



TestConX 中国
China™

October 23 - 25 2018

Suzhou - Shenzhen, China

Archive

COPYRIGHT NOTICE

The presentation(s)/poster(s) in this publication comprise the Proceedings of the 2018 TestConX China workshop. The content reflects the opinion of the authors and their respective companies. They are reproduced here as they were presented at the 2018 TestConX China workshop. This version of the presentation or poster may differ from the version that was distributed in hardcopy & softcopy form at the 2018 TestConX China workshop. The inclusion of the presentations/posters in this publication does not constitute an endorsement by TestConX or the workshop's sponsors.

There is NO copyright protection claimed on the presentation/poster content by TestConX. However, each presentation/poster is the work of the authors and their respective companies: as such, it is strongly encouraged that any use reflect proper acknowledgement to the appropriate source. Any questions regarding the use of any materials presented should be directed to the author(s) or their companies.

The TestConX China logo and TestConX logo are trademarks of TestConX. All rights reserved.

www.TestConX.org

Over the Air Test for Antenna in Package IC

Dongmei Han
Xcerra Corporation



Suzhou ■ October 23, 2018
Shenzhen ■ October 25, 2018



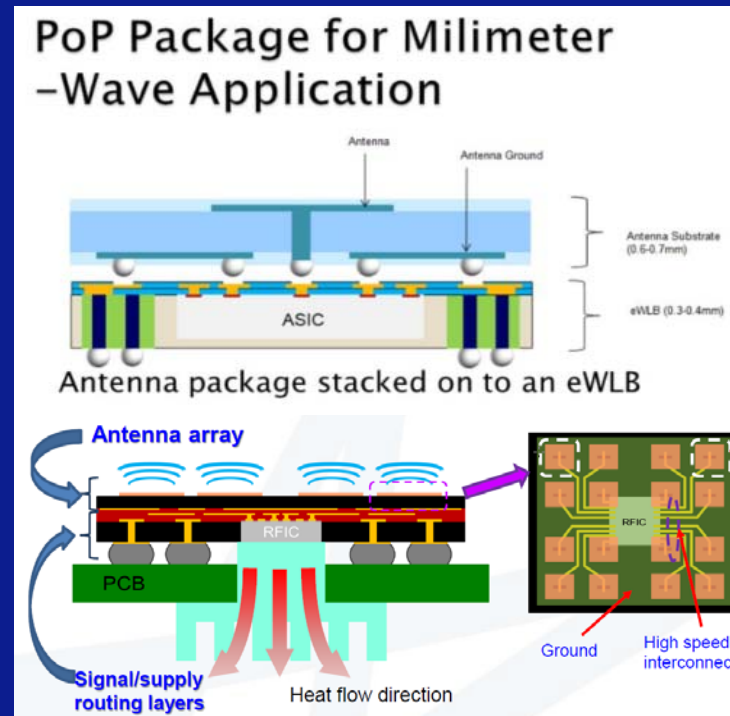
Contents

- AIP history
- AIP in current applications
- OTA requirement in mass production
- OTA solution advantage
- Different OTA solutions

AiP History

What is AiP Technology?

AiP technology is an antenna solution technology that implements an antenna or antennas on (or in) an IC package that can carry a highly-integrated radio or radar transceiver die (or dies)



Material by Bodhisatwa Sddhu from IBM Research Article: Enabling 5G: mmWave Silicon Integration and Packaging

How AiP Technology Evolved?

Inspired from the similarity between ceramic patch antenna and ceramic package, AiP evolved from used ceramic package through PCB mockup



Inspired from ceramic patch antenna

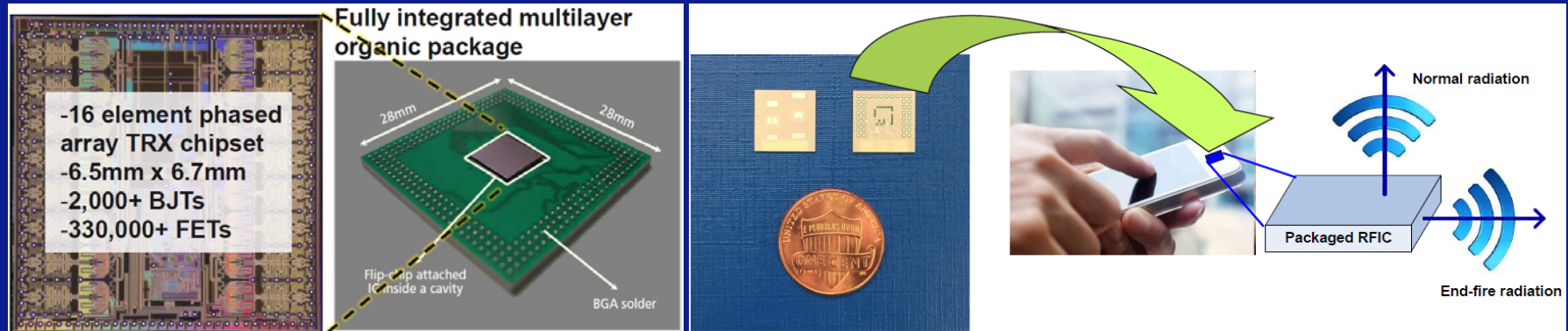
Evolved from ceramic package



Over the Air Test for Antenna in Package IC

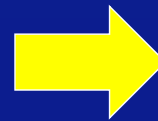
2018

Package Size Getting Smaller



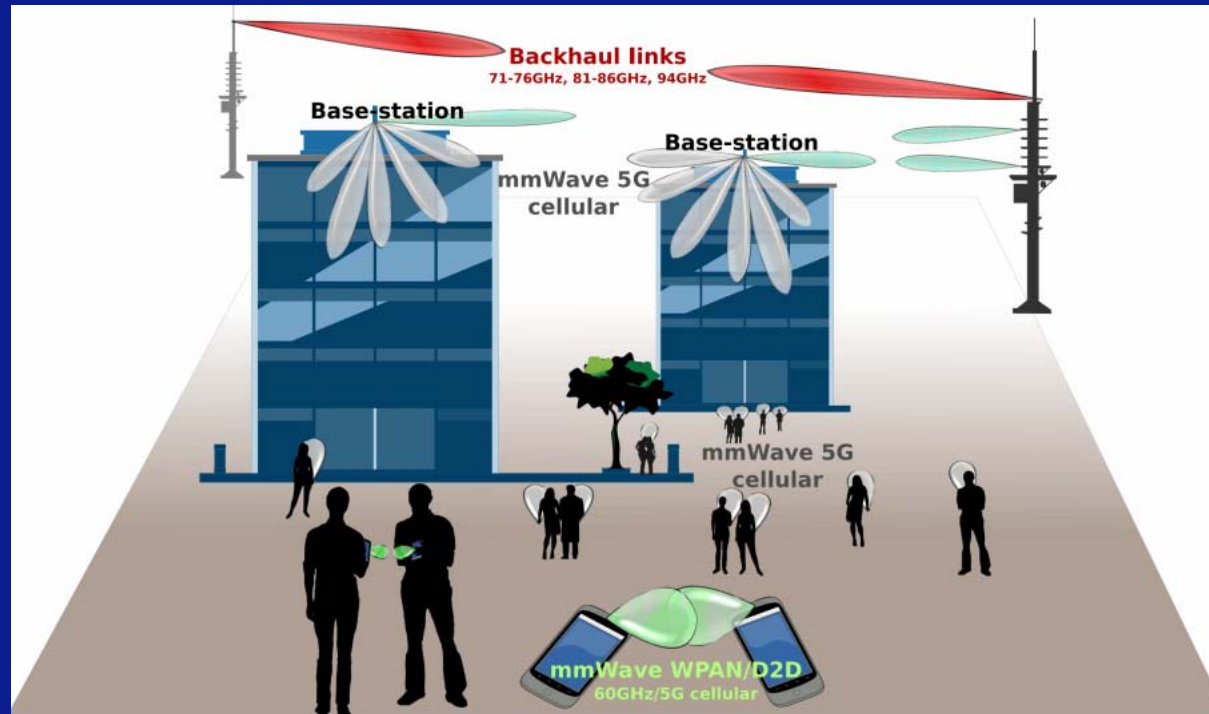
Material by Bodhisatwa Sddhu from IBM Research Article: Enabling 5G: mmWave Silicon Integration and Packaging

60 GHz 16-Element
Phased Array 28mm x 28mm
Transceiver chip



Portable devices
11mm x 11mm
Transceiver chip

5G mmWave Wireless Infrastructure



Material by Bodhisatwa Sddhu from IBM Research Article: Enabling 5G: mmWave Silicon Integration and Packaging



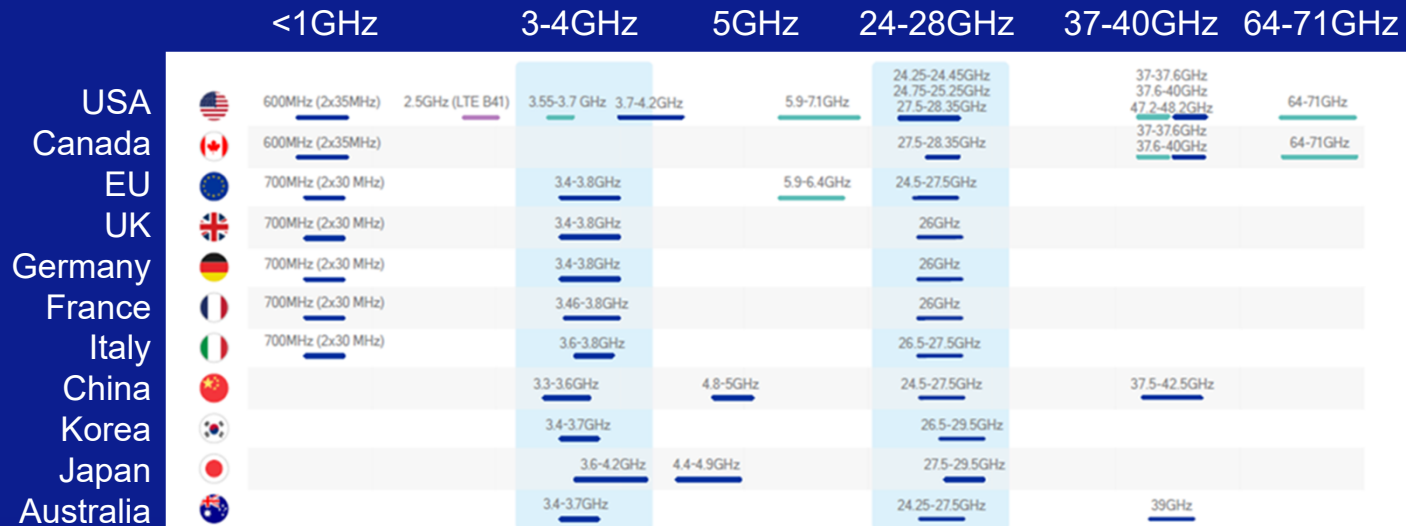
Cover the frequency up to 71 GHz

Over the Air Test for Antenna in Package IC

2018

6

5G mmWave Frequency Spectrum



Global snapshot of 5G spectrum

Around the world, these bands have been allocated or targeted

New 5G band



Material by Bodhisatwa Sddhu from IBM Research Article: Enabling 5G: mmWave Silicon Integration and Packaging



Cover the frequency up to 71 GHz

Over the Air Test for Antenna in Package IC

2018

7

Challenge

- AiP technology has been widely adopted by chip makers for 60GHz radios and gesture radars. It is strongly believed that AiP technology will also provide elegant antenna solutions to 5G and beyond operating in the lower millimeter-wave bands
- Over-the-air (OTA) antenna measurements are required for production testing

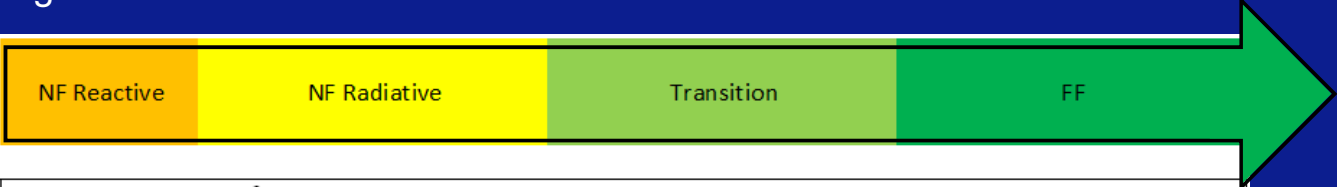
Far-Field Vs Near Field basics

- Different models allow predicting the behavior of antennas in function of the distance r from them:
 - Near-field:
 - 3 different zones:
 - a) For $r < \lambda/2\pi$, reactive zone
 - b) For $\lambda/2\pi < r < 2 \frac{D^2}{\lambda} \approx \lambda^1$, radiative zone
 - c) For $2 \frac{D^2}{\lambda} \approx \lambda < r < 2\lambda$, transition zone
 - In the case b) and c) which interests us, the radiative Power decreases in $1/r^5$
 - Far-field:
 - The most common model when we deal with wave propagation
 - Radiative Power decreases in $1/r^2$
 - This model is only valid for $r > 2\lambda$

¹ This approximation is valid because the longitude or diameter D of the antenna is always proportional to λ (between λ and $\lambda/2$).

NF-FF zones in function of the frequency

- As the NF-FF zones are **directly linked to the wavelength**, and so to the **frequency**, we are able to find the limit distances for which we are in Far or Near Field
 - These limits are given in the “distance line” below:

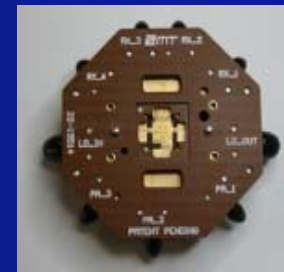
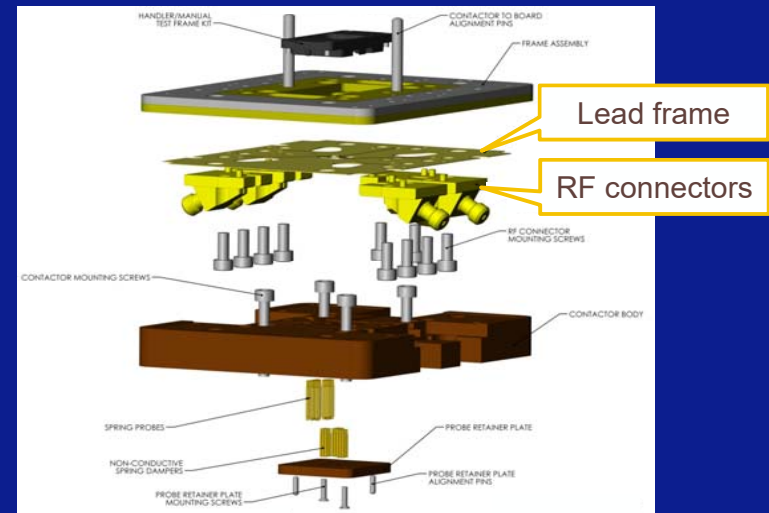


Frequency [GHz]	Wavelength [mm]	$R = 0$	$R = \frac{\lambda}{2\pi}$	$R = \lambda$	$R = 2\lambda$
30	10	0	1.6	10	20
40	7.5	0	1.2	7.5	15
50	6.0	0	1.0	6.0	12
60	5.0	0	0.8	5.0	10
70	4.3	0	0.7	4.3	8.6
80	3.8	0	0.6	3.8	7.5

- The differences between all these regions are given in the following slides

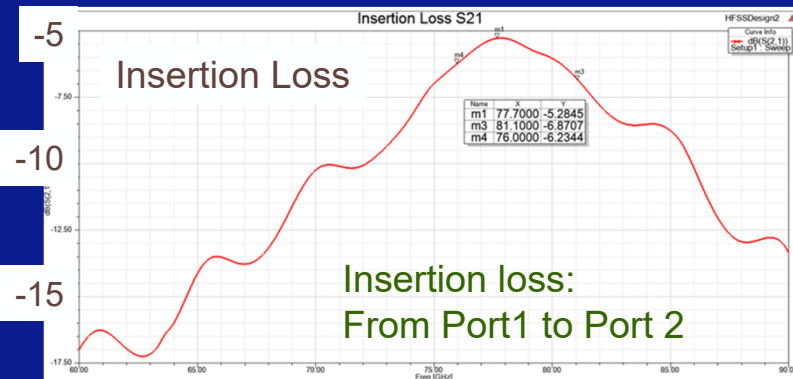
OTA Platform Based on Lead Frame Technology

- Core technology – Lead frame, is a thin layer of metal frame to which semiconductors are attached during the package assembly process.
- We use lead frame to transmit signals replace PCB in our contactor
- We build structures on lead frame to execute different RF performance

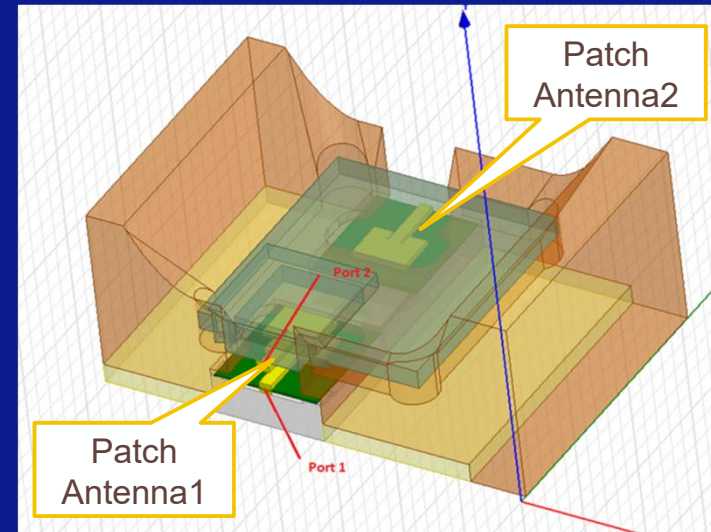


Over the Air Test for Antenna in Package IC

OTA Simulation @ 80GHz



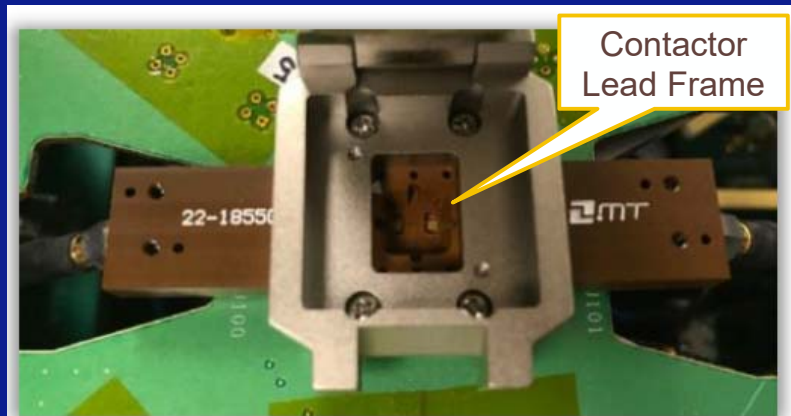
Insertion loss:
From Port1 to Port 2



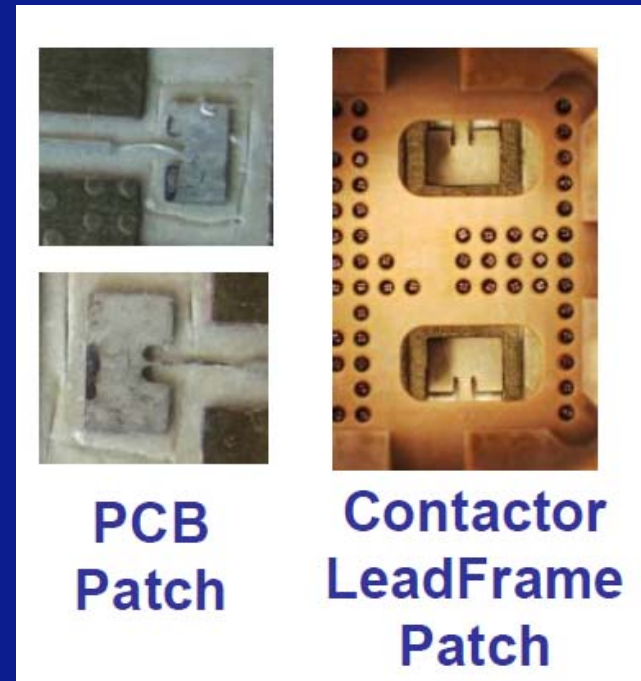
Modeled OTA Solution with
Patch Antenna in Contactor

OTA Product for Radar Application

- Fine machine tolerance
- Plug and play socket, easy to implement



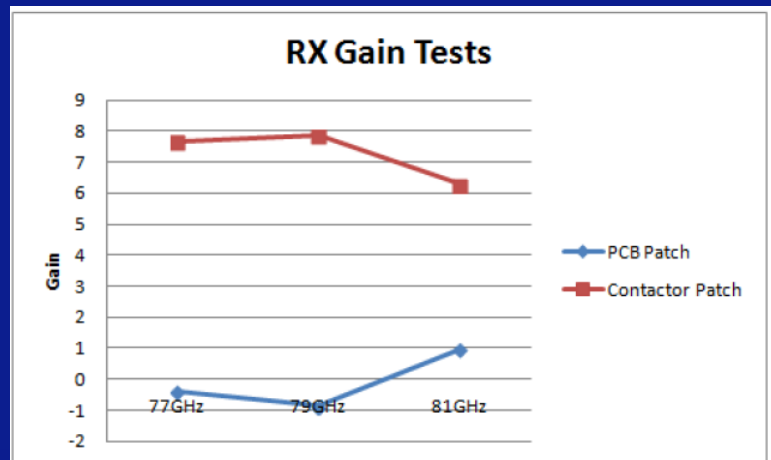
**Broadband Contactor + Patch
for 76-81GHz BGA AiP**



**PCB
Patch**

**Contactor
LeadFrame
Patch**

OTA for Radar Application Field Data



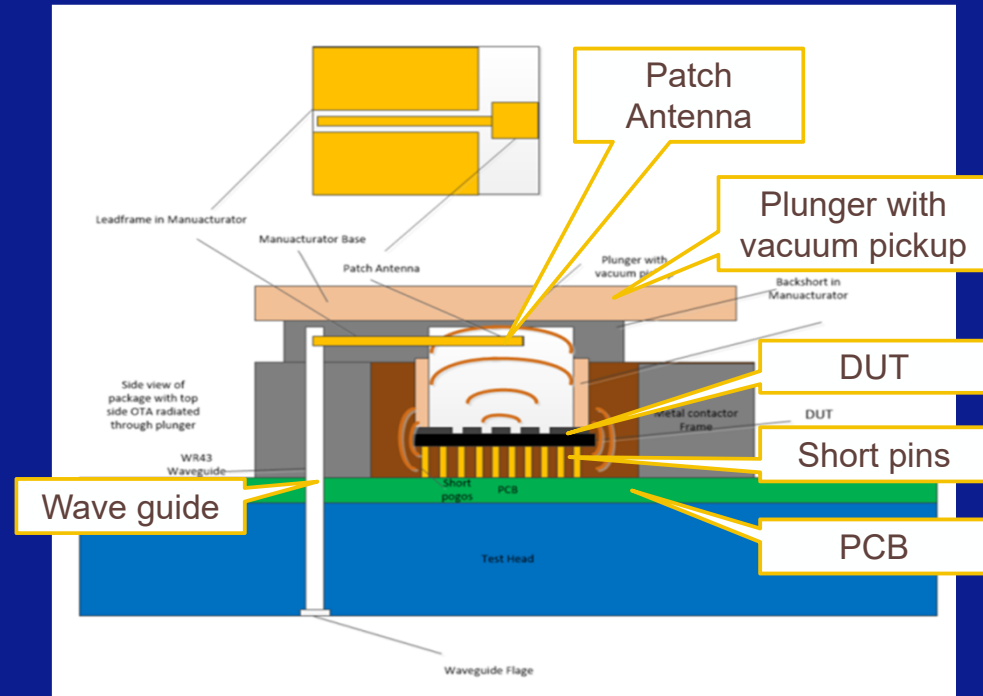
Test Results Superior with Patch Integrated in Contactor vs PCB

Test Fixture	RX Gain Test (dB)		
	Low 77GHz	Mid 79GHz	High 81GHz
PCB Patch	-0.37	-0.87	0.96
Contactor Patch	7.65	7.85	6.27

- Less tolerance
- Measurement data more close to lab data

Different Application Structures

This is one patch antenna to test antenna on the top DUT. Using lead frame connect to waveguide.



One Patch

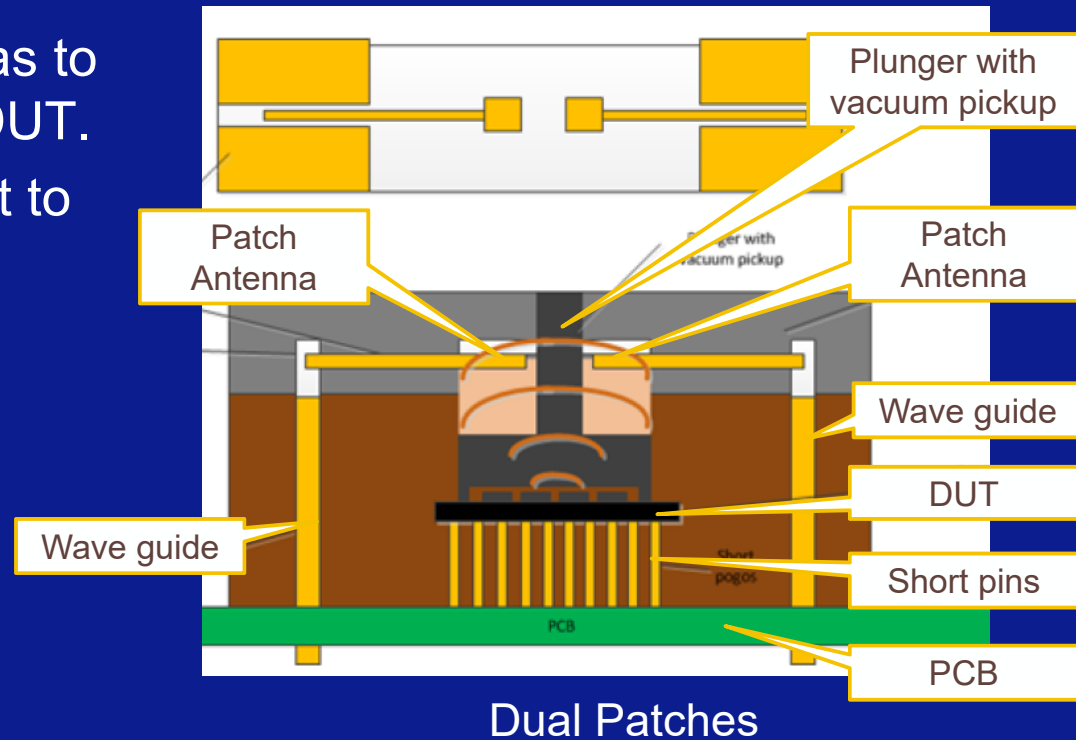
Over the Air Test for Antenna in Package IC

2018

15

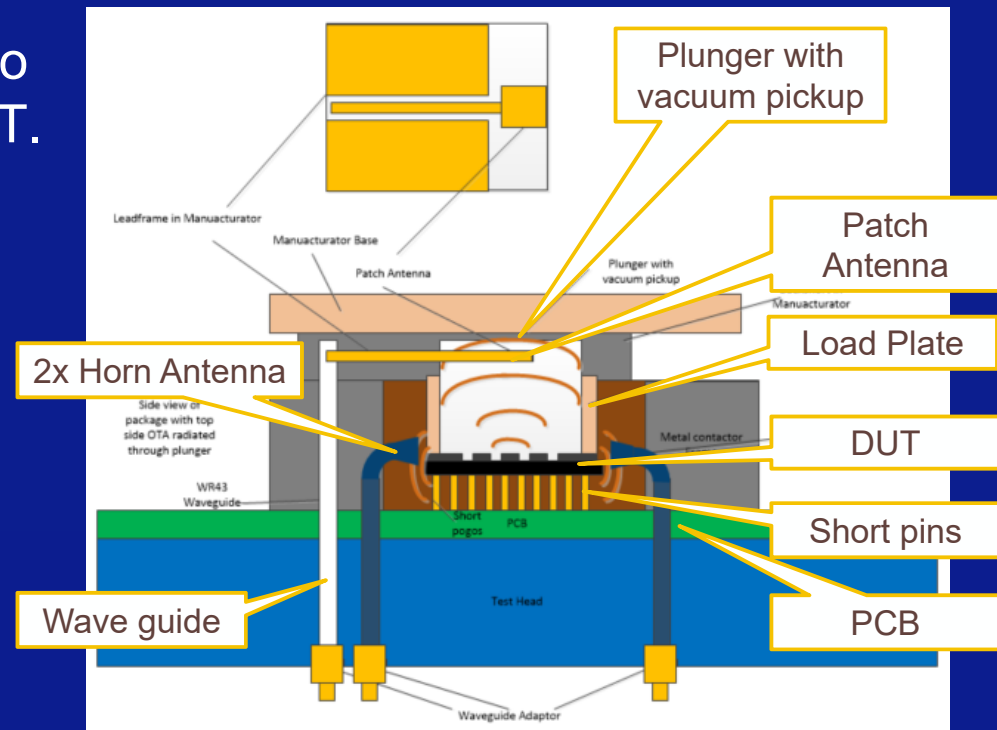
Different Application Structures (Continue)

This is two patch antennas to test antenna on the top DUT. Using lead frame connect to waveguides.



Different Application Structures (Continue)

This is one patch antenna to test antenna on the top DUT. Two waveguide horn antennas test antennas on DUT side. All connect to waveguides to tester side.



Patch and Horn Combination

Over the Air Test for Antenna in Package IC

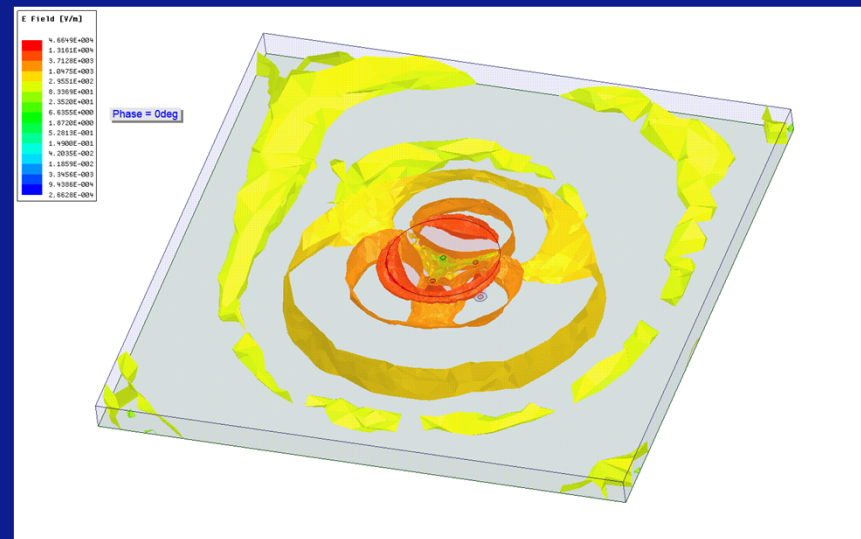
2018

17

OTA Design Considerations

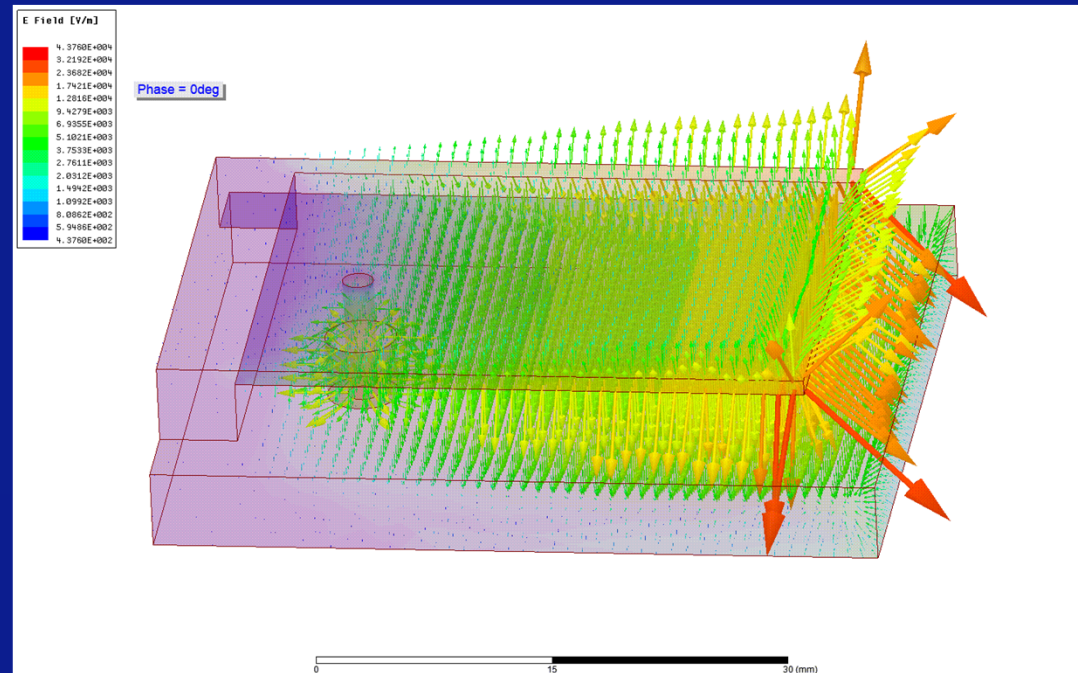
- Different frequency ranges
- Different polarizations

Mag E field Plot



OTA Design Considerations (Continue)

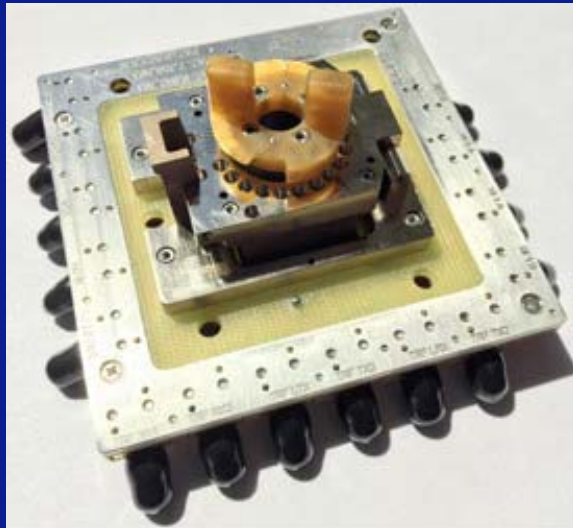
Vector E field Plot



Advantage of Socket

- Less path loss
 - CPW replace PCB traces
 - Waveguide transition to planar antenna
 - Eliminate cables by using waveguide interfacing tester side
- Longer life cycle
 - Lead frame life cycle is over million insertions
- Less tolerance
 - Precise machining process

OTA for 5G



A production interface solution that enables OTA testing of a 60GHz single-chip integrated Antenna in Package has been delivered to a customer. The solution integrates the OTA Contactor with patch antenna.

Conclusion

- AiP technology moves up to cmWave and mmWave makes package in socket test possible for production
- Using lead frame build antenna in socket makes reliable OTA test
- **Antennas in contactor design can test different applications with different radiation patterns and directivity out the top, sides and/or bottom of the AIP**