



ABSTRACT

This application note covers the requirements for compliance to regulatory standards for mmWave radar devices. Radio Equipment Directive (RED), a standard for equipment sold in Europe and Federal Communications Commission (FCC), the standard for the United States is reviewed in detail. The tools provided by TI for these tests, common issues, and resolutions to these issues are also covered.

The radar portfolio consists of 60GHz and 77GHz devices, however this document broadly focuses on the 60GHz devices. The information applies to both the antenna on PCB and Antenna on Package (AOP) variants of the 60GHz devices.

Note

All test reports and supporting documents can be found in the certification package on the [TIREX](#) page.

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1 Introduction

Note

This document is intended solely as an introductory guide to certifying equipment containing the TI mmWave Radar device. It is not an exhaustive reference and should not be considered a replacement for the standards put forward by the regulatory body. Consult your test house or regulatory body for your certification needs and requirements.

Products that emit intentional and non-intentional radiation are sold around the world; these products must adhere to regulatory compliance standards that apply to the regions in which they operate:

- FCC – US
- CE/RED – Europe
- TELEC / MIC – Japan
- ISED – Canada
- KCC / MSIP – Korea
- SRRC / CCC – China

All test reports and supporting documents can be found in the certification package on the [TIREX](#) page.

	57Ghz	85GHz
USA FCC	57-71GHz- Short range devices for "Interactive motion Sensing" (e.g. Google Soli), Fixed installations at low power 61- 61.5GHz - Fixed installations at high power See FCC section for more details	75- 85GHz -Level probing radar (downward facing,narrow beam) 76 - 81GHz -Vehicular Radar, Airplane-Installed wing tip radar 76- 77GHz - FOD at airports, Fixed Infrastructure
Europe CE / RE D	57- 64GHz – Open, restrictions on output power Level Probing Radar, Tank level probing radar 61- 65GHz - Open, Reduced restrictions on output power See RED section for more details	75- 85Ghz - Level Probing Radar, Tank Level Probing Radar 76-77Ghz - Vehicular Radar, Fixed Traffic Monitoring, Rail road crossings, Manned Rotorcraft 77- 81Ghz - Vehicular Radar
China SRRC / CCC	59- 64GHz - Open for radiolocation * 61- 61.5GHz - Open according to ISM rules	76-77GHz - Vehicular Radar
Korea KCC / MSIP	57-66GHz - Open, but low output power (Rule Code : K176C) 61-61.5Ghz - No Regulations so far, possibly open according to ISM rules	75-85GHz - Armature Satellite, Space Research, Radio astronomy, Astronomy Research, Geostationary Orbit Satellite 76-77GHz - ADAS Automotive Radar (Rule Code:K37G)
Japan MIC / TELEC	60 -61GHz - Low power equipment millimeter wave radar 57 - 66GHz - Millimeter wave image transmission and millimeter-wave data transmission	76 - 77GHz - Open 77-81GHz - Open, Possibly for Vehicular Radar

* Certification on this band is on hold at the time of writing.

Figure 1-1. Regions, Applications, and Operating Frequencies

The roles of these regulatory bodies are to ensure various devices can co-operate, equipment under tests (EUT) can handle the interference from other devices without irrecoverable loss of function, in-band and out of band power is within specified limits, spurious emissions is at acceptable levels, RF exposure are at safe levels etc.

This document briefly covers some of the tests done and tools provided by TI to setup and run the test on the TI mmWave short range radar. RED and FCC compliance tests are discussed in some detail; however, similar tools and information apply to other regulatory tests.

2 Typical Certification Procedure

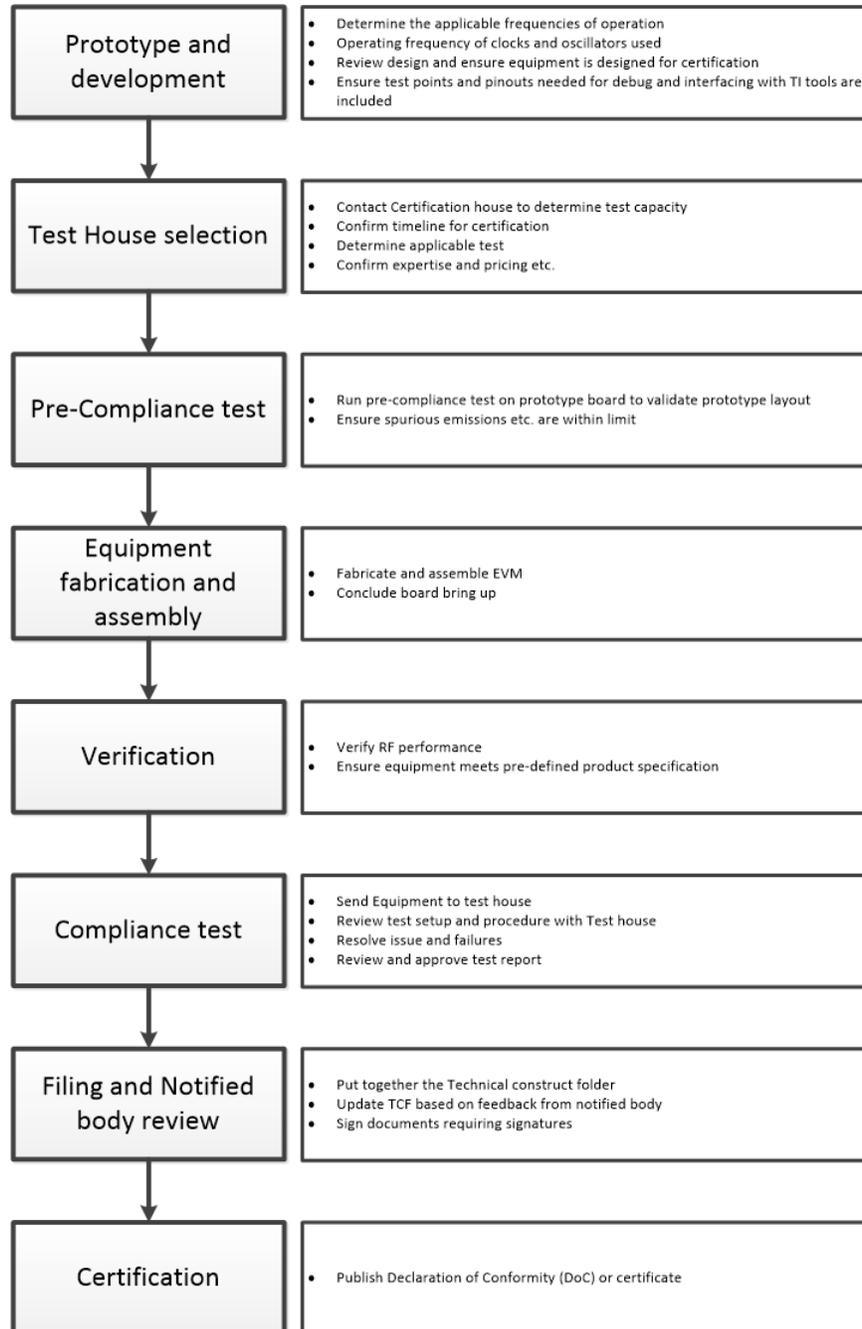


Figure 2-1. Typical process of building and certifying an equipment.

As shown in [Figure 2-1](#), beginning with the prototype and development phase, equipment must be designed with certification in mind to catch and avoid preventable issues later in the product life cycle.

3 Regulatory Compliance Overview

3.1 European Union Regulations - Radio Equipment directive (RED)

The DIRECTIVE 2014/53/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 April 2014 on the harmonization of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC. Article 3 Essential requirements can be found [here](#).

In accordance with the essential requirement for Radio and electrical equipment sold in the EU, the following harmonized standards apply to the 60-GHz radar equipment

- EN 62311. Safety, RF exposure - Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz – 300 GHz). This Standard covers the essential requirements of article 3.1(a) of Directive 2014/53/EU
- EN 62368-1. Audio/video, information and communication technology equipment - Part 1: Safety requirements, Electrical safety; This also covers the essential requirements of article 3.1(a) of Directive 2014/53/EU
- EN 301 489-3. ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements. This harmonized standard covers the essential requirements of article 3.1(b) of Directive 2014/53/EU and the essential requirements of article 6 of Directive 2014/30/EU.
- EN 305 550. Short Range Devices (SRD) Radio equipment to be used in the 40 GHz to 246 GHz frequency range; Harmonized Standard for access to radio spectrum. This covers the essential requirements of article 3.2 of Directive 2014/53/EU.

3.1.1 Efficient Use of the Radio Spectrum (EN 305 550)

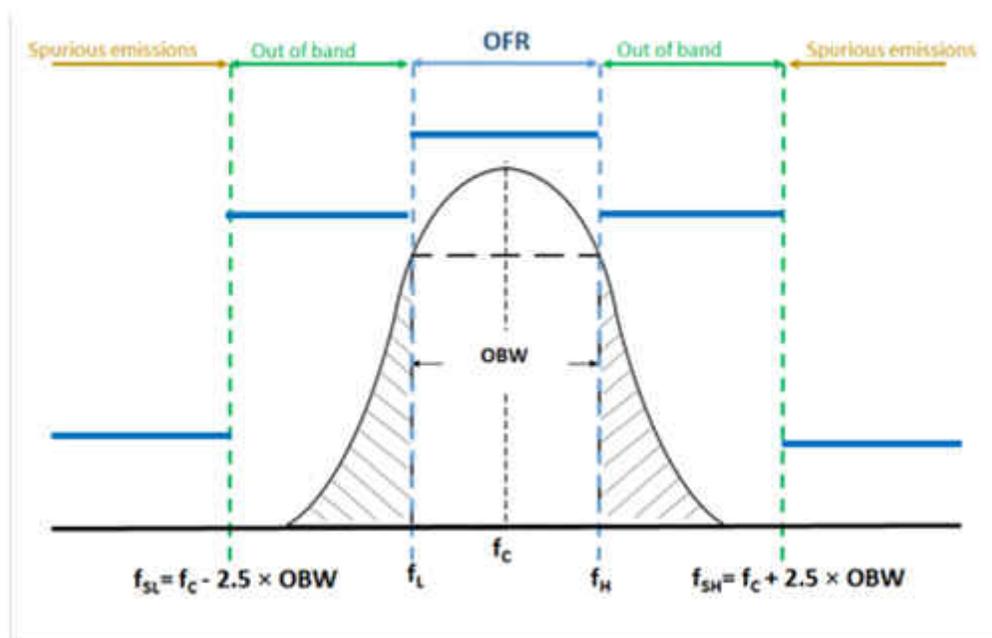


Figure 3-1. OFR, Out of Band and Spurious Emission Frequency Limit

The following limits and tests apply:

- Duty Cycle: The duty cycle is factored into mean power measurement when using a power meter; see section on duty cycle [Section 3.3.1](#).
- Permitted range of operating frequencies: See section 4.3.1 of EN 305 550 V2.1.0 (section 7.3 EN 305 550-1 V1.2.1). This is the authorized frequency range devices are permitted to operate.
- Operating frequency range (OFR): See section 4.3.2 of EN 305 550 V2.1.0 . This is the intentional operating frequency range of the device. The IWR6843 mmWave device falls in the 57 to 64 GHz band and can also be operated in the 61.0 GHz to 61.5 GHz bandwidth. The occupied bandwidth (OBW) is measured as the bandwidth occupying 99% of the total power in the operating frequency range.

Table 3-1. Operating Frequency Range

Bandwidth (GHz)	FL (GHz)	FH (GHz)
57 - 64	> 57	< 64
61.0 – 61.5	> 61	< 61.5
122 - 123	> 122	< 123
244 - 246	> 244	< 246

- Mean Power: See section 4.3.3 of EN 305 550 V2.1.0 (section 7.2 EN 305 550-1 V1.2.1) . Mean power is a measure of radiated power or mean equivalent isotropic Radiated power (EIRP); it refers to the highest transmitted power level during the transmission cycle. The limit for 57 to 64 GHz is 100 mW EIRP (20 dBm EIRP), same limit applies to 61.0 GHz to 61.5 GHz. When taking measurement using a signal analyzer the channel power function is used:

$$20dBm \text{ EIRP} = 115.23 \text{ dBuV/m @ } 3m \quad (1)$$

- Mean Power spectral density: See section 4.3.4 of EN 305 550 V2.1.0 (section 7.1 EN 305 550-1 V1.2.1). This is defined as the emitted power spectral density over the transmission bandwidth in the direction of maximum antenna gain. Limit for 57 GHz to 64 GHz is 13 dBm/MHz EIRP. No limit is defined for 61.0 GHz to 61.5 GHz.
- Out of band (OOB) emissions: See section 4.3.5 of EN 305 550 V2.1.0 (section 7.4 EN 305 550-1 V1.2.1). The OOB bandwidth is calculated as in [Equation 2](#).

$$F_{sl} = f_c - 2.5 \times OBW \quad (2)$$

$$F_{sh} = f_c + 2.5 \times OBW \quad (3)$$

[Table 3-2](#) shows the limits and bandwidth for out of band and spurious emissions for the mmWave device operating at both the full 4-GHz bandwidth and 500-MHz bandwidth.

The occupied bandwidth (OBW) is the width of the intentional signal mean power containing 99% of the total mean power, power below and above this limit (the out of band emission) should be equal to 0.5% of the mean power. This equates to -23dBc bandwidth of the signal.

Table 3-2. Out of Band and Spurious Emissions Bandwidth

OBW/OFR	Permitted operating frequency range	fsl	fl	fc	fh	fsh	OOB limit
4 GHz	57 GHz to 64 GHz	52	60	62	64	72	-20 dBm/Mhz
500 MHz(similar limits to 4 Ghz applies if operating outside of the 61 to 6.15 range)	61.0 GHz to 61.5 GHz	60	61	61.25	61.5	62.5	-10 dBm/Mhz

- Radiated spurious emissions: See section 4.3.6 of EN 305 550 V2.1.0 (section 7.5 EN 305 550-1 V1.2.1). The spurious emission frequency range includes frequency beyond the OOB limit. The spurious emission is measured up to the 2nd harmonic of the fundamental frequency; the IWR6843 operates from 60-64 GHz, with second harmonic at 128 GHz.
- Receiver spurious: See section 4.4.2 of EN 305 550 V2.1.0 (section 8 EN 305 550-1 V1.2.1). Per clause 4.4.2.1 the receiver spurious is only applicable when the equipment can work in receive-only mode. The test does not apply to mmWave devices as it operate in simultaneous transmit/receive mode.
- Receiver interference signal handling: See section 4.4.3 of EN 305 550 V2.1.0. This measures the capability of the device to coexist with other radio applications transmitting within the in-band, OOB, and remote band frequency limit. The interference source should transmit at 10-dBm equivalent EIRP for in band frequency and 20-dBm equivalent EIRP for OOB and remote band frequency.

$$\text{In band frequency} = \text{center frequency} (f_c) \tag{4}$$

$$O O B = F_c \pm O B W \tag{5}$$

$$\text{Remote band} = F_c \pm 10 \times O B W \tag{6}$$

3.1.2 RF Exposure Limit - EN 62311

This limit is set to prevent adverse effect on body tissue or body surface due to RF exposure.

Table 3-3. Frequency Range

Frequency Range	Equivalent plane wave power density (W/m ²)
2 – 300 GHz	10

$$\text{Power density} = \frac{\text{MeanPower}(WEIRP)}{4\pi R^2} \tag{7}$$

where

- R – Minimum separation distance

3.1.3 Electrical Safety - EN 62368

This standard covers safety of various equipment including audio/video, information and communication technology, and business and office machines rated for voltages below 600 V. The safety standard and safeguards are to prevent and reduce the chances of pain, injury, fire, and property damage caused by fire outbreaks as a result of equipment use. More on this can be found [here](#).

3.1.4 ElectroMagnetic Compatibility (EMC) - EN 301 489-1

The following criteria applies for the test per the standard for EMC emissions and immunity.

Table 3-4. EMC Emissions and Immunity Performance Criteria

Criterion	During Test	After Test
A	Operate as intended. No loss of function. No unintentional responses	Operate as intended. No loss of function. No degradation of performance. No loss of stored data or user programmable functions.
B	May show loss of function. No unintentional responses	Operate as intended. Lost functions shall be self-recoverable. No degradation of performance. No loss of stored data or user programmable functions.

The following clauses under EN 301 489-1 are applicable to the TI IWR6843 / MMWAVEICBOOST Evaluation Module combo, since the equipment required DC power and is not a telecommunication equipment some of the tests do not apply. Users must determine which test is applicable to their end equipment.

Table 3-5. Clause 8 of EN 301 489-1 – Methods of Measurement and Limits for EMC Emissions Results

Environmental phenomenon		Verdict
Enclosure of ancillary equipment measured on a standalone basis – Clause 8.2	Ancillary equipment Class B limits given in EN 55032	Pass
Ancillary equipment Radiated disturbance above 1 GHz at a measurement distance of 3 m		Pass
Ancillary equipment intended to be used in telecommunication centers only Class A limits given in EN 55032		Not applicable
Ancillary equipment intended to be used in telecommunication centers only Radiated disturbance above 1 GHz at a measurement distance of 3 m		Not applicable
DC power input/output ports – Clause 8.3	Class B limits according to EN 55032	Pass
Equipment intended to be used in telecommunication centers only		Not applicable
AC mains power input/output ports – Clause 8.4	Class B limits given in EN 55032	Not applicable
Equipment intended to be used in telecommunication centers only Class A limits given in EN 55032		Not applicable

Table 3-5. Clause 8 of EN 301 489-1 – Methods of Measurement and Limits for EMC Emissions Results (continued)

Environmental phenomenon		Verdict
Harmonic current emissions (AC mains input port)– Clause 8.5	The appropriate requirements of EN 61000-3-2/A1 for harmonic current emission apply for equipment with an input current up to and including 16 A per phase. For equipment with an input current of greater than 16 A per phase EN 61000-3-12 applies.	Not applicable
Voltage fluctuations and flicker (AC mains input port) – Clause 8.6	The appropriate requirements of EN 61000-3-3 for voltage fluctuations and flicker apply for equipment with an input current up to and including 16 A per phase. For equipment with an input current of greater than 16 A per phase EN 61000-3-11 [13] applies.	Not applicable
Telecommunication ports – Clause 8.7	Class B limits given in EN 55032	Not applicable
Equipment intended to be used in telecommunication centers only	Class A limits given in EN 55032	Not applicable

Table 3-6. Clause 9 of EN 301 489-1 Test Methods and Levels for Immunity Tests Results

Environmental phenomenon	Test port	Basic standard	Verdict
Radio frequency electromagnetic field (80 MHz to 1000 MHz and 1000 MHz to 6000 MHz) – Clause 9.2	Enclosure	EN 61000-4-3	Pass
Electrostatic discharge ¹ – Clause 9.3	Enclosure	EN 61000-4-2	Pass
Fast transients, Common mode– Clause 9.4	AC mains power port	EN 61000-4-4	Not applicable
Signal ports, telecommunication ports, control ports		Not applicable	
DC power ports		Pass	
Radio frequency, common mode (0.15 MHz to 80 MHz) – Clause 9.5	AC mains power port	EN 61000-4-6	Not applicable
Signal ports, telecommunication ports, control ports		Not applicable	
DC power ports		Pass	
Transients and surges – Clause 9.6	12 V and 24 V DC supply voltage input ports of mobile radio and ancillary equipment, which are also intended for mobile use in vehicles.	ISO 7637-2	Not applicable
Voltage dips and interruptions – Clause 9.7	AC mains power port	EN 61000-4-11	Not applicable
Surges line to line and line to ground – Clause 9.8	AC mains power port	EN 61000-4-5	Not applicable
Telecommunication ports		Not applicable	

3.2 Federal Communications Commission (FCC)

The mmWave devices in the mmWave Radar portfolios are capable of transmitting and receiving FMCW signals in either the 60-GHz to 64-GHz band or the 76GHz to 81GHz frequency band. Based on the device operation the devices are considered intentional radiators. Operation within the band 57-71 GHz is covered under FCC 15.255 for most industrial use cases. 76GHz to 81GHz is for automotive use cases covered under FCC part 95, as stated in FCC 95.3331 permissible uses cases under this band includes vehicular radars, fixed or mobile radars in airport air operations areas but does not include aircraft mounted radars or FOD detection radars.

Level sensing customers need to also use the 76GHz to 81GHz frequency band devices, however for level sensing the applicable FCC standard can be found in FCC 15.256.

The summary of the standards applicable to the fixed field disturbance sensor or short range interactive motion sensing use cases are discussed in following sections.

3.2.1 End Equipment and FCC Clause

[Table 3-7](#) Shows key end equipment categories, the allowed frequency band and the applicable FCC clauses based on interpretation of the standard.

Table below shows understanding at the time of writing and may not be up to date. Recommendation is to confirm the specifics of your use case with FCC

Table 3-7. End Equipments

End Equipment	Frequency Band	FCC clause
Area scanner for Zone occupancy	60GHz	FCC 15.255 - fixed field disturbance sensors
Automated Doors and Gates	60GHz	FCC 15.255 - fixed field disturbance sensors
Gesture Recognition	60GHz	FCC 15.255 - short-range devices for interactive motion sensing
High accuracy level sensing	77GHz	FCC 15.256 – level probing radars
Long range people detection	60Ghz	FCC 15.255 - fixed field disturbance sensors
People Counting	60Ghz	FCC 15.255 - fixed field disturbance sensors
Robotics	77GHz	FCC Part 95 (if robot is used to move people or goods)
Traffic Monitoring	60GHz	FCC 15.255 - fixed field disturbance sensors
Vital signs	60GHz	FCC 15.255 - fixed field disturbance sensors
Automotive InCabin Sensing	60GHz	FCC 15.255 - fixed field disturbance sensors (if car is stopped)
Automotive Sensing	77GHz	FCC Part 95

3.2.2 Fundamental Emmission levels

Limit for Fundamental emission for most of the mmwave radar 60-GHz to 64-GHz devices are covered under 15.255.C2 and 15.255.C3

Frequency Band (Ghz)	Average Radiated TX Power	Peak Radiated TX power	Peak Conducted TX power
61-61.5	40 dBm	43dBm	No specified limit
57-71	No Specified limit	10dBm	-10dBm

1. For fixed field disturbance sensors operating in the 61.0 -61.5Ghz band emissions outside this bandwidth but within the 57-71GHz must not exceed average power of 10dBm and peak power of 13dBm.
2. Intentional uses cases outside the 61.0 -61.5Ghz band must meet the 57-71Ghz band, not the additional limits for out-of-band 61.0 -61.5Ghz use cases.

3.2.3 Spurious Emission

Spurious emissions is covered under FCC 15.255D. Below the 40 Ghz, spurious emmission should meet the limit in the table below, For more details see FCC 15.209.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
Above 960	500	3

Between 40GHz and 200Ghz spurious emmissions should not exceed 90 pW/cm2 at a distance of 3 meters. In general the spurious emission should not exceed the level of the fundamental emission.

3.2.4 Frequency Stability

The frequency stability limits are set under 15.255F. The fundamental emission must stay within the allowed bands over temperature and input voltage variation

Allowed band	Temperature range	Input Voltage Variation
61-61.5Ghz	-20C to + 50C	85% to 115%
57 -71Ghz	-20C to + 50C	85% to 115%

3.2.5 Radiation Exposure Requirement

There are various sections of the FCC standard applicable to radiation exposure and compliance to all is mandated depending on the use cases.

1. [1.1307\(b\)](#) - Actions that may have a significant environmental effect, for which Environmental Assessments (EAs) must be prepared.
2. [1.1310](#) - Radiofrequency radiation exposure limits.
3. [2.1091](#) - Radiofrequency radiation exposure evaluation: mobile devices.
4. [2.1093](#) - Radiofrequency radiation exposure evaluation: portable devices.

3.2.6 FCC Waiver and Other Relevant Information

FCC has granted waivers for some applications under specific use cases and conditions, these waivers allow usage outside current interpretations of the FCC standards. An example of a request for waiver for part 15 that was approved under short range interactive motion sensing devices can be found [here](#).

Customers interested in applying for waivers need to begin the process in the early stages of the product design as the turnaround time for waiver process is undefined

3.3 Applicable Terms and Equations

3.3.1 Duty Cycle Factor

The duty cycle factor is calculated as the duty cycle across bursts multiplied by the duty cycle within each burst.

$$Duty\ Cycle\ Factor\ (dB) = 10\log\left(\frac{1}{X}\right) \quad (8)$$

Where X = Duty Cycle

Table 3-8. Duty Cycle Correction Calculated Using Duty Cycle Within and Between Bursts

BW Mode	On Time	Period	Duty Cycle	On time	Period	Duty cycle	Duty cycle Linear	Duty Cycle	Duty cycle correction
	Between Burst			Within Burst			Total		
1300	4.29	16.06	0.267	29.66	33.33	0.890	0.24	23.76	6.24

3.3.2 Effective Isotropic Radiated Power (EIRP)

EIRP is defined as the sum of the transmitted power and antenna gain, when these two parameters are known the EIRP can be calculated as in [Equation 9](#). It indicates the maximum radiated power at the peak angle of a non-isotropic antenna.

$$EIRP = P_t - L_c + G_a \quad (9)$$

where

- P_t is the TX power
- L_c is Cable or routing loss
- G_a is the antenna gain

3.3.3 Friis Equation

For the test setup a power meter is used to measure received power (P_R), the gain of the receiving antenna (G_R) is known, operating frequency and the distance of the receiving antenna to the EUT is measured. The unknown transmit power of the EUT TX chain is calculated using Friis equation, as in [Equation 10](#).

$$EIRP(Friis) = P_T \times G_T = \frac{P_R}{G_R} \times \left(\frac{4\pi D}{\lambda}\right)^2 \quad (10)$$

where

- P_R is the measured power
- G_R is the gain of receive measurement antenna
- D is the measurement distance
- λ is the wave length

3.3.4 Far-Field Boundary

The far field boundary is given as in [Equation 11](#). As the name implies, it is the region far from the antenna. The fundamental signal is measured beyond this boundary because the electromagnetic field's characteristics, such as antenna pattern, do not change in the EUT's far field.

$$R(far - field) = \left(\frac{2 \times L^2}{\lambda}\right) \quad (11)$$

where

- L is the largest antenna dimension in meters
- λ is the wave length in meters

4 Tools and Setup

TI [MMWAVESTUDIO](#) is designed for evaluation and characterization of TI mmWave sensors. [MMWAVEVISUALIZER](#) enables the real time point cloud plot of the data output of the [mmWave software development kit \(SDK\)](#) out-of-the-box demo. Both tools allow for chirp parameter configuration needed for the tests.

4.1 Hardware Setup

For certification, test, and characterization of EUT, TI recommends adding an option to include the 60-pin SAMTEC connector compatible with MMWAVEICBOOST. The MMWAVEICBOOST carrier card enables debug, emulation, and direct interface to mmWave tools such as the MMWAVESTUDIO and mmWave visualizer through USB connectivity. Raw analog-to-digital converter (ADC) data capture can be enabled by pairing the MMWAVEICBOOST with a DCA1000EVM real-time data capture adapter. To configure the MMWAVEICBOOST, refer to the [user's guide](#).

For customers unable to include the 60-pin connector, [Figure 4-1](#) shows the essential peripherals needed to interface with mmWave studio and mmWaveVisualizer for test and certification purposes.

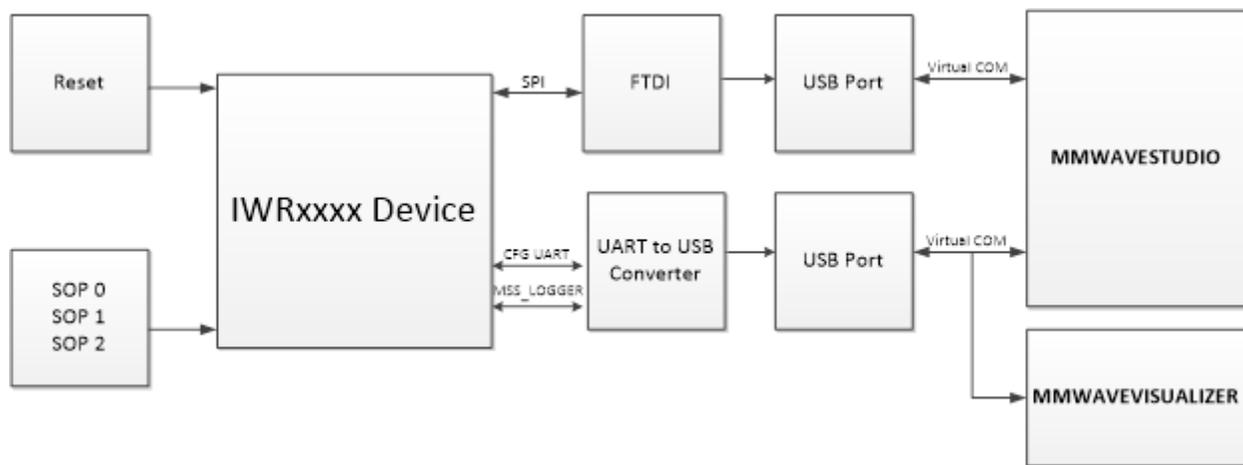


Figure 4-1. Interfacing with TI Tools

4.2 MMWAVESTUDIO

mmWave Studio provides an easy to use platform to set up and configure chirps needed for certification. Using LUA scripts some level of automation can be achieved. For more on the use of mmWave Studio, refer to the [user's guide](#).

4.2.1 Running LUA Scripts

To run the scripts, click browse, navigate to the directory containing the LUA script, select the script, and hit Run. Sample LUA scripts used for certifying the IWR6843 EVMs are included in the certification package.

The TIREX package needs to be downloaded and installed to access the LUA scripts

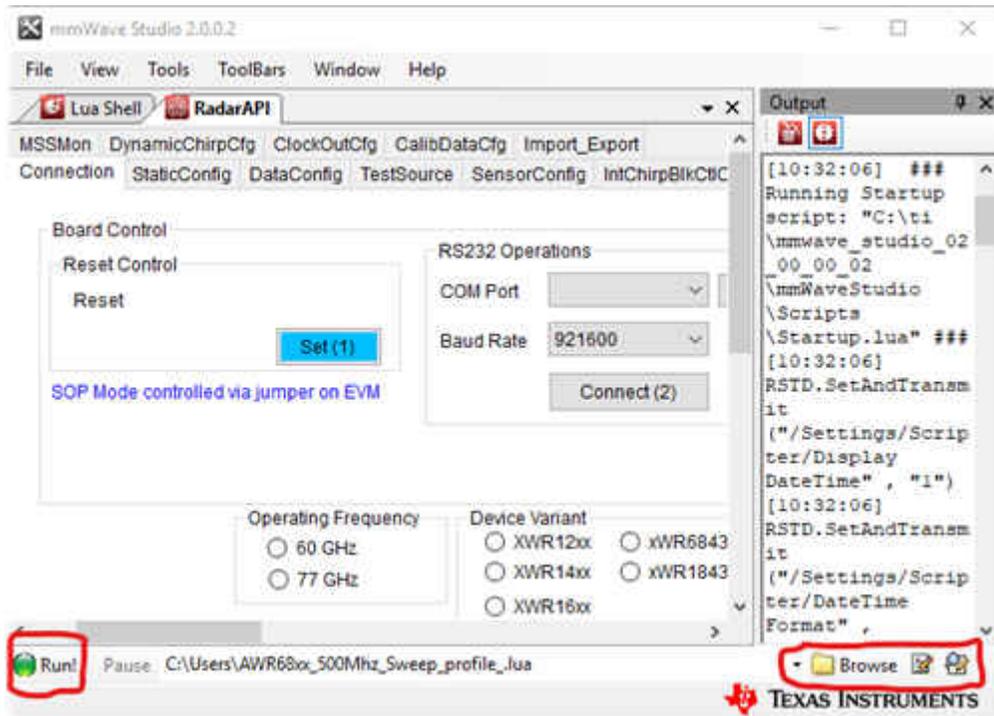


Figure 4-2. Running the LUA Script

4.3 mmWave Visualizer

The effect of EMC and interference can be tested using the [mmWave Visualizer](#). Using a corner reflector at a known distance, normal operation and post-interference behavior of the EUT is confirmed. For more on the SDK out-of-box demo, refer to the [TIREX page](#). MmWave Visualizer can also be used to configure the mmWave device to transmit various chirps needed for the test.

4.4 IWR6843ISK-ODS Test Case

For the IWR6843 test, mmWave studio was used for chirp generation and test relating to [Section 3.1.1](#), mmWave Visualizer / Out-of-box demo was used for [Section 3.1.4](#).

Three different chirp configurations were tested; the LUA scripts can be found in the certification package.

Table 4-1. Chirp Configurations

Bandwidth	Operating Frequency Range	Review
300 MHz	61-61.5 GHz	ar1.ProfileConfig(0, 61.1, 2, 3.4, 18, 0, 0, 0, 0, 0, 0, 0, 0, 16.693, 1, 128, 10000, 0, 131072, 30)
		ar1.ChirpConfig(0, 0, 0, 0, 0, 0, 0, 1, 0, 1)
		ar1.FrameConfig(0, 0, 0, 128, 16, 0, 1)
1300 MHz	57-64 GHz	ar1.ProfileConfig(0, 60.25, 3.6, 3.5, 29.7, 0, 0, 0, 0, 0, 0, 0, 0, 43.995, 1, 256, 10000, 0, 131072, 30)
		ar1.ChirpConfig(0, 0, 0, 0, 0, 0, 0, 1, 0, 1)
		ar1.FrameConfig(0, 0, 0, 128, 16, 0, 1)
4000 MHz	57-64 GHz	ar1.ProfileConfig(0, 60.25, 7, 5.0, 69.5, 0, 0, 0, 0, 0, 0, 0, 0, 53.265, 1, 256, 4000, 0, 131072, 30)
		ar1.ChirpConfig(0, 0, 0, 0, 0, 0, 0, 1, 0, 1)
		ar1.FrameConfig(0, 0, 0, 128, 16, 0, 1)

A breakdown of the configuration parameter is shown in [Table 4-1](#). Details on the Ar1 commands used in the script can be found by entering "help ar1.command"; for example, "help ar1.ProfileConfig" in the Lua shell of mmWave studio. For a complete list of supported ar1 commands, enter "help ar1" in the lua shell.

- Profile configuration API which defines chirp profile parameters - ar1.ProfileConfig(UInt16 profileId, Single startFreqConst, Single idleTimeConst, Single adcStartTimeConst, Single rampEndTime, UInt32 tx0OutPowerBackoffCode, UInt32 tx1OutPowerBackoffCode, UInt32 tx2OutPowerBackoffCode, Single tx0PhaseShifter, Single tx1PhaseShifter, Single tx2PhaseShifter, Single freqSlopeConst, Single txStartTime, UInt16 numAdcSamples, UInt16 digOutSampleRate, UInt32 hpfCornerFreq1, UInt32 hpfCornerFreq2, Char rxGain)
- Chirp configuration API which defines which profile is to be used for each chirp in a frame - ar1.ChirpConfig(UInt16 chirpStartIdx, UInt16 chirpEndIdx, UInt16 profileId, Single startFreqVar, Single freqSlopeVar, Single idleTimeVar, Single adcStartTimeVar, UInt16 tx0Enable, UInt16 tx1Enable, UInt16 tx2Enable)
- Frame Configuration API defines Frame formation which has sequence of chirps to be transmitted subsequently - ar1.FrameConfig(UInt16 chirpStartIdx, UInt16 chirpEndIdx, UInt16 frameCount, UInt16 loopCount, Single periodicity, Single triggerDelay, UInt16 TriggerSelect)

Focusing on the 1300-MHz test case:

- As shown in [Table 3-8](#), the On time within burst is approximately the rampEndTime, period is sum of rampEndTime and idleTimeConst. Between burst, the period is the periodicity shown in frame configuration
- The far field boundary was calculated using [Equation 11](#). With the largest antenna dimension as 13 mm, the far field is calculated as shown in [Table 4-2](#). All RF tests were done in the far field region.

Table 4-2. Far Field Boundary

Center Frequency	L (m)	Lambda (m)	Far Field (m)
60.85	0.0130	0.0049	0.0690

- More details on the test results, standards, and measurement are covered in [Section 3.1](#) and can be found in the certification package on [TIREX](#).

5 Common Issues and Resolutions

5.1 Peak Power

Problem statement: peak power is above the regulatory limit.

Solution: Implement TX power back off

ar1.ProfileConfig (0, 60.25, 7, 5.0, 69.5, TXBO, TXBO, TXBO, 0, 0, 0, 53.265, 1, 256, 4000, 0, 131072, 30)

Power back off, TXBO = 3, 6, 9, 12 ... (see [SDK Documentation](#) for supported values)

Deep Dive:

- IWR6843ISK TX Power = 10 dBm/TX antenna
- TX gain = 8 dBi

For simultaneous 3 TX use case:

$$TX\ power = 10\log(10^{10} + 10^{10} + 10^{10}) \tag{12}$$

$$Total\ TX\ Power = TX\ power + TX\ gain = 14.8 + 8 = 22.8dB \tag{13}$$

When using the mmWave Visualizer and accompanying config file instead of a LUA script the TX power back-off is specified by setting the TX backoff in the ProfileCFG parameter where each of the 8 bit values corresponds to TX1, TX2 and TX3 respectively.

For example for a 6dB back-off on all TX channels, the TX power control word would be 0x060606 i.e. 394758 (use this decimal value). Here's the corresponding profileCfg command.

profileCfg 0 62.00 30 10 69.72 **394758** 0 28.42 1 128 2180 0 0 24

This is defined in the mmwavelink html documentation

5.2 Occupied Bandwidth

Problem statement: Device is not transmitting within the permitted ISM occupied bandwidth.

Solution: Update signal bandwidth as needed

Deep Dive:

According to Draft ETSI EN 305 550 V2.1.0, occupied bandwidth is defined as the width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to 0.5% of the total mean power of a given emission. This roughly corresponds to the -23 dBc bandwidth of the signal.

For larger bandwidth, such as the 4-GHz bandwidth, there is a large frequency jump from (64 GHz to 60 GHz) which results in undershoots, affects the settling time, and can result in failure of the -23 dBc bandwidth limit.

For example the 1300MHz use case in the bandwidth is determine as shown below, it can be changed by either changing the slope or chirp parameter in the chirp config

Table 5-1. ProfileCFG

Bandwidth	ProfileCFG
1300 MHz	ar1.ProfileConfig(0, 60.25, 3.6, 3.5, 29.7,0, 0, 0, 0, 0, 43.995, 1, 256, 10000, 0, 131072, 30)

$$Bandwidth = Frequency\ slope\ (MHz/uS) \times Ramp\ end\ time(uS) \tag{14}$$

$$= 43.983 / 29.70 \tag{15}$$

$$= 1306.3\ MHz \tag{16}$$

5.3 Spurious Emissions

Problem Statement: Spurious emissions measurements show spikes at certain frequencies, resulting in failure.

Solution: Add a metal shield over the device and ensure it is properly connected to ground.

Deep Dive:

An embedded system design usually consists of various clocks and clock sources running at different frequencies. Depending on layout, these clocks can introduce noise (emissions) at fundamental frequency or multiples of fundamental frequency. Adding a shield sufficiently connected to ground around the device and clock sources creates a Faraday cage that keeps the electromagnetic field enclosed.

5.3.1 14.4-GHz Harmonics

Problem Statement: Spurious EMI showing at multiples of 14.4 GHz on the non-AOP module

Solution: Use of metal shield or RF absorber.

Deep Dive:

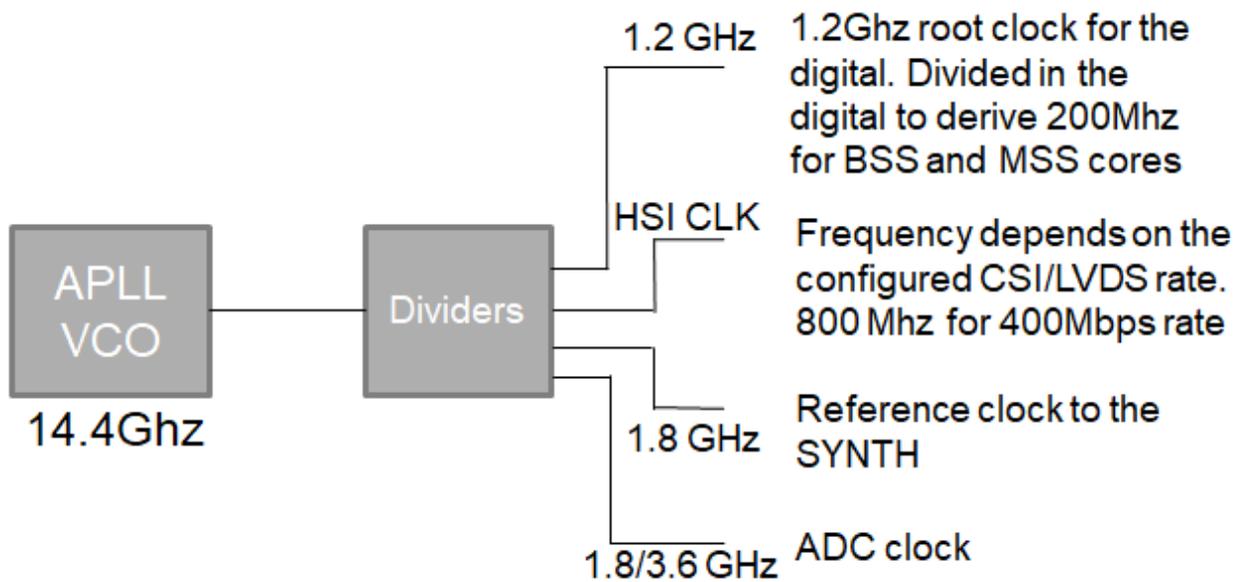


Figure 5-1. APLL VCO Clock

All the clocks in the system are derived from the 14.4-GHz APLL. [Figure 5-1](#) shows the root clock tree within the radar device. During test and certification, 14.4-GHz peak and harmonics of this frequency may show up as spurious emissions, as shown in [Figure 5-2](#), the 2nd harmonics of 14.4 GHz (28.8 GHz) causing radiated emission beyond the regulatory limit.

This issue does not apply to the Antenna on Package (AOP) devices and shielding is inapplicable

5.3.2 Suggested Resolution

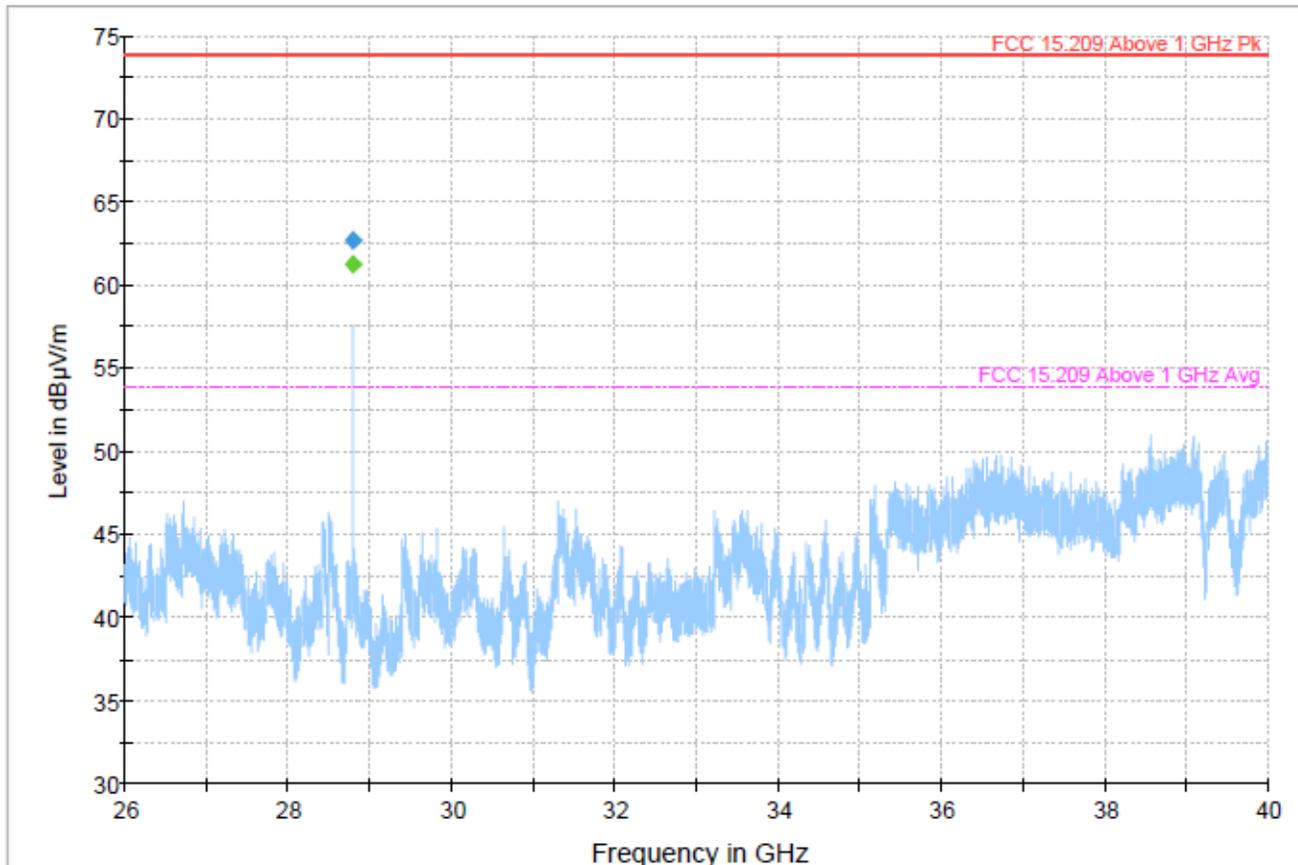
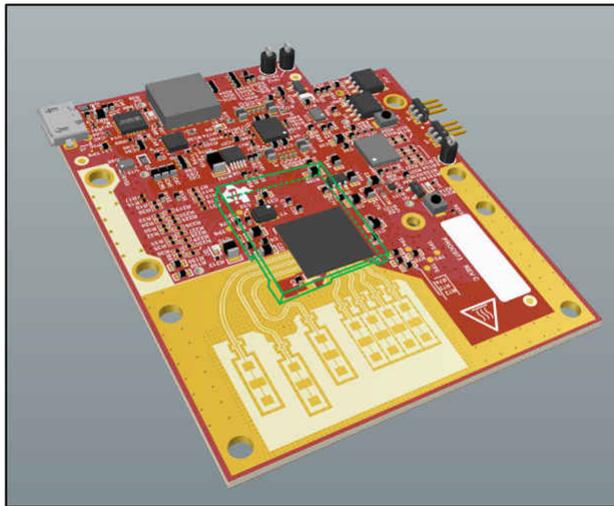


Figure 5-2. 28.8-GHz Spurious EMI

5.3.2.1 Hardware Measures

- The shield or absorber should be placed as shown in [Figure 5-3](#) and [Figure 5-4](#).
- Applicable mmwave devices, decoupling caps, crystal, and the surrounding PCB area should be covered by shield or absorber.
- The shield should be well grounded, covering the components of interest, and absorbers should be properly adhered to PCB and components of interest.
- Ensure the height of the shield from the PCB is greater than or equals to 2mm above the RF traces; otherwise the RF transmission lines may couple with the shield and RF matching might get disturbed. Manufacturing tolerances, wear and tear, shield assembly, and so forth must be considered so that a 2-mm+ height from the board is always maintained.
- When using an RF absorber, the antenna should not be covered; the absorber should be placed such that it does not go beyond the edge of the IC on the areas with the TX and RX traces
- Example of an absorber used to suppress the emission is Cuming Microwave (GDX/PPGA 0.03").



All RF traces should be at least 2 mm away from shielding cover.

Figure 5-3. Shield Placement

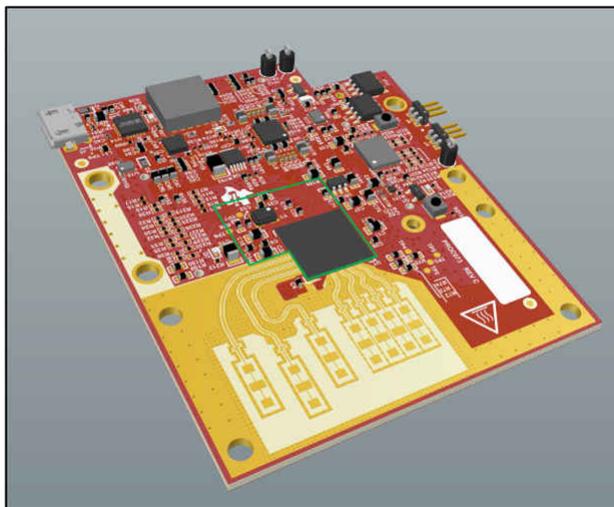


Figure 5-4. RF Absorber Placement

5.3.2.2 Software Measures

APLL VCO RTRIM setting in BSS firmware:

- Emissions for 14.4 GHz and its harmonics can be reduced by changing the setting of the APLL VCO on applicable mmWave devices. Appropriate APLL VCO RTRIM settings can decrease the magnitude of the spurious emissions at 14.4 GHz and 28.8 GHz
- For detailed instructions on how to modify application software to change the APLL VCO RTRIM setting and allowed values, refer to the following guide within the mmWave Industrial Toolbox:

<MMWAVE_INDUSTRIAL_TOOLBOX_INSTALL_PATH>/certification/RTRIM Modification Guide

Example Path: [Industrial Toolbox](#) or Navigate to Industrial Toolbox from [mmWave Sensors](#)

5.4 Overshoot

Problem Statement: Test results shows an overshoot or undershoot at the start of the chirp.

Solution: Increase the TX start time

```
ar1.ProfileConfig (0, 62.10, 2, 3.4, 18, 0, 0, 0, 0, 0, 16.693, 1, 128, 10000, 0, 131072, 30))
```

The highlighted parameter above signifies TX start time of 1 μ S.

Deep Dive:

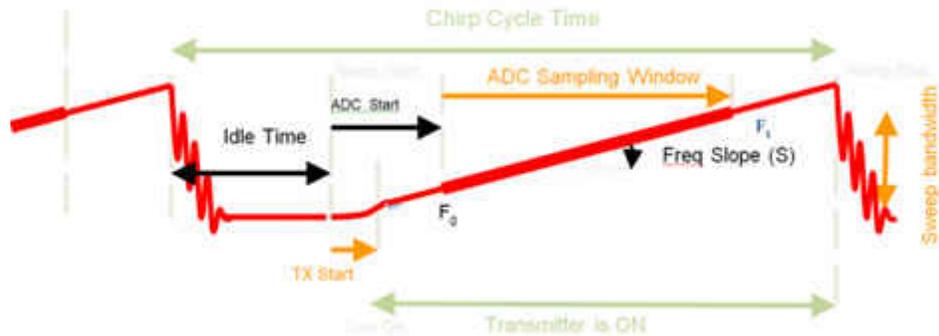


Figure 5-5. Chirp Diagram

TX start time indicates the time elapsed from the start of the frequency ramp to the time the transmitter is turned on. At the beginning of the ramp marked by ramp start in Figure 5-5, the synthesizer, HPF analog filter, decimation filter, and so forth are switched on, and may require some settling time. If TX is turned on within the transient period it may result in overshoot or undershoot in the transmitted signal.

5.5 Frequency Stability

5.5.1 Generating CW Signal

Problem Statement: Generating CW signal for frequency stability measurement.

Solution: Using the DCA1000EVM and MMWAVESTUDIO to transmit a CW signal.

Deep Dive:

The continuous wave LUA script (AWR68xx_xxGHz_CW_profile.lua) included in the certification package can be used to generate CW signals. The frequency generated is a single tone at the set frequency using the ar1.ContStrConfig API.

5.5.2 Frequency Stability Over Temperature and Voltage Range

Problem Statement: Frequency is not within the limit over the temperature and voltage range.

Solution: Adjust the capacitors on the clock to ensure ~0 PPM deviation at room temperature.

Deep Dive:

FCC part 15.255, Frequency stability: Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the temperature range -20 to + 50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

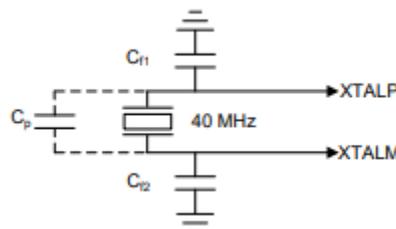


Figure 5-6. 40-Mhz Crystal Capacitance

$$\text{LoadCapacitor } C_L = C_{f1} \times \frac{C_{f2}}{C_{f1} + C_{f2}} + C_p \quad (17)$$

where

- Cp is the parasitic capacitance
- Cf1 and Cf2 are capacitors in parallel

IWR6843 requires a 40-MHz crystal or external oscillator to the CLKP pin; this is used for initial boot up and as reference for the internal APLL and other clocks. For the IWR6843ISK EVM, the crystal is implemented as shown in [Figure 5-6](#). The capacitors are chosen to satisfy requirement shown in [Table 5-2](#).

Table 5-2. Capacitor Requirements

Name	Description	Min	Typ	Max	Unit
Fp	Parallel resonance crystal frequency		40		MHz
CL	Crystal load capacitance	5	8	12	pF
Temperature range	Expected temp range of operation	-40		105	°C
Frequency tolerance	Crystal frequency tolerance	-50		50	ppm

To meet the FCC requirements, the capacitors should be tuned such that the oscillator frequency deviation is at 0 ppm at room temperature and frequency deviation stays within the frequency band across voltage and temperature .

6 References

- [Radio Equipment Directive](#)
- [Radio Equipment Directive \(RED\)](#)
- [ISM-Band and Short Range Device Regulatory Compliance Overview](#), Matthew Loy, Raju Karingattil, Louis Williams
- [DIRECTIVE 2014/53/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL](#)
- [Short Range Devices \(SRD\); Radio equipment to be used in the 40 GHz to 246 GHz frequency range; Harmonised Standard for access to radio spectrum](#)
- [ElectroMagnetic Compatibility \(EMC\)standard for radio equipment and services; Part 1: Common technical requirements; Harmonised Standard covering the essential requirements of article 3.1\(b\) of Directive 2014/53/EU and the essential requirements of article 6 of Directive 2014/30/EU](#)
- [Short Range Devices; Measurement Techniques for Automotive and Surveillance Radar Equipment](#)
- [1999/519/EC: Council Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields \(0 Hz to 300 GHz\)](#)
- [ElectroMagnetic Compatibility \(EMC\)standard for radio equipment and services; Part 1: Common technical requirements; Harmonised Standard covering the essential requirements of article 3.1\(b\) of Directive 2014/53/EU and the essential requirements of article 6 of Directive 2014/30/EU](#)
- [Programming Chirp Parameters in TI Radar Devices](#)
- [FCC Part 15](#)
- [FCC Part 95](#)

7 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision B (February 2021) to Revision C (December 2021)	Page
• Updated Suggested Resolution section.....	17

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