WI：SLB-mmW Paris(France) Nov 2024 meeting # mmWave Measurements Introduction

Date: 2024-11-20

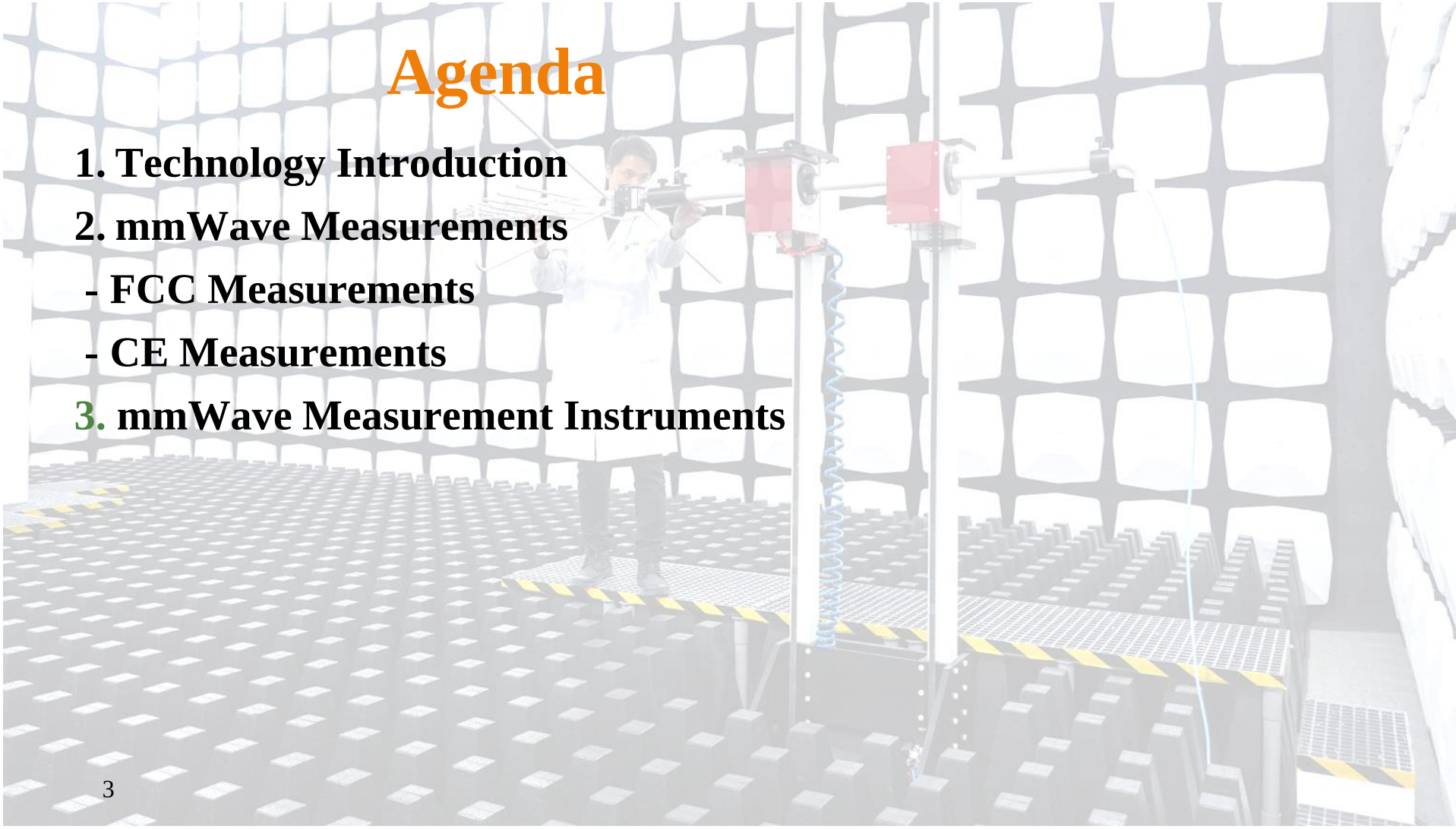
Source:

Affiliation	Contact	Email
DEKRA	Juan Carlos Mora	JuanCarlos.Mora@dekra.com

2024 DEKRA

Juan Carlos Mora, Nov 2024

mmWave Measurement Introduction



Agenda

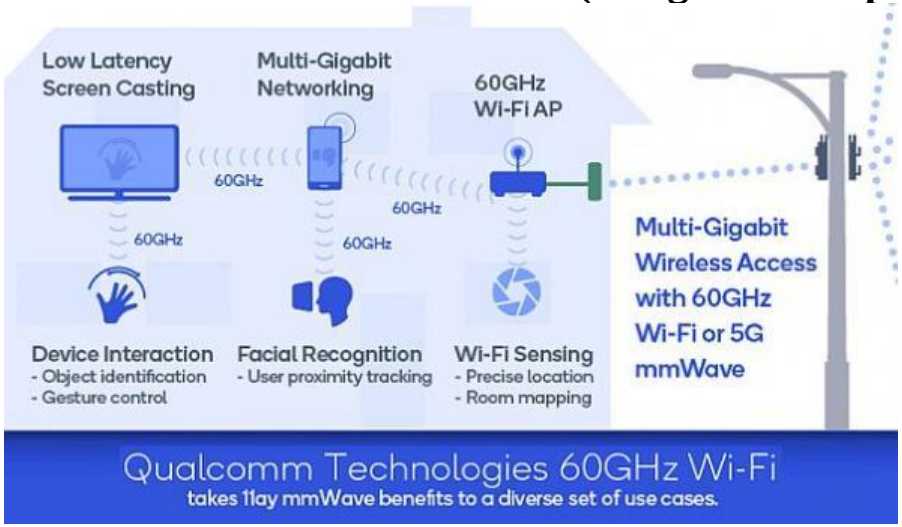
1. Technology Introduction
2. mmWave Measurements
   - FCC Measurements
   - CE Measurements
3. mmWave Measurement Instruments

Technology Introduction

Some examples

60 GHz application

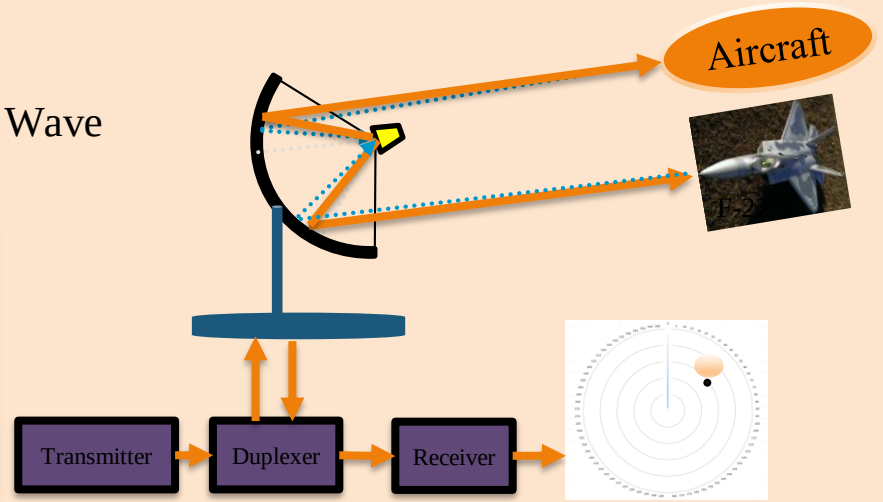
- **WiFi & SRD device**
- **Level Probing Radar (LPR)**
- **Soli Motion Sense Radar (Google mobile phone Pixel 4)**



Source:
http://www.measuring.org.tw/supplier/product_detail.asp?id=767&pid=114
https://atap.google.com/soli/
https://www.vega.com/en/products/product-catalog/level/radar/vegapuls-sr-68
https://www.qualcomm.com/news/onq/2018/10/16/pushing-boundaries-wireless-new-60-ghz-wi-fi-chipset-portfolio-video

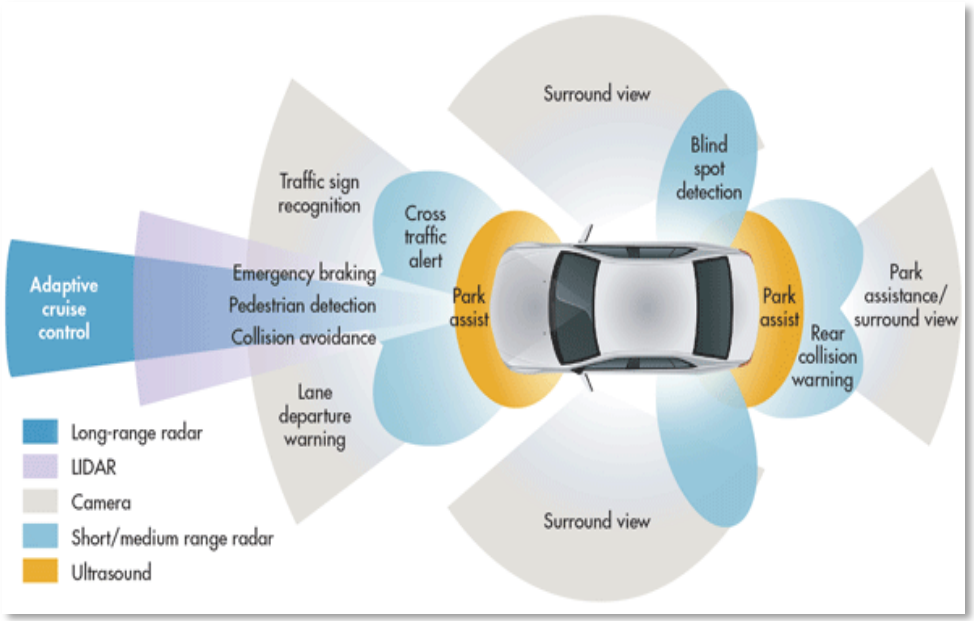
Radar Technology

- **RADAR: Radio (Aim) Detecting And Ranging**
- **The Radar detects the present of objects by using electromagnetic energy.**
- **The original use was about ship anti-collision devices, but the radar technology was develop so rapidly because of the war.**
- **So the radar system can measure the direction, height, distance, course, and speed of these objects.**
- **And it can to determine the position of airplanes, ships, or other obstacles that are invisible to the naked eye because of distance, darkness, or weather.**
- **Radar signal type**
  1. CW Radar: Continuous wave
  2. Pulse Radar
  3. FMCW Radar: Frequency Modulated Continuous Wave
  4. Doppler Radar
  5. UWB Radar



Radar Design Principle

- **Basic design of Radar system:**
  1. Transmitter
  2. Duplexer
  3. Receiver
  4. Antenna
  5. Indicator
- **Principle of Measurement**
  1. Distance
  2. Direction
  3. Maximum Unambiguous Range
  4. Minimal Measuring Range
  5. Elevation angle
  6. Range Resolution
  7. Accuracy

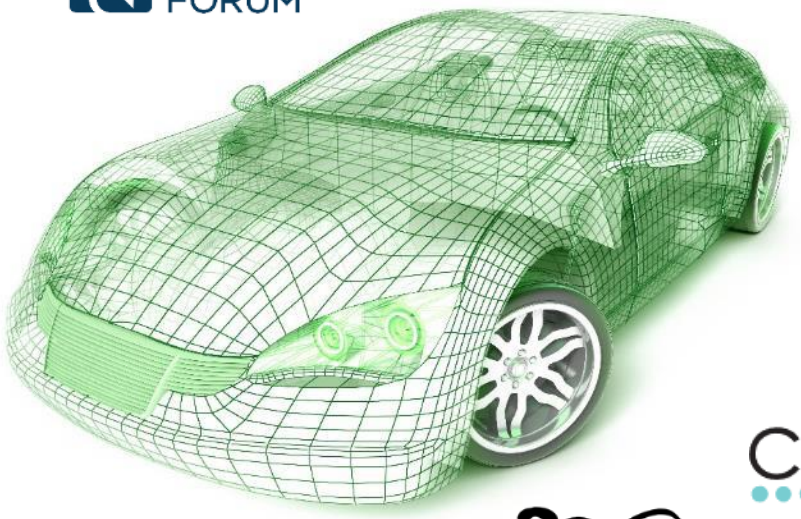


Secure: V2X considered necessary for L3/L4 ADAS

Radar Scenario in ADAS

While being future proof and scalable to meet the requirements of use cases of tomorrow, e.g., Advanced Driver Assistance Systems (ADAS), where vehicles can cooperate, coordinate and share sensed information, and ultimately Driverless.

Interest Group and Standardization Requirements

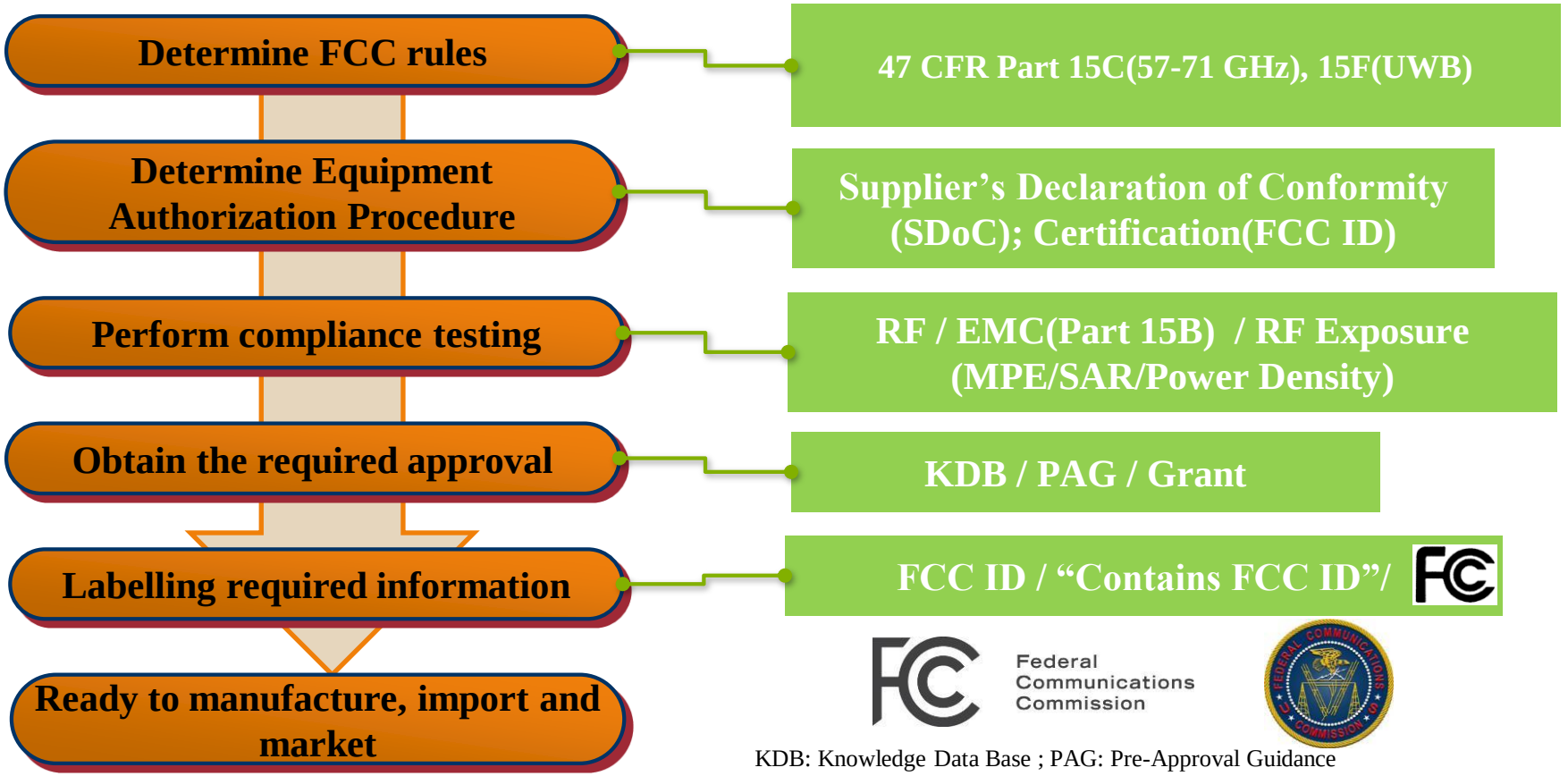


DEKRA provides certification services for most important schemes

mmWave Measurement

FCC Certification Process –

Steps to Obtain an Equipment Authorization



KDB: Knowledge Data Base ; PAG: Pre-Approval Guidance

57GHz~71GHz Regulatory standards — FCC/IC

Follow to FCC CFR47 Part 15 Subpart C § 15.255 / ISED RSS-210

Test Items	Limit	Note
Equivalent Isotropically Radiated Power (EIRP)-WiGig	PK:43 dBm/85 dBm (Outdoor fixed P to P) AV: 40 dBm/82 dBm (Outdoor fixed P to P)	
Equivalent Isotropically Radiated Power (EIRP)-fixed field disturbance sensor	PK/AV: 40 dBm/43 dBm (within the 61 to 61.5 GHz) PK/AV: 10 dBm/13 dBm (outside of the 61 to 61.5 GHz, but still within the 57-71 GHz)	
Conducted and Peak EIRP -For fixed field disturbance sensors other than above and SRD for interactive motion sensing	-10 dBm/10 dBm (EIRP)	
Occupied Bandwidth	NA	
Spurious emissions (below 40 GHz)	Follow to part 15.209	
Spurious emissions (40 to 200 GHz)	90 pW/cm2 (at 3 m)	
Frequency stability	Within the 57 ~71GHz band	Temperature range:-20℃ to +50 ℃ Input voltage of 85% to 115% of rated input voltage
AC line conducted emissions	Follow to part 15.207	

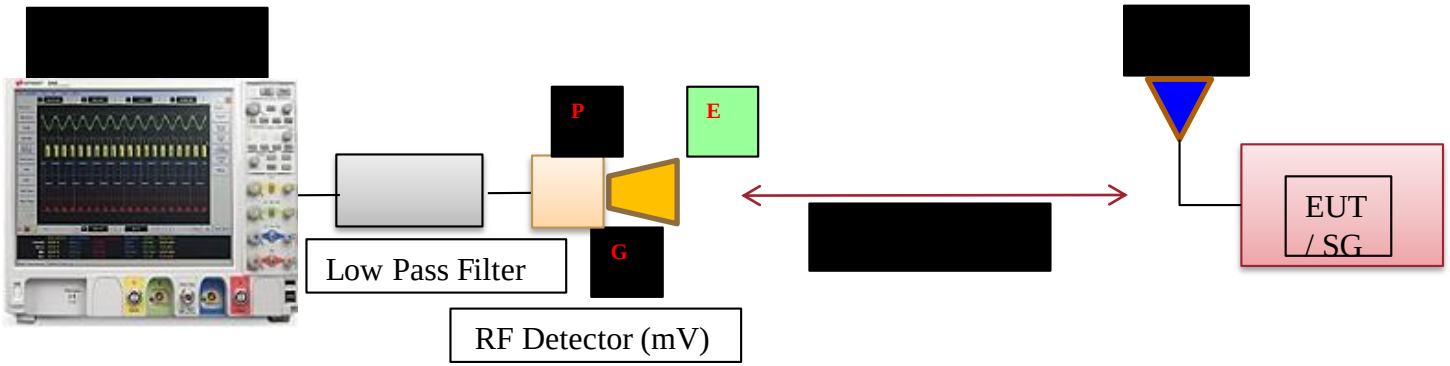
Peak EIRP (Equivalent Isotropic Radiated Power)

Follow to the FCC Part § 15.255 paragraph (C)(4),the peak power shall be measured with an **RF detector** that has a detection bandwidth that encompasses the 57-71 GHz band and has a video bandwidth of at least 10 MHz. The average emission levels shall be measured over the actual time period during which transmission occurs.

Follow to the below formula then calculate to the strength field (E):

$$E = 126.8 - 20\log(\lambda) + P - G$$

where
E is the field strength of the emission at the measurement distance, in dBμV/m
P is the power measured at the output of the test antenna, in dBm
λ is the wavelength of the emission under investigation [300/fMHz], in m
G is the gain of the test antenna, in dBi
NOTE—The measured power P includes all applicable instrument correction factors up to the connection to the test antenna.

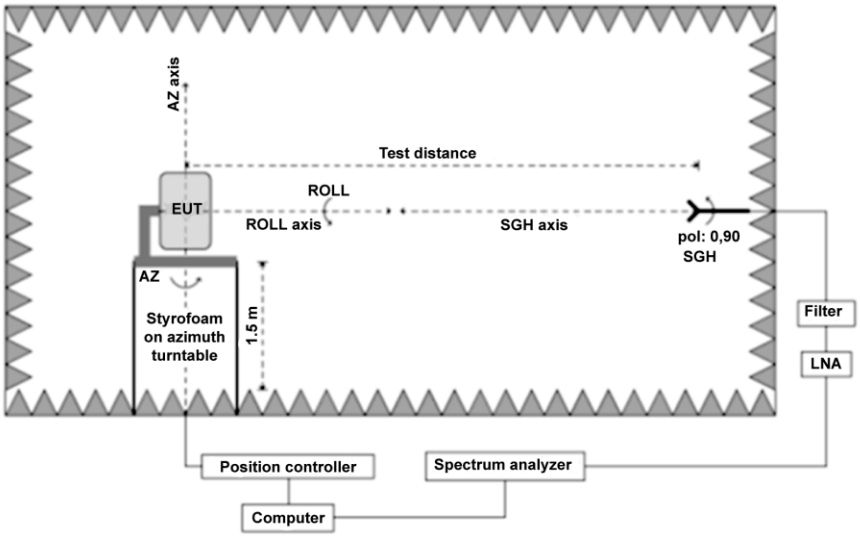


Spurious Emission (above 50GHz) for millimeter-wave

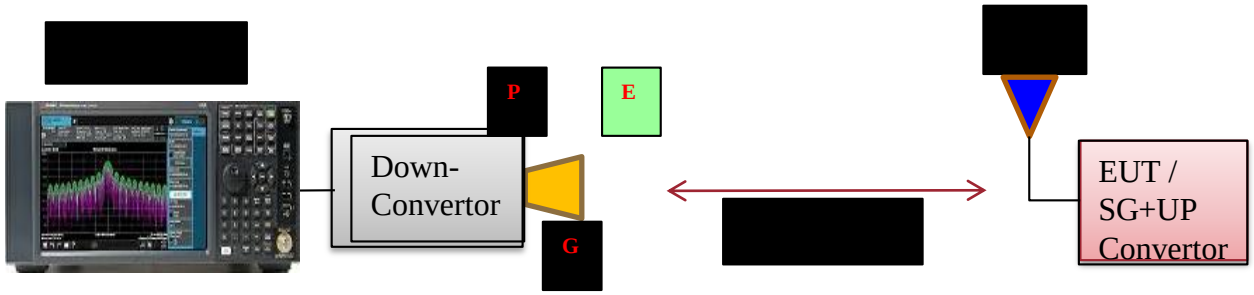
Follow to the ANSI C63.10 section 9.1.3 Test sites:

- The test site should be a fully anechoic chamber.
- Test object is on a positioner at a height of 1.5m.
- The measurement antenna is placed at a height of 1.5m.
- Far-field test distance:

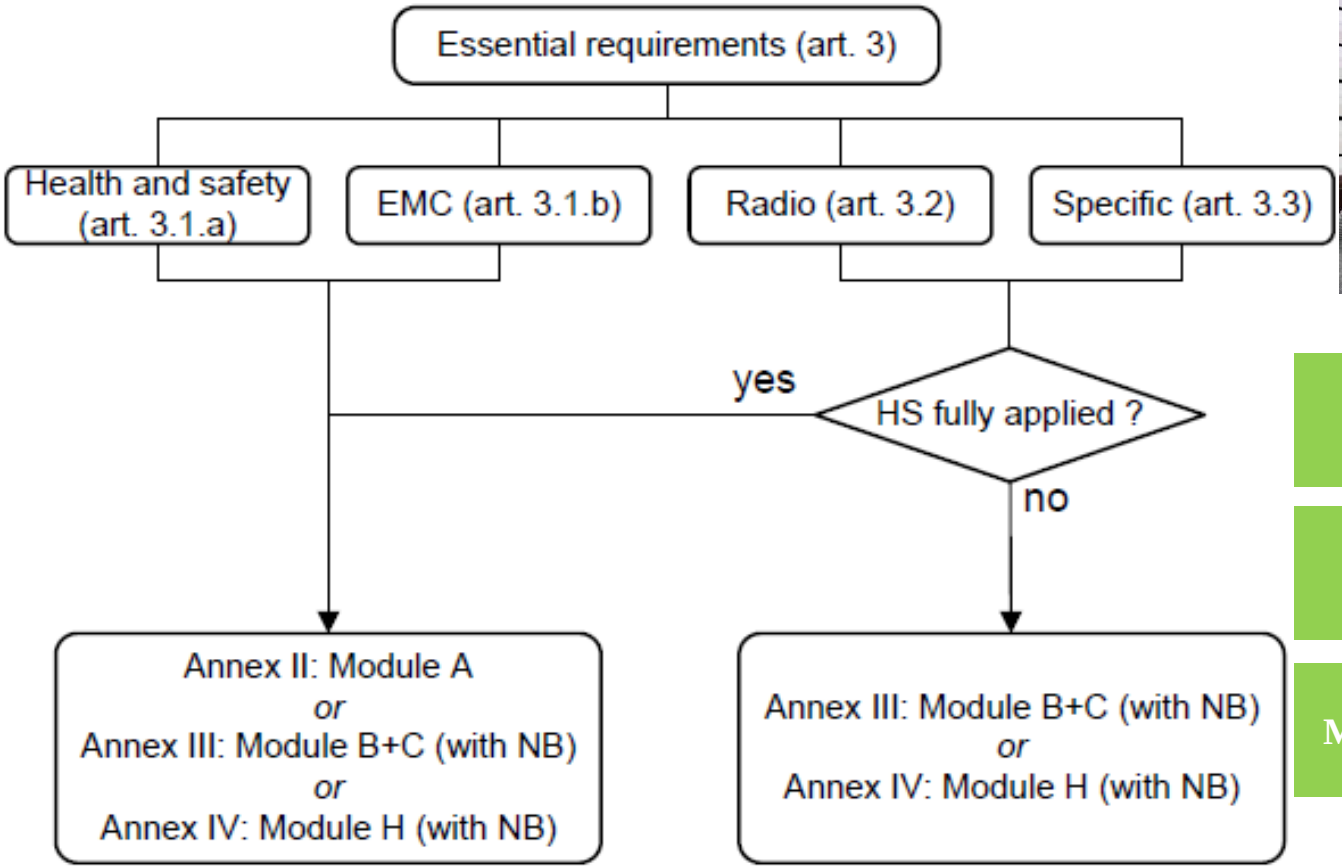
$$R > \frac{2D^2}{\lambda}$$

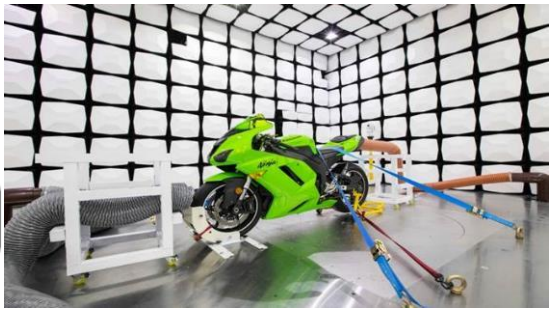


For fundamental or out-of-band emissions the far-field boundary distance of the EUT antenna or measurement antenna.



CE RED – Conformity Assessment Procedures



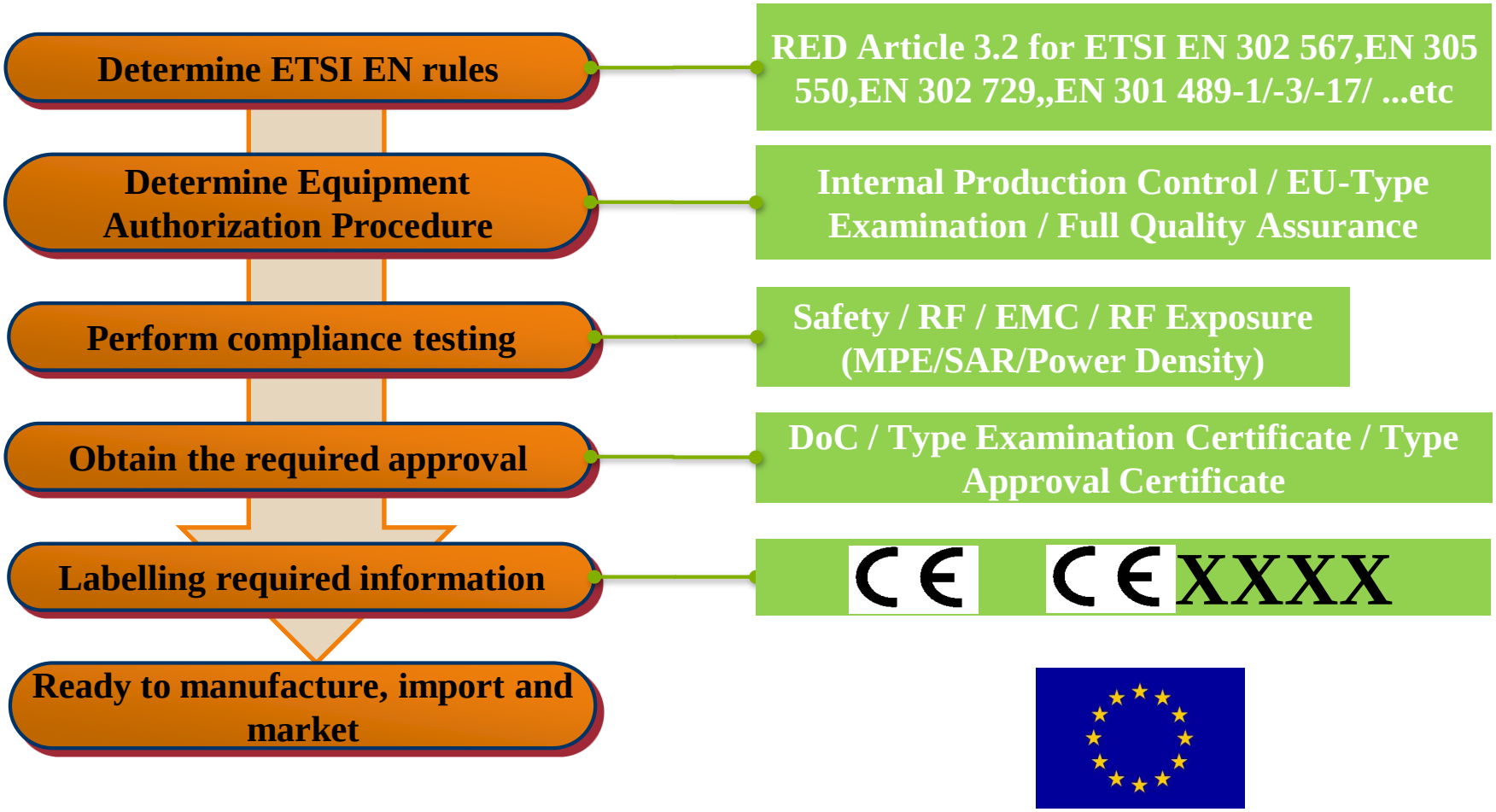


Module A: Internal Production Control

Module B+C: EU-Type Examination

Module H: Full Quality Assurance

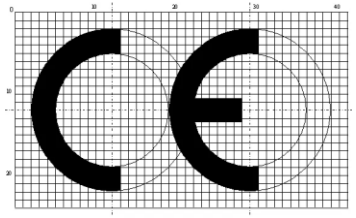
CE RED Certification Guide for 2014/53/EU



60GHz / 77GHz Regulatory standards-ETSI

RF (3.2 of 2014/53/EU)	Role & Activities	EMC (3.1b of 2014/53/EU)	Safety (3.1a of 2014/53/EU)	Note
EN 302 567	Multiple-Gigabit/s radio equipment operating in the 60 GHz band	EN 301 489-1/-17	LVD (2014.35.EU)	57-71GHz
EN 301 091 -1	Equipment for automotive applications	EN 301 489-1/-3	LVD (2014.35.EU)	76-77GHz
EN 301 091 -2	Fixed infrastructure radar equipment	EN 301 489-1/-3	LVD (2014.35.EU)	76-77GHz
EN 301 091 -3	Railway/Road Crossings obstacle detection system applications	EN 301 489-1/-3	LVD (2014.35.EU)	76-77GHz
EN 302 264-1/-2	TTT, RTTT; Short Range Radar equipment operating in the 77 GHz to 81 GHz band	EN 301 489-1/-3	LVD (2014.35.EU)	77-81GHz
EN 303 360	Obstacle Detection Radars for Use on Manned Rotorcraft	EN 301 489-1/-51	LVD (2014.35.EU)	76-77GHz

- **TTT: Transport and Traffic Telematics,**
- **RTTT: Road Transport and Traffic Telematics**



60GHz Regulatory standards – CE

Follow to ETSI EN 302 567

Test Items	Limit
Spectral power density	23 dB/MHz
RF Output power (EIRP)	40 dBm
Transmitter unwanted emissions in the spurious domain	Up to 142GHz
Receiver unwanted emissions	-57 dBm (30 MHz to 1GHz)/-47dBm (up to 142 GHz)
Adaptivity (medium access protocol)	See next slide
Short Control Signalling Transmissions (SCST)	within an observation period of 100 ms; SCST shall be less than 10 ms within said observation period.
Receiver Adjacent Channel Rejection	See slide 17
Transmitter unwanted emissions in the out-of-band domain	See next slide
Occupied Channel Bandwidth	99% OBW less than the declared nominal Channel Bandwidth
Receiver Sensitivity level	- 50 dBm + 1,5 × 10 log10 (Pmax / Pout) (Pmax and Pout in W EIRP)

EN 302 567 test limits

Table 4: Transmitter spurious emissions

Frequency range	Emission Limit ERP (≤ 1 GHz) EIRP (> 1 GHz)	Measurement Bandwidth
30 MHz ≤ f < 87,5 MHz	-36 dBm	100 kHz
87,5 MHz ≤ f ≤ 118 MHz	-54 dBm	100 kHz
118 MHz < f < 174 MHz	-36 dBm	100 kHz
174 MHz ≤ f ≤ 230 MHz	-54 dBm	100 kHz
230 MHz < f < 470 MHz	-36 dBm	100 kHz
470 MHz ≤ f ≤ 694 MHz	-54 dBm	100 kHz
694 MHz < f ≤ 1 GHz	-36 dBm	100 kHz
1 GHz < f < Fl GHz	-30 dBm	1 MHz
Fh GHz < f < 142 GHz	-30 dBm	1 MHz
NOTE: Information in this table is based on ERC Recommendation 74-01 [i.10].		

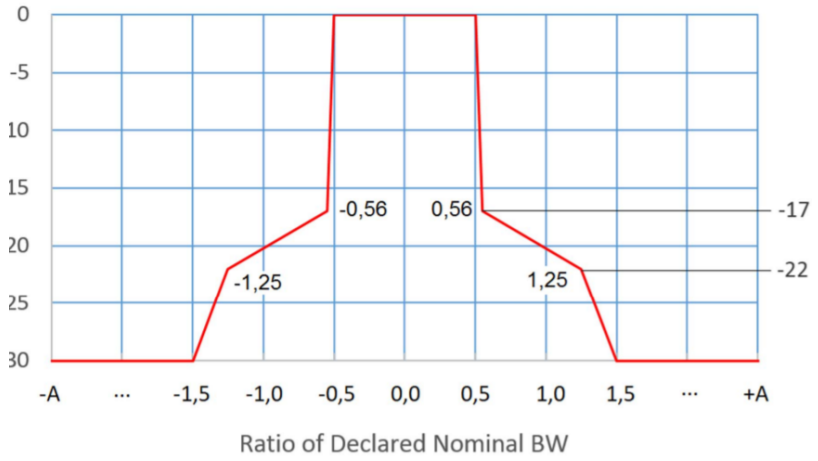


Figure 1: Transmit Mask

Transmitter unwanted emissions in the out-of-band domain

Table 5: Receiver spurious emissions

Frequency band	Emission Limit ERP (≤ 1 GHz) EIRP (> 1 GHz)	Measurement Bandwidth
30 MHz ≤ f ≤ 1 GHz	-57 dBm	100 kHz
1 GHz < f ≤ 142 GHz	-47 dBm	1 MHz
NOTE: Information in this table is based on ERC Recommendation 74-01 [i.10].		

EN 302 567-Adaptivity/ Receiver Adjacent Channel Rejection

Test items	Limits
Maximum Channel Occupancy Time (COT)	<5ms
Idle Period	>8us
Energy detection threshold for the CCA	-80 dBm + 10 × log10 (Operating Channel Bandwidth (in MHz)) + 10 × log10 (Pmax / Pout) (Pmax and Pout in W EIRP)
Short Control Signaling Transmission (SCST)	10 ms

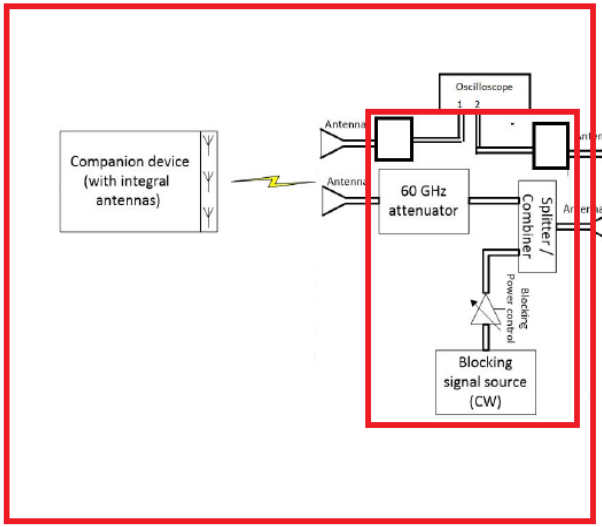
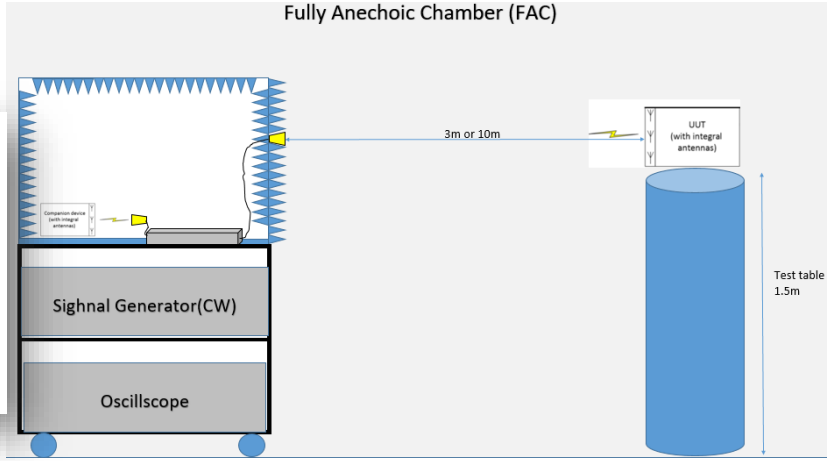


Table 6: Receiver Adjacent Channel Rejection level

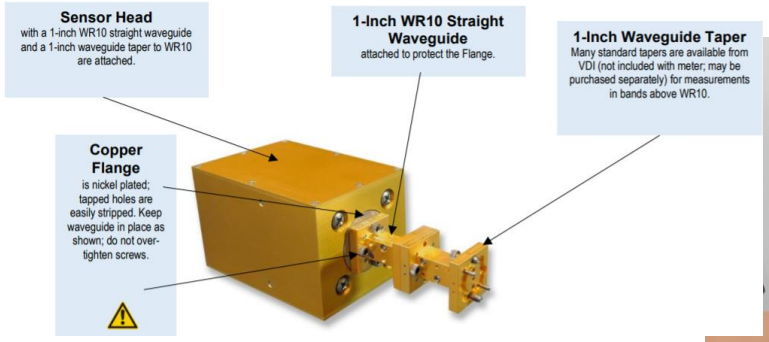
Wanted signal mean power from companion device (dBm) at the input of UUT	Unwanted signal frequency (GHz)	Unwanted signal power (dBm) at the input of UUT	Type of unwanted signal
P_{min} + 6 dB	Operating Channel Centre Frequency - Nominal Channel BW	min(-65, P_{min} + 8 dB)	CW
P_{min} + 6 dB	Operating Channel Centre Frequency + Nominal Channel BW	min(-65, P_{min} + 8 dB)	CW

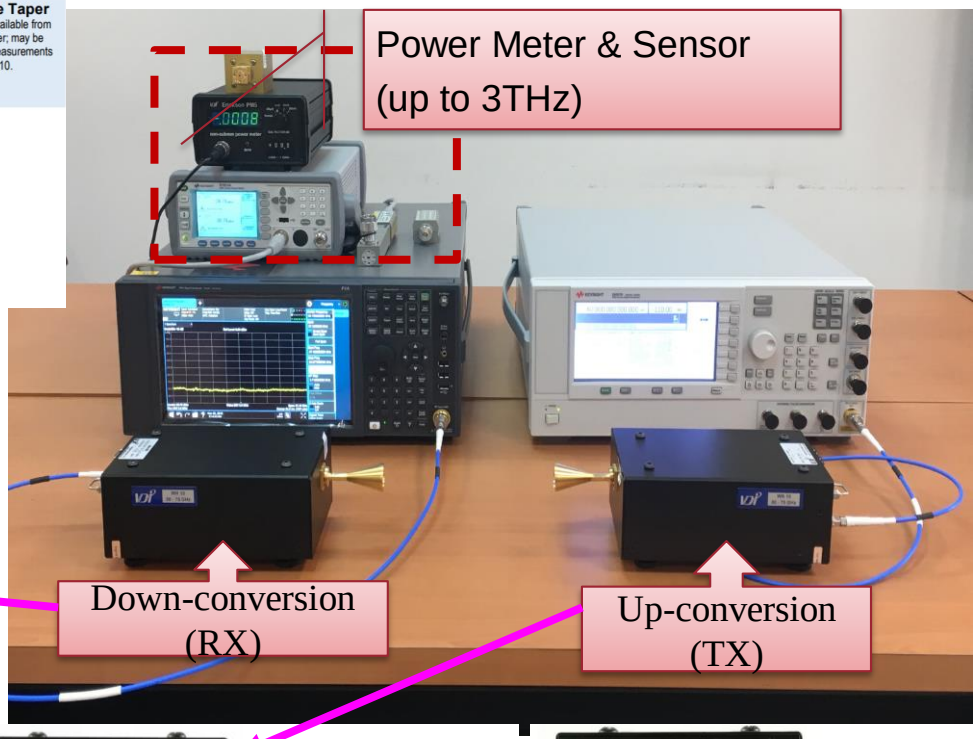


mmWave Measurement Instruments

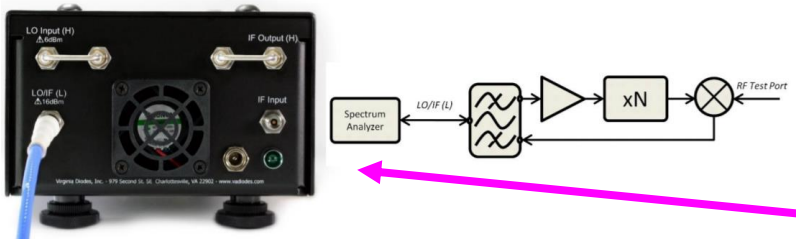
Measurement Instrument Configuration

Sensor Head, Waveguide and Taper

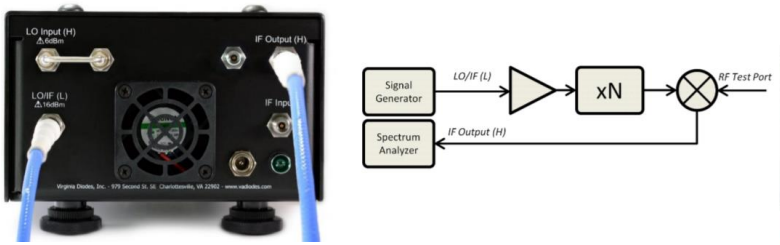


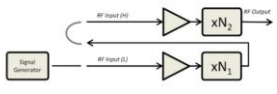


CONFIGURATION A: Spectrum Analyzer Extension



CONFIGURATION B: Block Down-Conversion (Low Frequency LO Input)





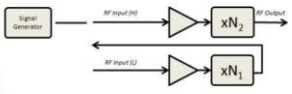
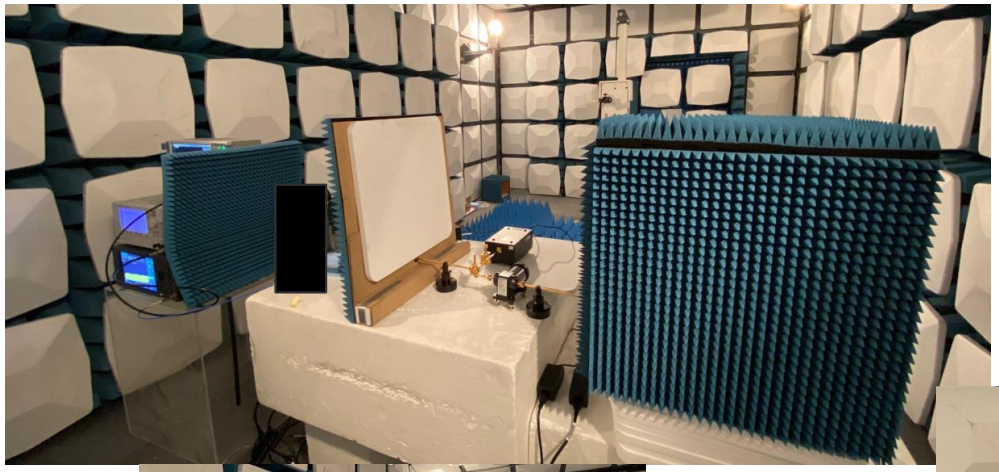


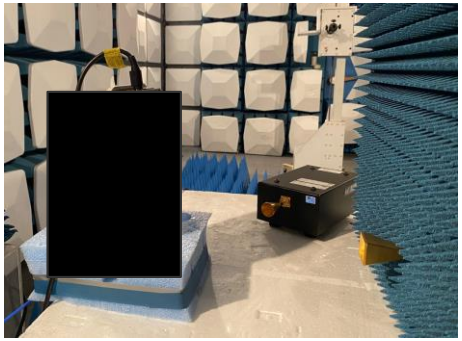
Figure 1: Low Frequency Operation
Proper configuration details for Low Frequency operation are shown. A coaxial jumper connection must be used for Low Frequency operation. N_1N_2 is the multiplication factor this configuration.

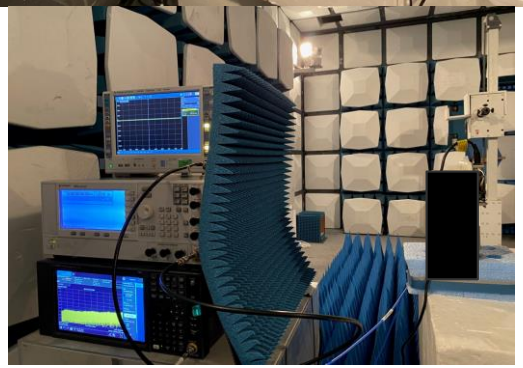
Figure 2: High Frequency Operation
Proper configuration details for High Frequency operation are shown. Coaxial jumper must be removed for High Frequency operation. N_2 is the multiplication factor for this configuration.

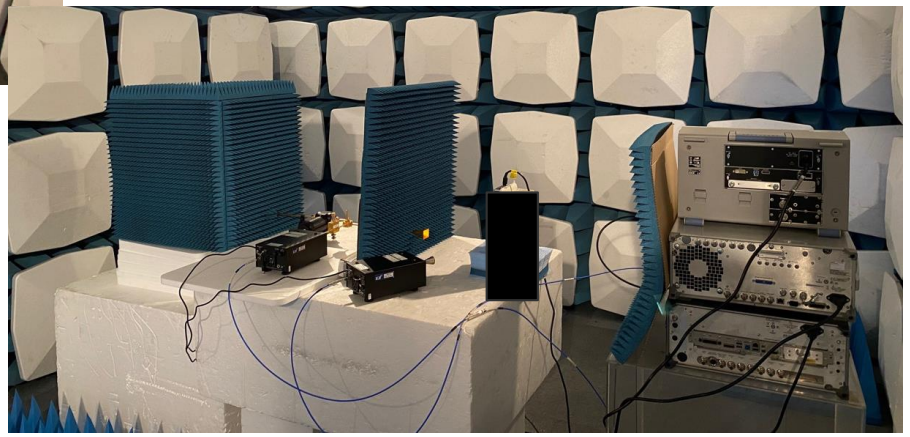
Receiver Interference Check

Adaptivity / Receiver Adjacent Channel Rejection
Setup in Chamber



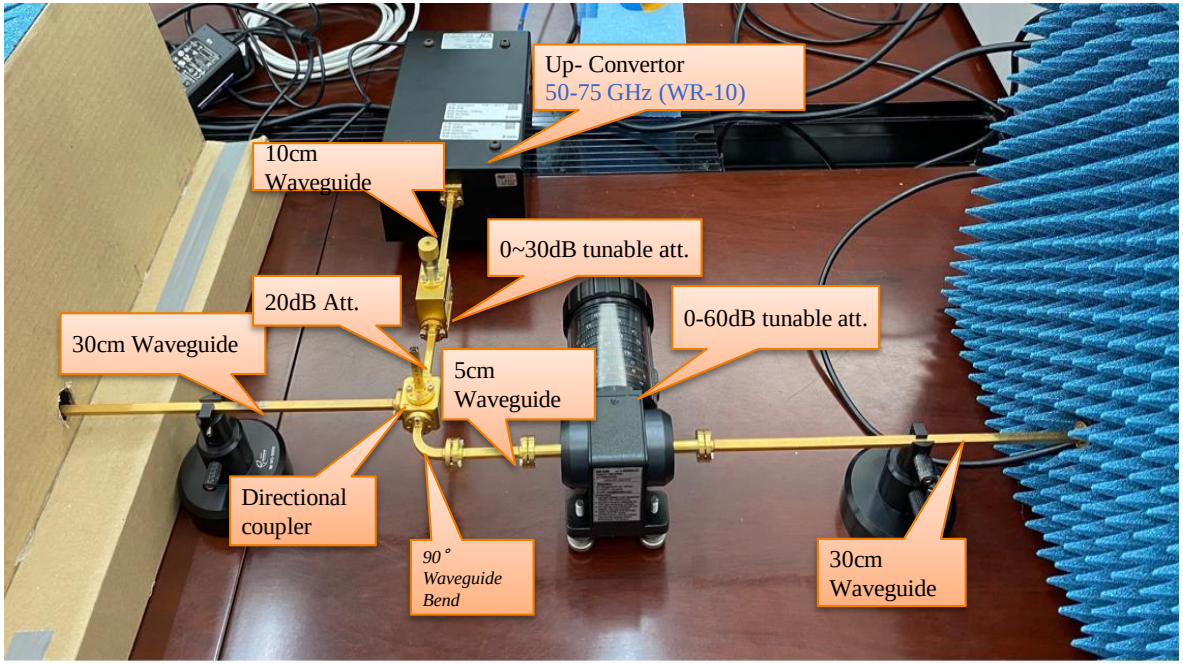


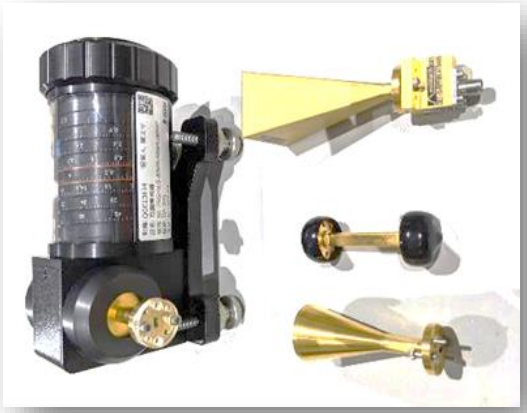




Radiated Measurement Configuration

Setup photo – Configuration and Components





Radiated Measurement – mmWave facility in DEKRA

To cover UWB, 60GHz and Radar Measurement up to 325 GHz.

DEKRA

THANK YOU FOR TAKING CARE OF SAFETY!