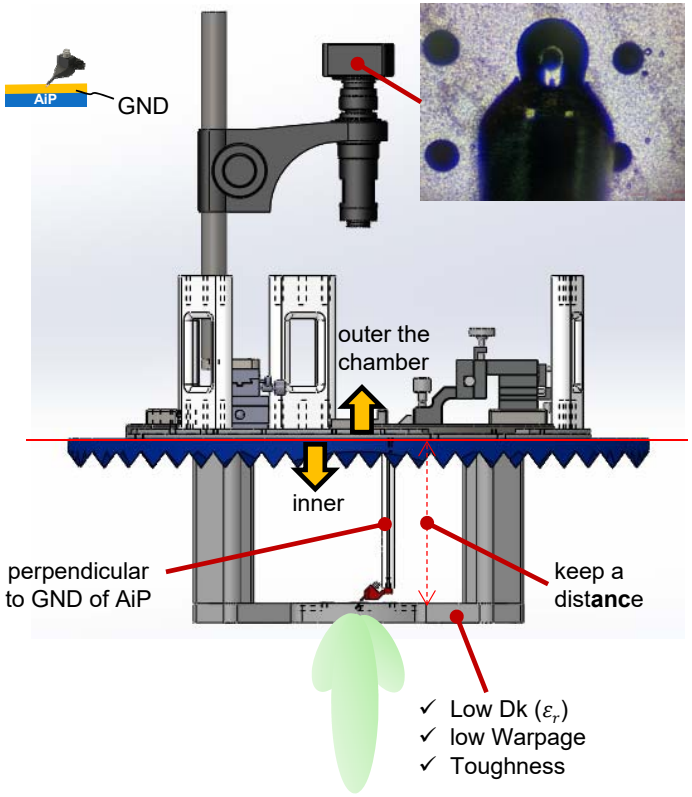
Field OTA

Algorithm of image

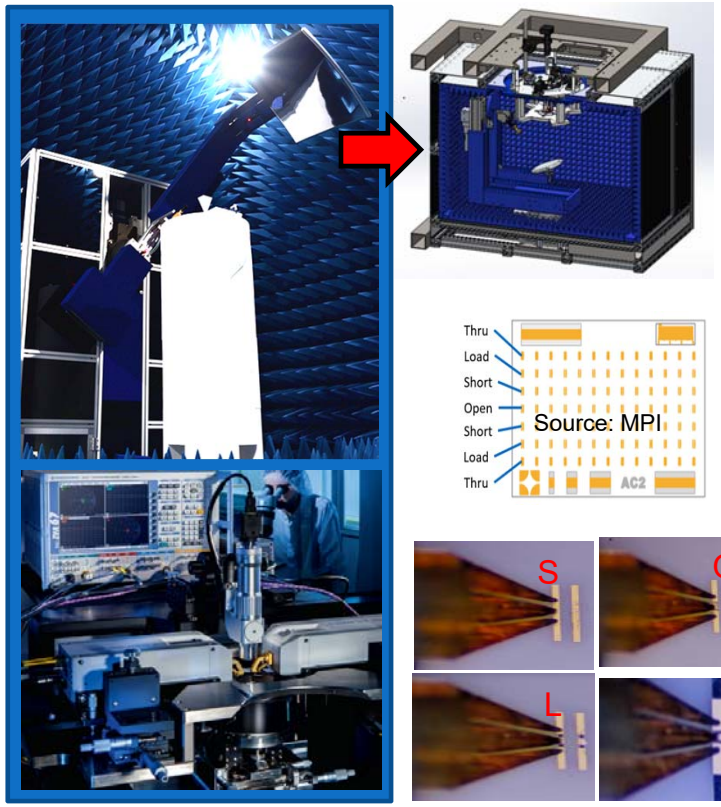


Challenges of Probing OTA

Avoid interference between AiP and probe station

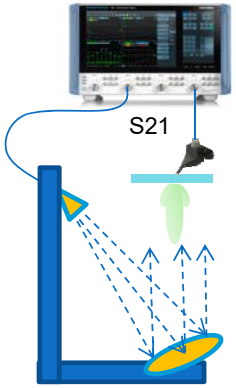


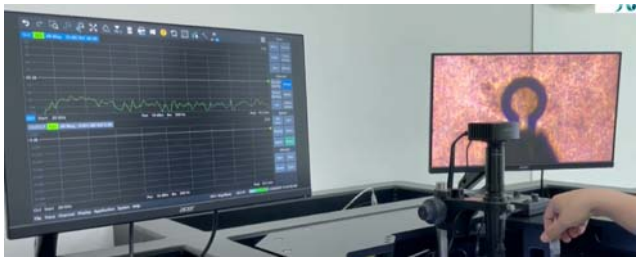
S-parameter and OTA (Over-the-air) test in one

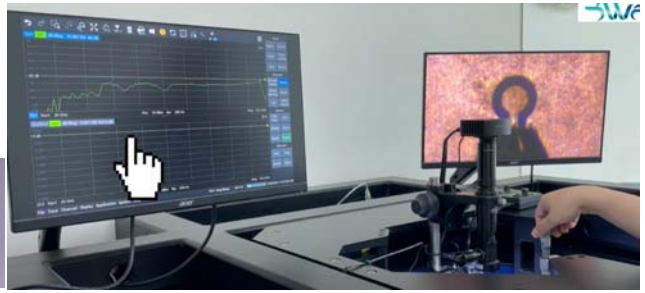


Contact stability

- ✓ Operator's feeling
- ✓ Image from high-resolution optical microscope
- ✓ S21 signal remains stable







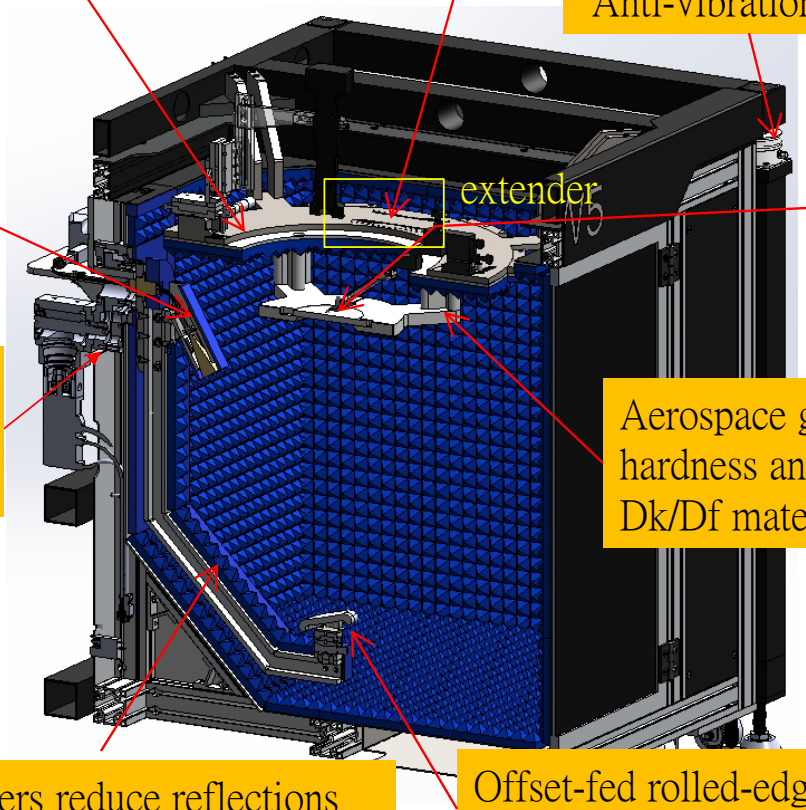
Probing OTA – MW5e

Metal frame can isolate the probe and the other fixtures

Low path loss is achieved by a short distance between an extender and an AUT.

Anti-vibration rack

Absorbers reduce sidelobes



The probe and probe station are kept a distance by an extension design.

Reduced path loss by waveguide

Aerospace grade hardness and low Dk/Df material

Absorbers reduce reflections

Offset-fed rolled-edge reflector (Edge diffraction suppression)

Features :

1. The probe station is outside the chamber (Easy to operate)
2. S-parameter and radiation pattern measurement in one (Time saving)
3. 3D-CATR (Compact)

Solved problems :

1. Calibration to the tip of the probe
   - ☐ Antenna input impedance measurement form the RFIC-antenna feed point
   - ☐ Load pull & G/T measurement
   - ☐ Passive radiation pattern measurement
   - ☐ Beam chart modeling
2. Predict Phase Array performance
   - ☐ Reduce IC cost
   - ☐ Debug

MW5e for Passive OTA

ZNA (R&S)

IF : 26 GHz

IF : 26 GHz

E-band Extender (R&S)

E-band Extender

1.0 cable + probe

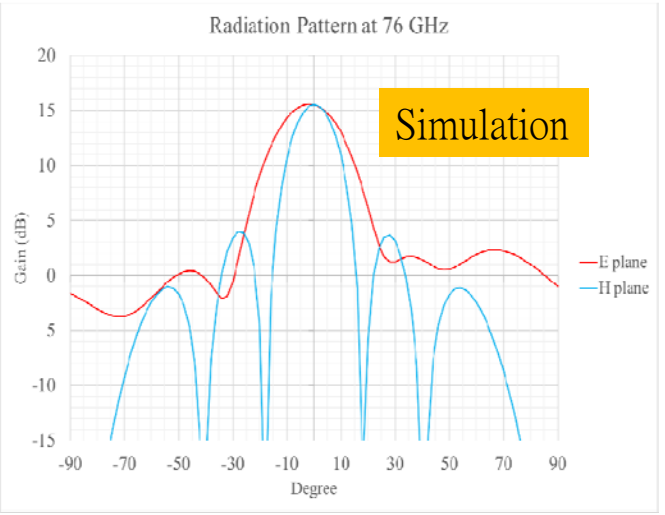
Flexible/Rotation waveguide

AUT (南亞塑膠)

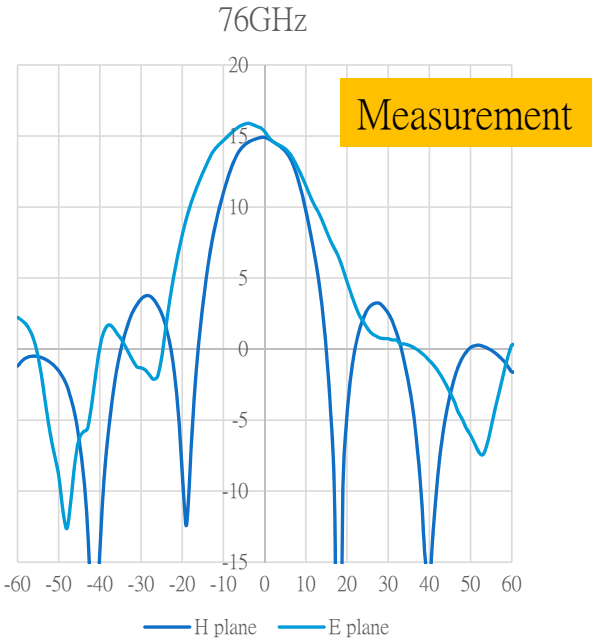
Feed Ant.

Reflector

Leaky wave



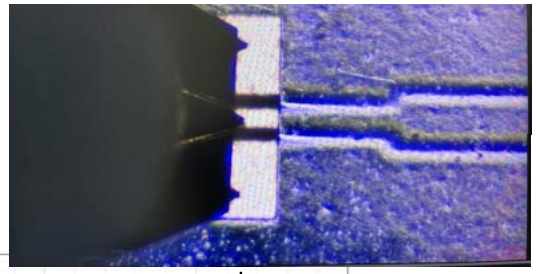
Simulation

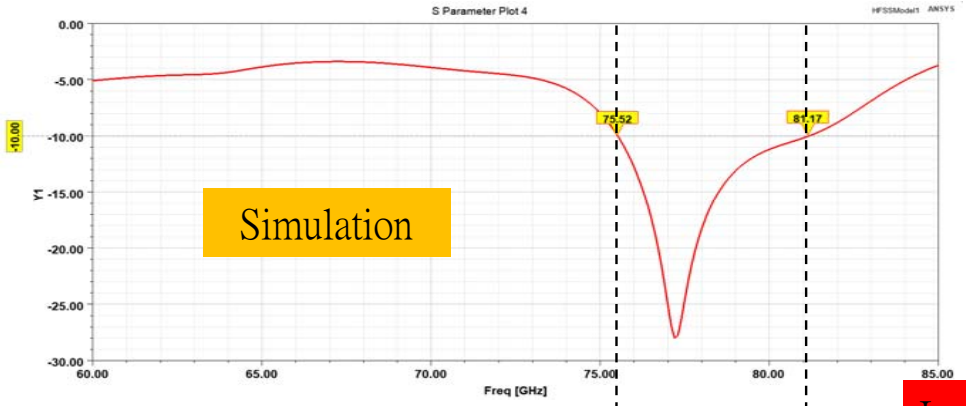


Measurement

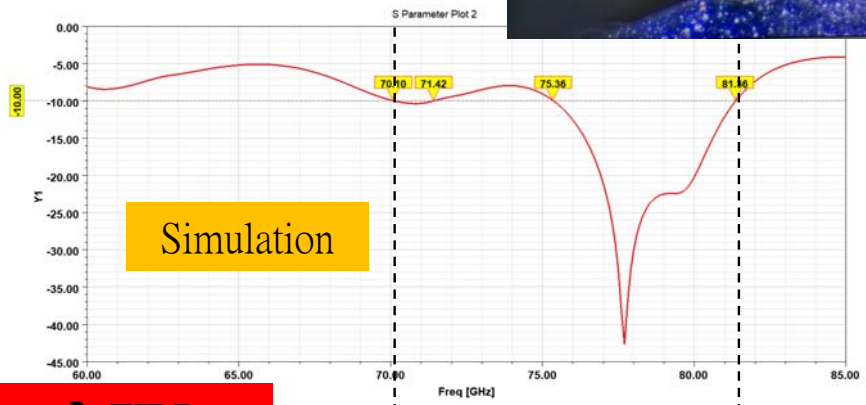
S-parameter Results

BW: 69.6 – 82.3GHz
Matching network !!



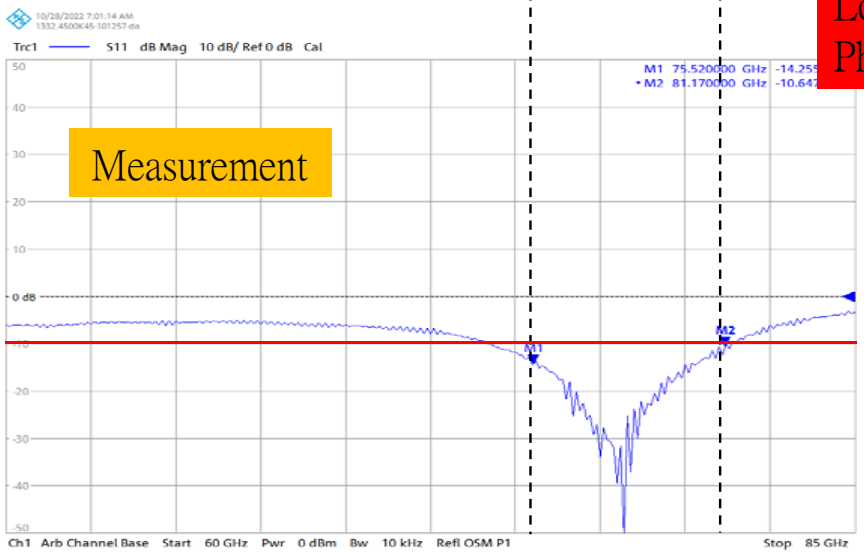


Simulation



Simulation

Load poor ➔ EIRP
Phase ➔ beam forming



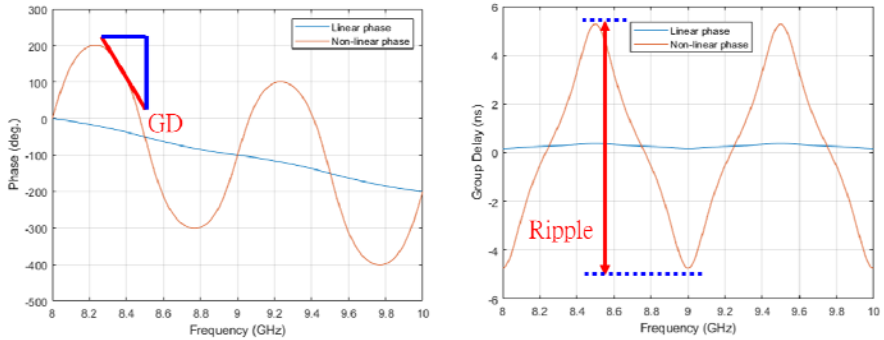
Measurement

-10 dB

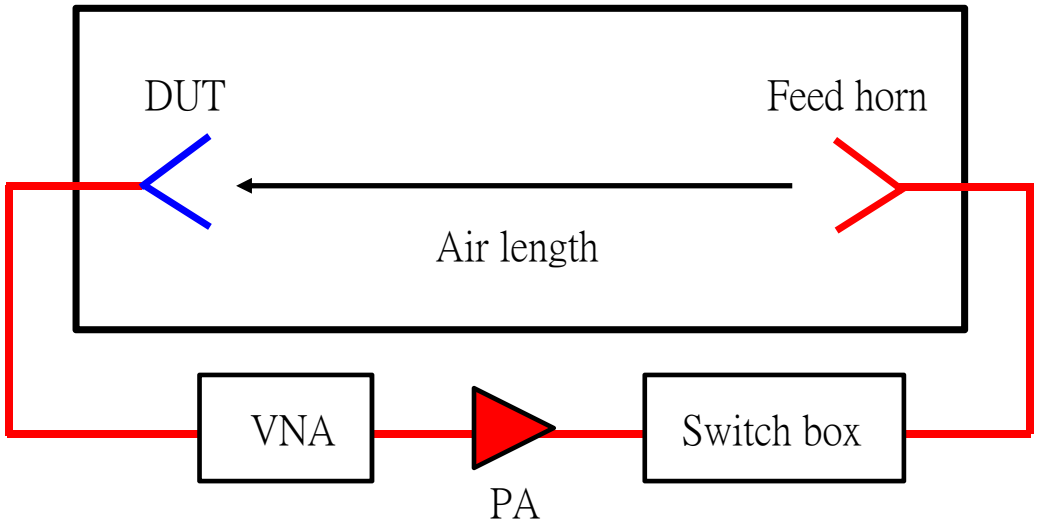
Measurement

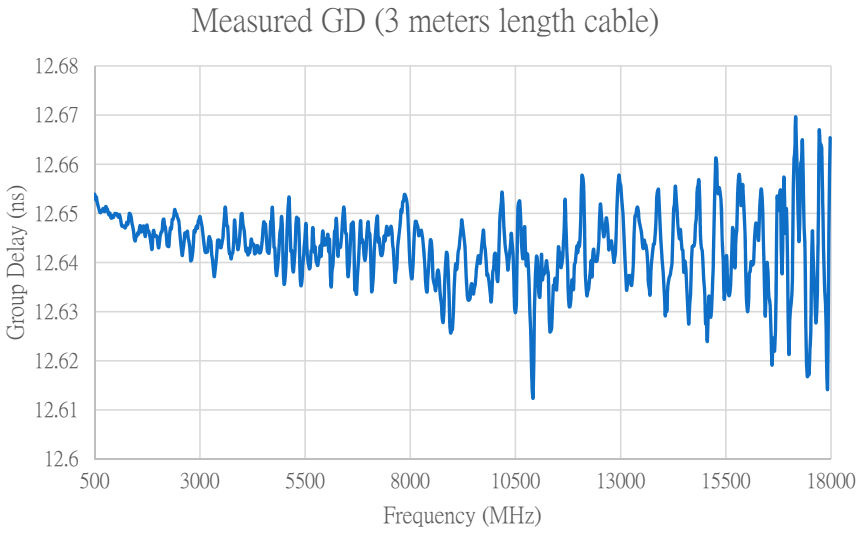
-10 dB

Antenna GD OTA Measurement



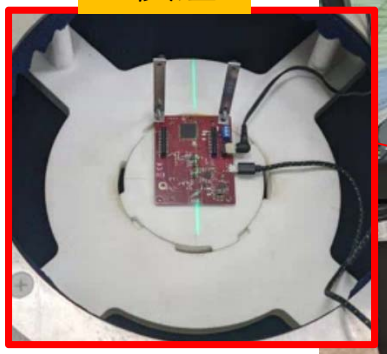
Chamber block diagram

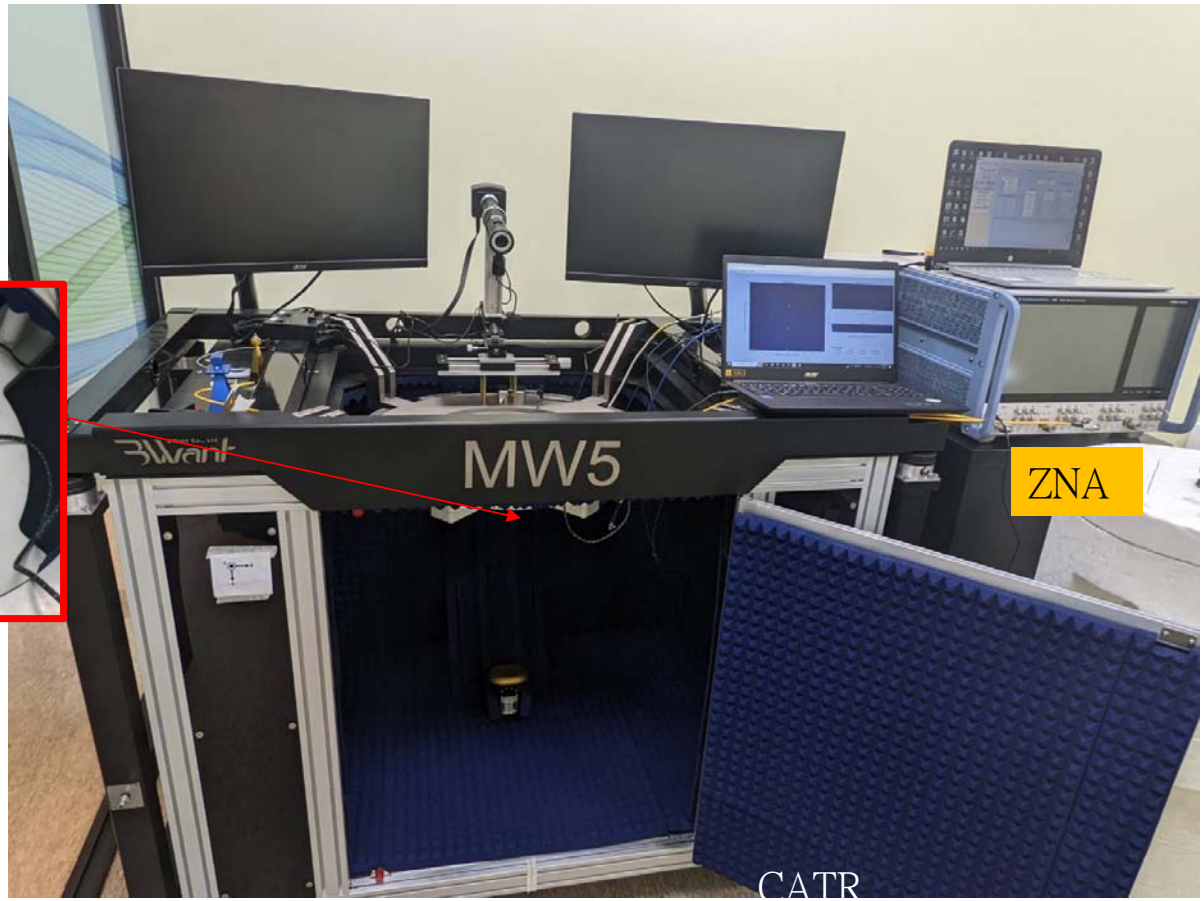




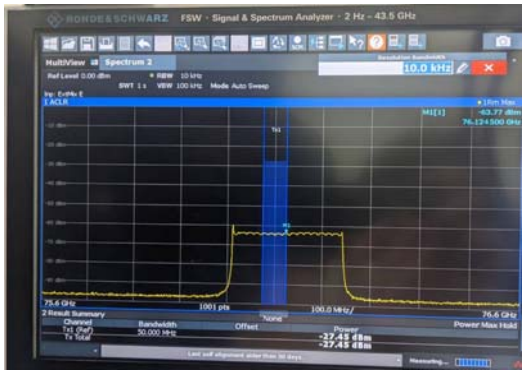
EIRP Measurement

TI模組





SA量測結果



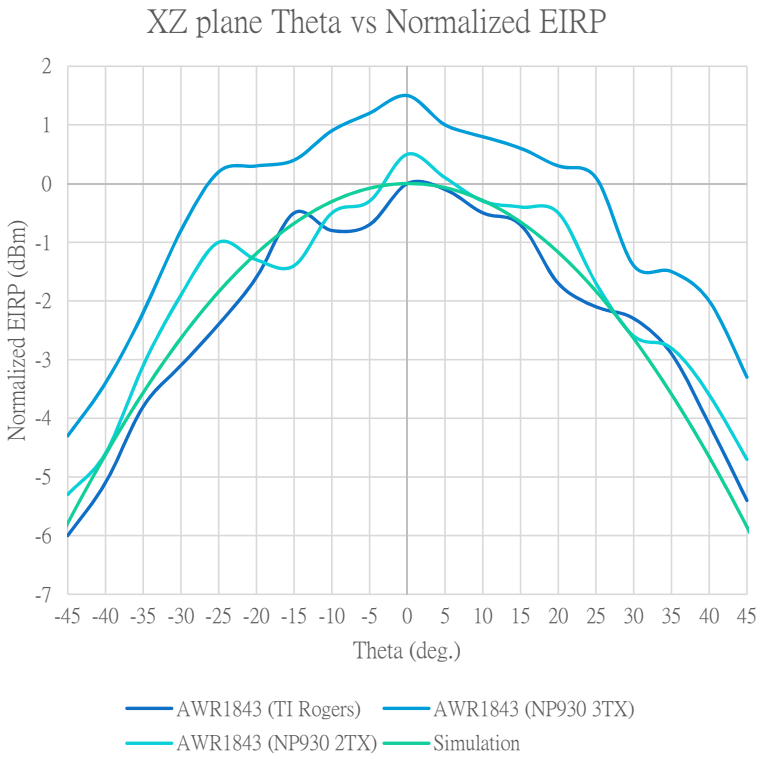
ZNA量測結果

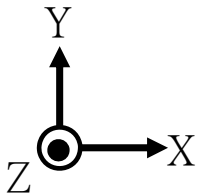
EIRP Measurement Result

Freq. : 77~78.7 GHz

Theta (deg.)	AWR1843 (TI Rxxx)	AWR1843 (NP930 3TX)	AWR1843 (NP930 2TX)
-45	-6	-4.3	-5.3
-40	-5.1	-3.4	-4.6
-35	-3.8	-2.2	-3.1
-30	-3.1	-0.8	-1.9
-25	-2.4	0.2	-1
-20	-1.6	0.3	-1.3
-15	-0.5	0.4	-1.4
-10	-0.8	0.9	-0.5
-5	-0.7	1.2	-0.3
0	0	1.5	0.5
5	-0.1	1	0.1
10	-0.5	0.8	-0.3
15	-0.7	0.6	-0.4
20	-1.7	0.3	-0.5
25	-2.1	0.1	-1.7
30	-2.3	-1.4	-2.6
35	-2.9	-1.5	-2.8
40	-4.1	-2	-3.6
45	-5.4	-3.3	-4.7
HPBW	65	67	67

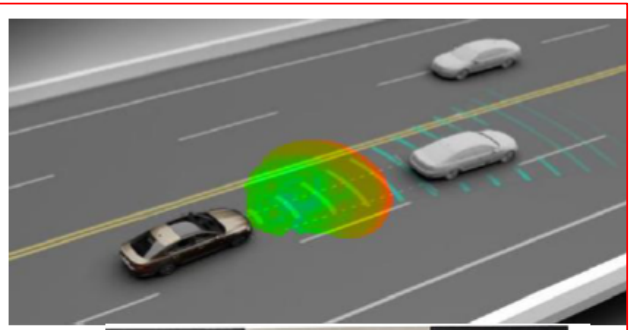
- Ref. : TI EVB
- Design by NP822 : better 1.5 dBm

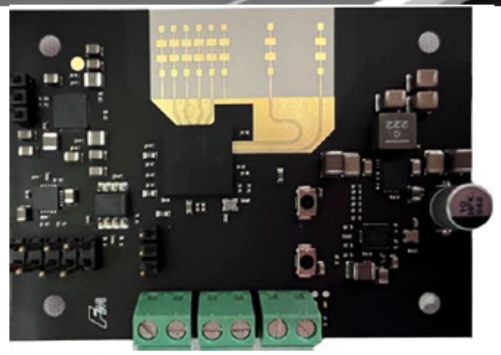




Challenges of Field OTA

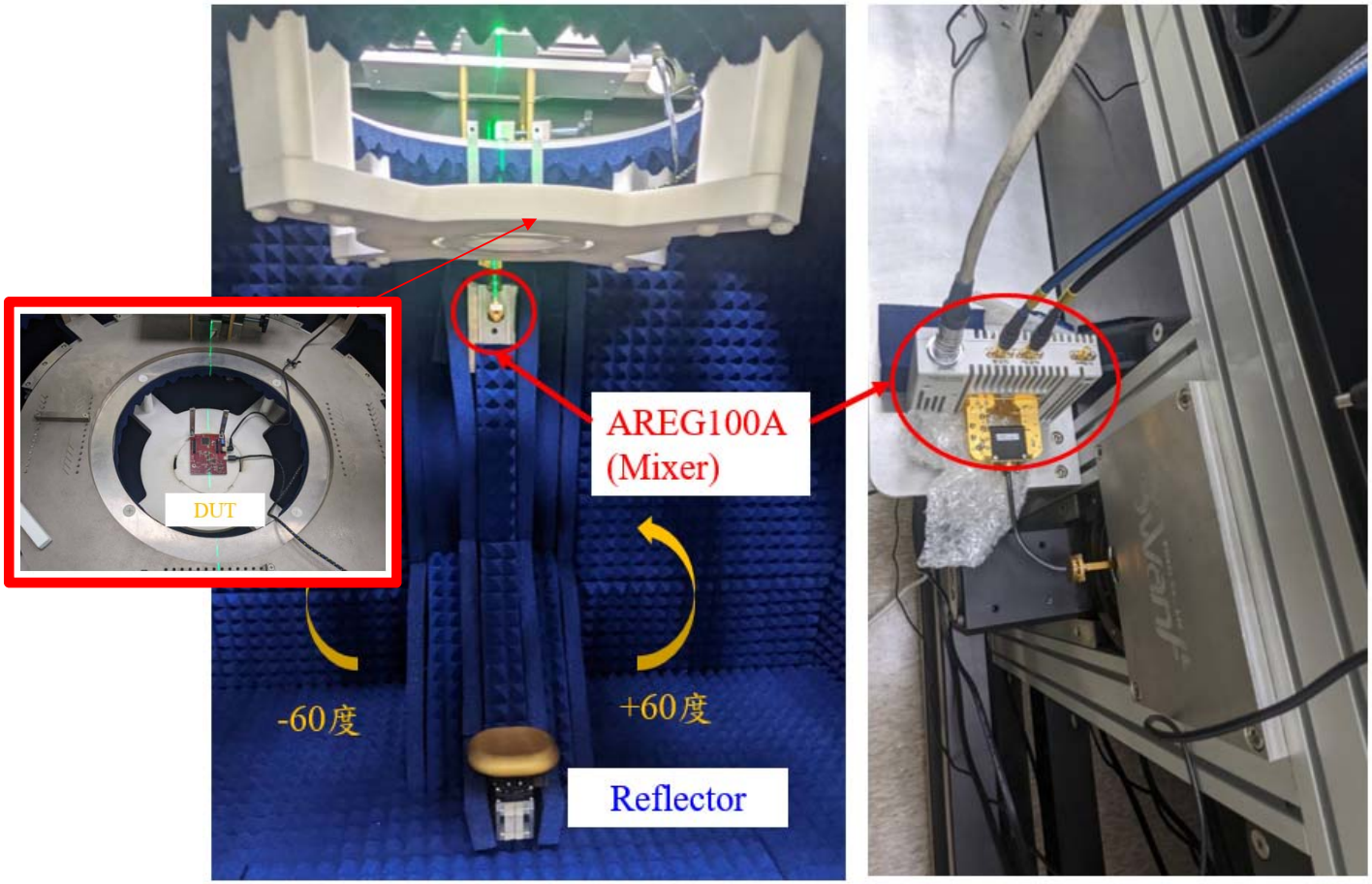
Item	Spec.
Frequency	77~81GHz
VSWR(Typical)	≦ 3
Dimension(Bending) ,mm	71x50x0.52
Peak gain (dBi)	11.46
Measuring Range	Under development
Detection Angle	100°
Interface	USBC/CAN BUS

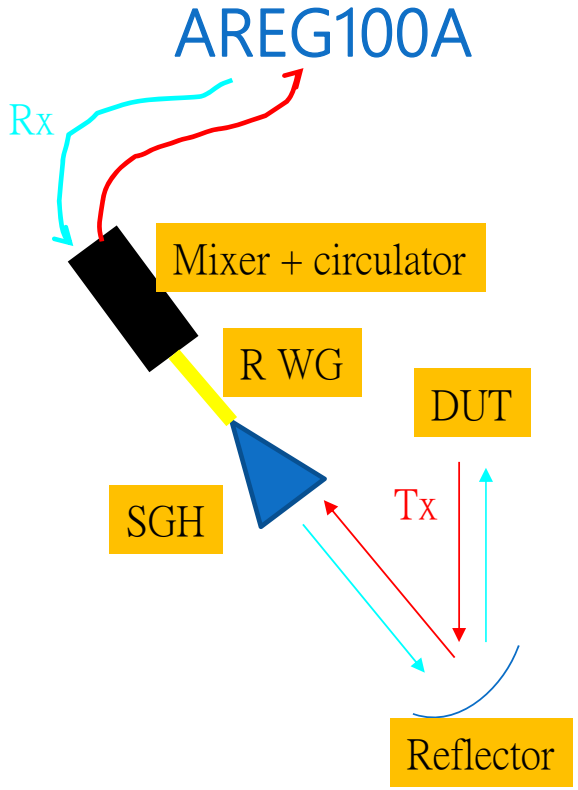




FLEXium 惜福 感恩 承擔 分享

Field OTA Measurement – MW5e

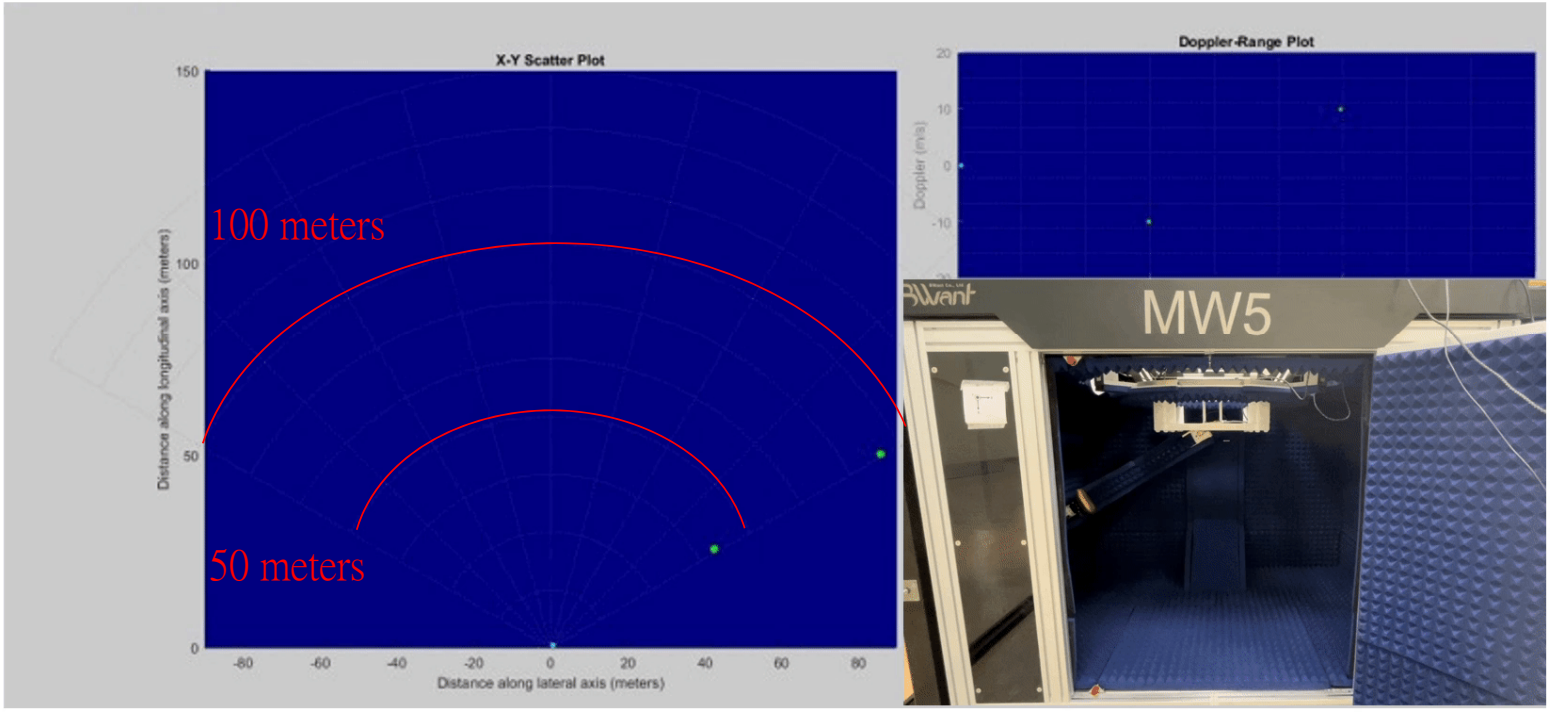




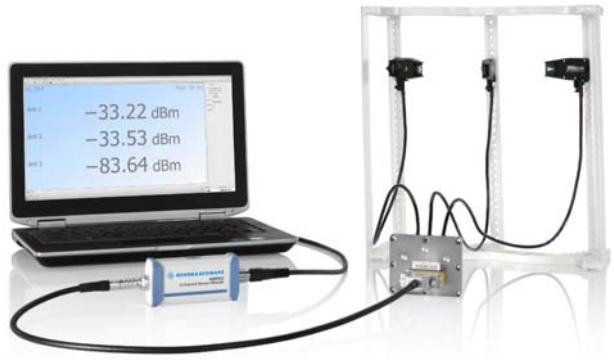
Measurement Result – Field OTA

Test angle: -60 to +60 deg(step 5deg) with 2 target

- Range 50 meters **Doppler 10 m/s RCS 20 dB**
- Range 100 meters **Doppler -10 m/s RCS 20 dB**



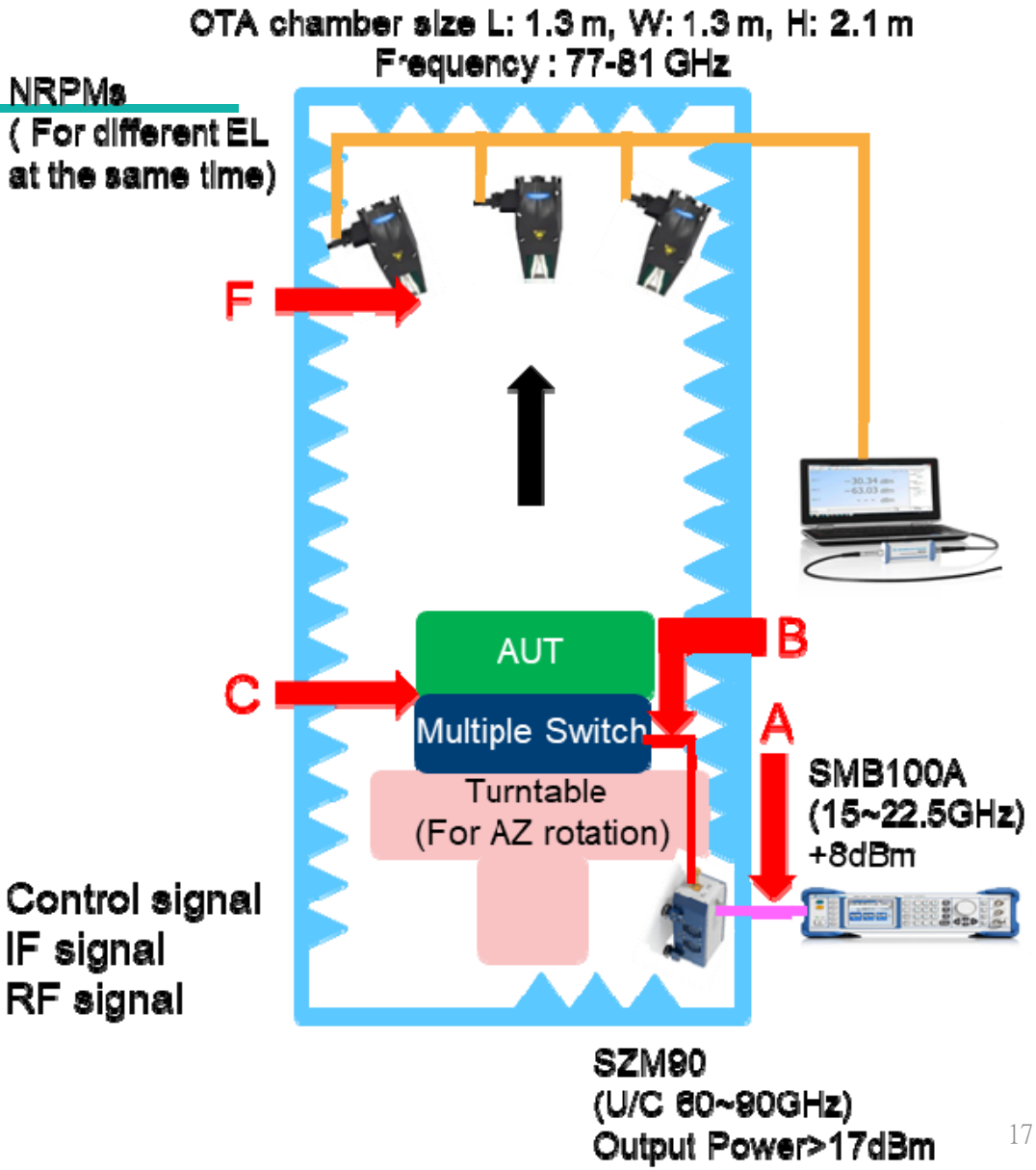
EIRP OTA - MP



NRPM

SZM90

SMB100A



Conclusion

- 4D Image Radar Need High Sensitive Antennas
- S-parameter : Wideband Impedance Matching
- Radiation Patterns : Coverage
- EIRP : Substrate/S11/Ant. Gain
- Group Delay : Phase Distortion Measure
- Image : Application Scenarios Emulate
- MW5e : Probing/System/Field OTA 3 in 1

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