On-chip Test with Microstrip Patch Antennas

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Abstract:

This paper presents a perspective of the development of microstrip antennas for use in WLCSP and WLP semiconductor test. The work that will be discussed includes designing, manufacturing, and installing microstrip patch antenna in contactors and probe heads for test. With an increasing number of transmitters and receivers on-chip, interest in microstrip antennas in contactors and probe heads is increasing. The top five reasons for increasing interest in microstrip antenna are: they are physically very simple, they are small, they are flat, they are easy to feed, and they are easy to make. Microstrip patch antennas are becoming increasingly useful because they can be printed directly onto a circuit board and mounted in the probe head for testing devices with on-chip antennas. The on-chip antenna needs to meet various requirements such as compact size, good operating bandwidth, and good radiation efficiency. With all of that, devices with on-chip antennas should be tested.

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On-Chip 5G and ADAS Microstrip Patch Antennas Test Interfaces

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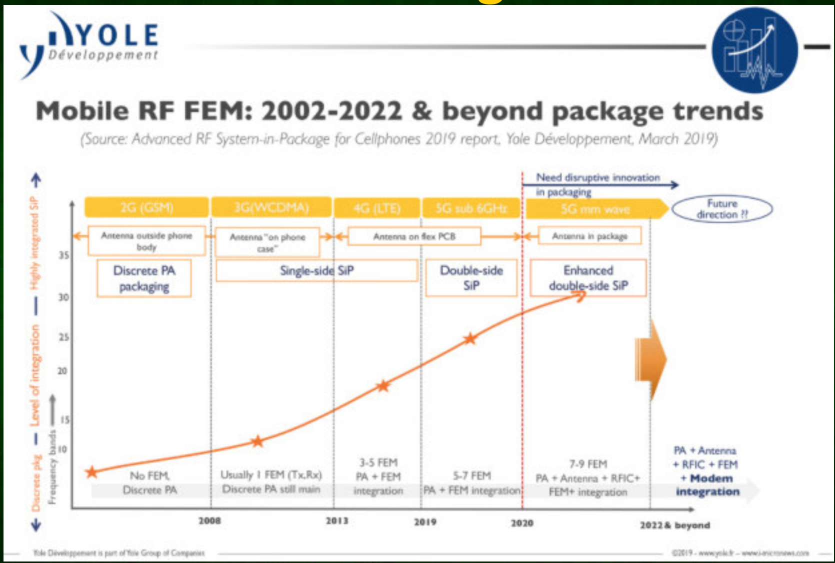
Overview

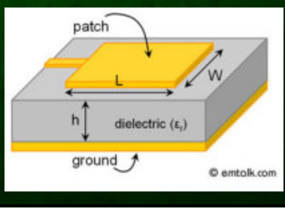
- **Introduction to Microstrip Patch Antennas**
  - Construction
  - Geometry
  - Analysis
  - Examples
- **Alternative Antenna Test Interface Structures**
- **Summary**

5G RF Antenna Integration Trends



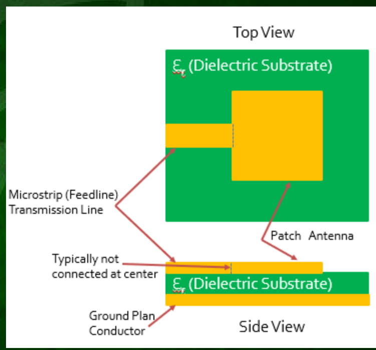
Microstrip Patch Antenna - Introduction

- A microstrip or patch antenna is a low-profile antenna that has a number of advantages over other antennas: it is lightweight, inexpensive, and electronics like LNA's and SSPA's can be integrated with these antennas quite easily
- Testing over-the-air devices at the die and package level effectively with microstrip patch antennas
- While the microstrip patch antenna can be a 3-D structure (wrapped around a cylinder, for example), it is usually flat and that is why patch antennas are sometimes referred to as planar antennas.



Microstrip Patch Antenna - Construction

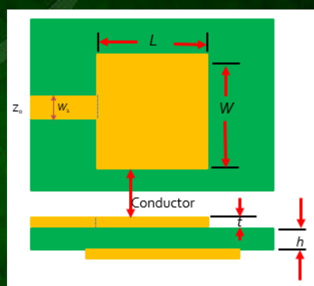
- **The original microstrip or patch antenna was patented in 1955**
- **Construction of the microstrip antenna includes:**
  - Dielectric substrate
  - Ground plan conductor
  - Thin radiating conductor element
  - Microstrip feedline



- **In a properly designed microstrip antenna the radiation intensity is in a direction normal to the radiating element, i.e., broadside**

Microstrip Patch Antenna - Geometry

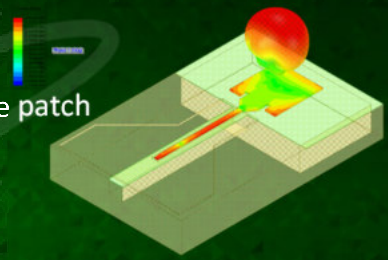
- **The shape and size of an antenna is a function of its purpose**
- **L is the Length and it is the resonant dimension**
  - L=λ/2: Typically 1/2 Wavelength
- **W is the Width affects the bandwidth**
  - W= 1.5 L is typical
- **The position of the transmission line is relative to impedance**
  - t is the thickness of the conductor
  - h is the height of the dielectric, typically should be < 0.05 λ



- **The ground plan needs to be as big as the patch and is typically a little larger than the patch**

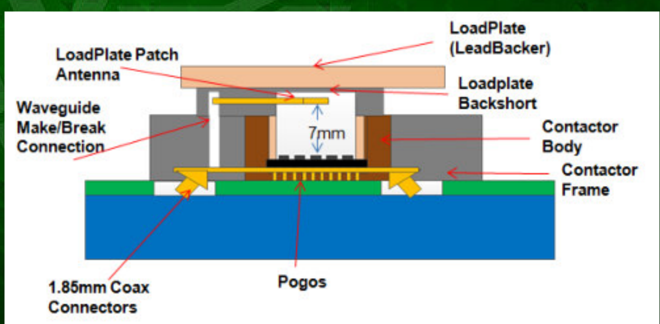
Microstrip Patch Antenna - Analysis

- **Why does it radiate?**
  - We have a transmission line connected to this patch
  - We have energy flowing down the transmission line to the patch
  - The patch is terminated as an open circuit
  - So the current has no where to go
  - Consider the current voltage distribution
    - When current terminates in this open circuit situation it forces the voltage and current to come out of phase, i.e. It turns out to be 90° degrees out of phase
    - 90° degrees out of phase is actual key to the radiation of the patch and that the reflection coefficient gamma $|\Gamma|$ equals 1
    - When ever you have the magnitude of the reflection coefficient equal to one, your current and voltage are going to be 90 degree out of phase



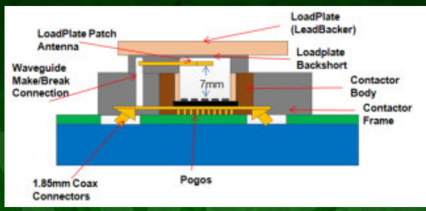
Microstrip Patch Antenna - Backshorts

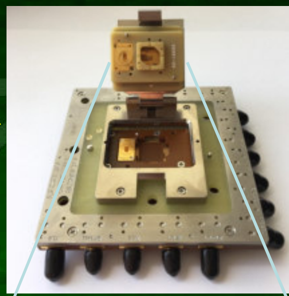
- **Defines the impedance of the trace and the antenna patch**
- **Trace impedance = 50 ohms, Patch Antenna = 300-500 ohms**
- **Back short is a deflector for the radiation out of the patch and directs it upwards**



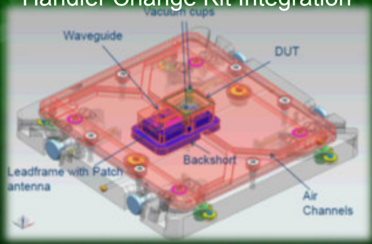
72GHz xWave OTA for Pick and Place Handler (MT2168)

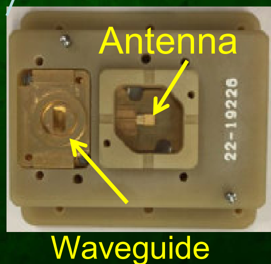
- xWave Contactor with Integrated Patch in Workpress/Leadbacker
- Broadband Performance and Wide Beamwidth
- Far-field Communication with NO IMPACT TO TEST CELL





Handler Change Kit Integration

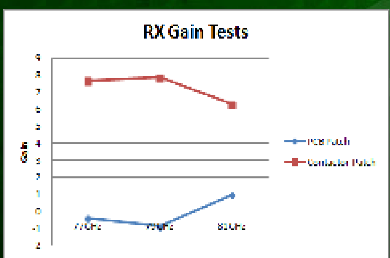




81GHz xWave OTA Automotive Radar Testing

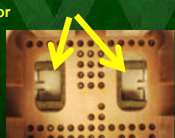
- xWave Contactor with integrated Patch Antennas outperforms PCB patches
- Uses 81GHz Kestrel tester module cabled directly to patches in contactor
- Integrated with Cohu MX tester

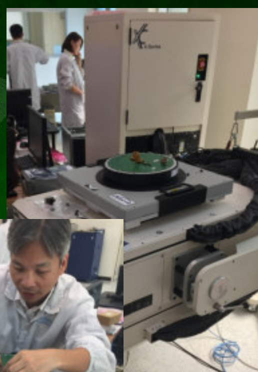
	RX Gain Tests		
	Low Band	Mid Band	High Band
Test Fixture	77GHz	79GHz	81GHz
PCB Patch	-0.37	-0.87	0.96
Contactor Patch	7.65	7.85	6.27



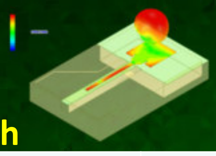
PCB Patch

Dual Tx/Rx Patch antenna in contactor



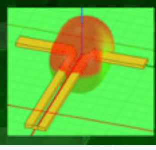


Alternative Antenna Test Interface Structures



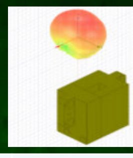
Patch

Shape	Square
Size=f(frequency)	λ/4
Bandwidth	Medium
Beam width	Medium
Gain	8-9dB
Polarization	Dual



DiPole

Shape	2 arms
Size=f(frequency)	λ/2
Bandwidth	Medium
Beam width	Medium
Gain	2-5dB
Polarization	Single



WaveGuide

Shape	waveguide
Size=f(frequency)	λ/2 to λ
Bandwidth	Wide
Beam width	Narrow-Wide
Gain	5-20dB
Polarization	Single

Microstrip Patch Antenna Test Interface Summary

- **Increased levels of antenna integration in mobile RF FEMs will continue to drive disruptive packaging technologies that will require adaptable production OTA test interface solutions**
- **Microstrip Patch Antennas are a good option when space is limited for integration into a handler leadbacker for testing singulated modules or into a probehead for testing WLCSP or 3DICs with Antenna on Chip**
- **Alternative antenna structures such as waveguide, dipole, or exotic patch designs could be driven by specific applications to address requirements such as gain, phase, or polarization**