RADIO EQUIPMENT DIRECTIVE TEST PLAN

FOR

MILLIMETER WAVE RADAR SENSOR DEVELOPMENT BOARDS

MODEL SERIES: 1243, 1443, 1642 AND 1843

DOCUMENT NUMBER: 11647276-TP1V6

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Revision History

Rev.	Issue Date	Revisions	Revised By
V1	4/20/2017	As Issued	M. Heckrotte
V2	4/25/2017	Revised applicable standard for 77-81 GHz Band from Draft EN 302 264 v2.1.0 to Final Draft EN 302 264 v2.1.1	M. Heckrotte
V3	5/9/2017	Revised RF Exposure and EMC requirements	M. Heckrotte
V4	5/12/2017	Revised Limitations of Scope	M. Heckrotte
V5	6/4/2019	Added 3TX Configuration with ES2 silicon Added ES3 silicon for 1TX and 2TX configurations	M. Heckrotte
V6	7/31/2019	Removed suggestions that the user manual include advice regarding other products that use these same chipsets	M. Heckrotte

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1. PURPOSE AND SCOPE

1.1. Introduction

This Test Plan has been developed by UL Verification Services Inc., in consultation with Texas Instruments.

1.2. Purpose

This Test plan defines the requirements for assessment of the equipment under test (EUT) to the Essential Requirements of the Radio Equipment Directive (2014/53/EU). This test plan will be included as part of the Technical Construction File (TDF) that will be generated as part of the approval process called out by the Radio Equipment Directive (RED).

The EUT consists of a series of development boards to support the operation of Texas Instruments' 1243, 1443, 1642 and 1843 series of millimeter-wave radar sensor chipsets intended for Transport and Traffic Telematics applications.

1.3. Scope

This Test Plan applies to Models AWR1243BOOST, AWR1443BOOST, AWR1642BOOST, AWR1843BOOST, IWR1443BOOST, IWR 1642BOOST and IWR1843BOOST. It is based upon technical information, drawings, and documentation available at the time of development. It will define the operating parameters and test conditions to be observed during testing. This document includes the following information:

a) Details of the Equipment Under Test.
b) Test Layout, including cable lengths, layouts, and any bonding/grounding arrangements.
c) Confirmation of performance criteria and details of the acceptable limits of degradation.
d) A description of any additional input/output test equipment used to exercise the EUT.

This test plan in no way detracts from or supersedes any contractual specifications placed upon the manufacturer by other organizations.

1.4. Limitations of Scope

This Test Plan, and the anticipated Notified Body Type Examination Certificate associated with this Test Plan, only covers operation of the EUT within the operating boundaries established by this Test Plan and the associated Test Reports.

Such boundaries include, but are not necessarily limited to, Operating Bandwidth, Operating Power and Number of Simultaneous Transmitters.

The EUT is a development board intended for Research and Development (R&D) purposes to enable Texas Instruments' customers and prospective customers to design suitable end products utilizing one or more of the Chipsets that comprise the model families documented in this Test Plan. The operating software furnished with the EUT provides such professional R&D users flexibility to adjust radio parameters to evaluate and optimize their end product designs.

As such it is recognized that professional R&D users might choose to configure the EUT to operate beyond the boundaries over which the EUT was evaluated for compliance with applicable Standards and/or Directives.

The EUT User Manual shall include instructions to the user, that should the user choose to configure the EUT to operate outside the operating boundaries documented in this Test Plan and associated Test Reports, the EUT shall be operated inside a shielded chamber.

2. MANUFACTURER'S DESCRIPTION OF EQUIPMENT

2.1. EUT Description

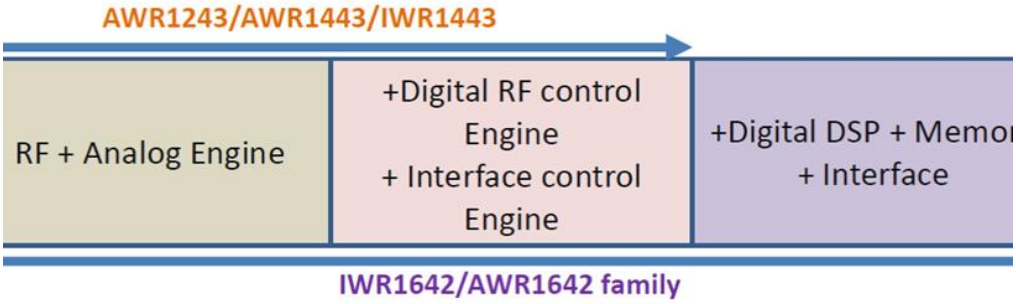
2.1.1. Summary of Models

The EUT consists of a radar chipset, compatible development board and an interface board.

User software with a GUI is installed in a third-party control computer that is connected to the interface board via a USB interface.

Power is furnished by a third-party laboratory bench-top power supply with a 5 VDC output.

Overview of Chipsets:



Overview of Models:

Models AWR1243BOOST, AWR1443BOOST, AWR1642BOOST, AWR1843BOOST, IWR1443BOOST, IWR 1642BOOST and IWR1843BOOST are Millimeter Wave Radar Sensor Development boards.

Model Name	Chipset Number	Features
AWR1243BOOST	AWR1243	No DSP or memory. Limited digital features.
AWR1443BOOST	AWR1443	No DSP. Limited memory. Limited digital features.
AWR1642BOOST	AWR1642	DSP and Memory. All digital features
AWR1843BOOST	AWR1843	DSP and Memory. All digital features
IWR1443BOOST	IWR1443	No DSP. Limited memory. Limited digital features.
IWR1642BOOST	IWR1642	DSP and Memory. All digital features.
IWR1843BOOST	IWR1843	DSP and Memory. All digital features.

All models include a MMWAVE-DEVPACK board which is used to interface the 1243/1443/1843 and 1642 Series boards to a computer via a USB interface.

2.1.2. Chipsets

Operating Bands: 76-77 GHz and 77-81 GHz

FMCW modulation

The 1443 chipset family includes TI's AWR1243, AWR1443, AWR1843, IWR1443 and IWR1843 radar sensor devices while the 1642 chipset family includes TI's AWR1642 and IWR1642 radar sensor devices. All of the devices have the same RF front end and operate in the same bands with the same output power, modulation, bandwidth etc.

Summary of Similarities and Differences:

- 1642 chipsets have an additional internal Digital Signal Processor (DSP) for internal computation
- The DSP also has additional memory
- 1642 chipsets have 2 transmitters while 1443 chipsets have 3 transmitters
- All the transmitters are identical in all the chipsets
- All chipsets have 4 receivers
- In the 76-77 GHz band either 1 or 2 transmitters can be used at a time
- In the 77-81 GHz band only single-transmitter operation is included within the scope of this Test Plan
- AWR1243, AWR1443, AWR1843, IWR1443 and IWR1843 are exactly same silicon with efuse differences
- AWR1642 and IWR1642 are exactly same silicon with efuse differences
- 1642 chipsets include a Trace Interface for debug purposes
- 1443 chipsets do not include the Trace Interface
- 1642 chipsets support both the 76-77 and 77-81 GHz bands
- 1443 version PG1.0 chipsets only support the 77-81 GHz band
- 1443 version PG2.0 chipsets support both the 76-77 and 77-81 GHz bands
- 1443 chipsets only enable 2 simultaneous transmitters
- 1843 chipsets enable 3 simultaneous transmitters

2.1.3. Printed Circuit Boards

Summary of Similarities and Differences:

- 1642 boards include Trace Interface connections for debug purposes
- 1642 boards utilize 4-element antennas on both TX and RX
- 1642 boards have 2 transmit antennas
- 1642 boards have 6 receive antennas; the outer 2 dummy antennas are connected to ground to provide better symmetry to the inner 4 active antennas that are respectively connected to the 4 receivers

- 1642 boards have a ground cut radius of 7.88 mils between the chipset TX output pin connections
- 1642 Rev. A boards include a noise filter and Zener diode at the 5 VDC input
- 1642 boards include a 40 MHz crystal for the 1642 chipset and a 16 MHz crystal for the UART interface controller

- 1443 boards do not include the Trace Interface connections
- 1443 boards utilize 3-element antennas on both TX and RX
- 1443 boards have 3 transmit antennas
- 1443 Rev. E1 boards have 4 receive antennas respectively connected to the 4 receivers
- 1443 Rev. A boards have 6 receive antennas; the outer 2 dummy antennas are connected to ground to provide better symmetry to the inner 4 active antennas that are respectively connected to the 4 receivers
- 1443 Rev. E1 boards support the PG1.0 chipset and only support the 77-81 GHz band
- 1443 Rev. A boards support the PG2.0 chipset and support both the 76-77 and 77-81 GHz bands
- 1443 Rev. E1 boards have a ground cut radius of 10.24 mils between the chipset TX output pin connections
- 1443 Rev. A boards have a ground cut radius of 7.88 mils between the chipset TX output pin connections
- 1443 Rev. A boards include a noise filter and Zener diode at the 5 VDC input
- 1443 boards include a 40 MHz crystal for the 1443 chipset and a 16 MHz crystal for the UART interface controller

Summary of Differences for 1243/1443/1642 Rev B EVMs, compared to 1243/1443/1642 REV A EVMs

- The radar chip has been moved from ES2 to ES3 revisions of the silicon
- The onboard PMIC has changed
- The onboard flash chip has changed

Summary of Similarities and Differences for 1843

- 1843 Rev B and 1843 Rev C utilize the ES2 revision of silicon

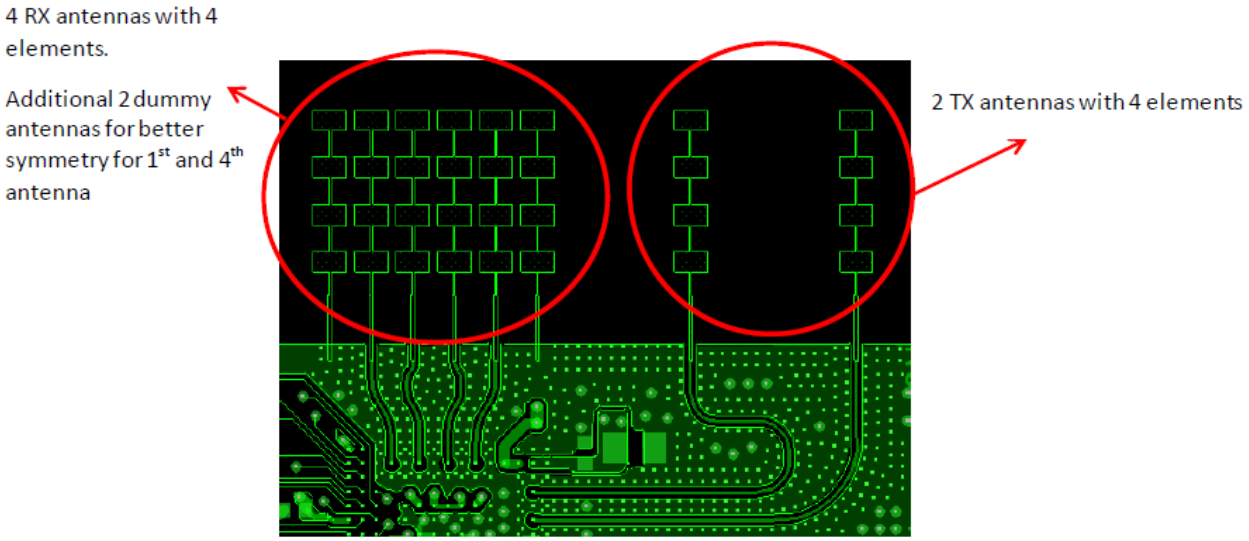
1843 Rev C EVM, compared to 1843 Rev B EVM

- Changed power supply circuitry
    - Changed filtering
    - Added test pad pin
    - Changed board layout to improve thermal performance

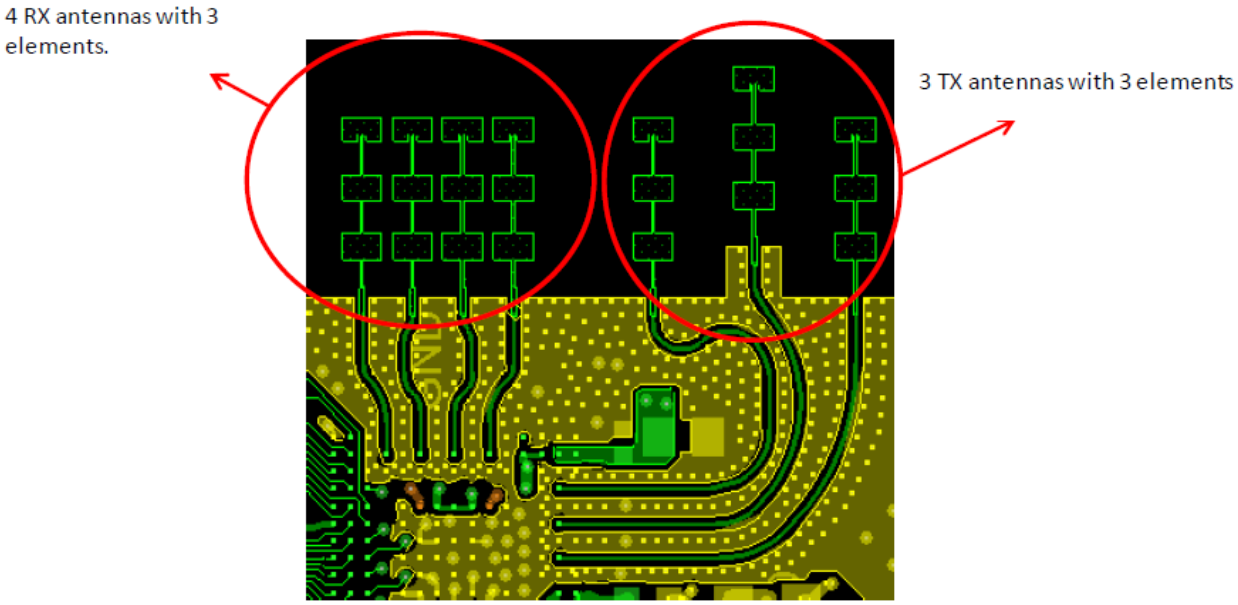
2.1.4. Antennas

Integral antennas are etched on the Printed Circuit Boards.

Model 1642 utilizes 4-element antennas and 2 Dummy RX antennas

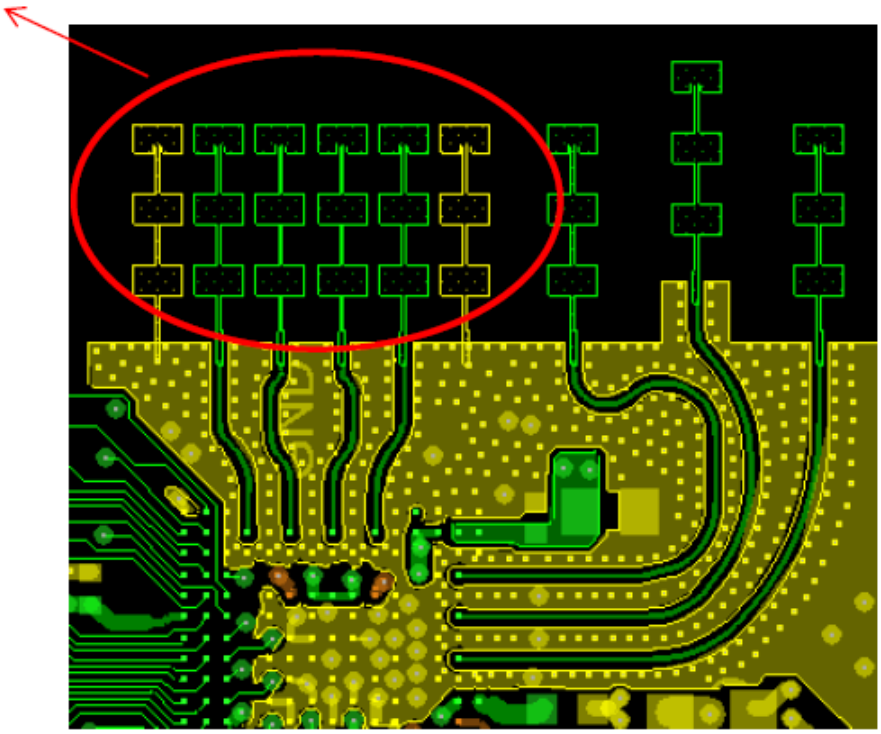


Model 1443 utilizes 3-element antennas; the Rev. E1 board without Dummy RX antennas is shown below



Models 1243/1443/1843 utilize 3-element antennas; the Rev. A board with Dummy RX antennas is shown below

Antennas with dummy antennas



The maximum transmit antenna gain is 11.7 dBi. The following Table lists the gain of each receive antenna, for the available combinations of Antenna Design and Antenna Array Design

Antenna config	RX1 peak gain (dBi)	RX2 peak gain (dBi)	RX3 peak gain (dBi)	RX4 peak gain (dBi)
3 element without Dummy Rx antennas.	10	8.7	8.6	10
3 element with Dummy Rx antennas.	9.1	9.1	9	8.9
4 element with Dummy Rx antennas.	10.6	9.9	9.8	11

2.1.5. Interface Board and I/O

The interface board, MMWAVE-DEVPAK, utilizes a USB port.

2.1.6. Power

Power requirement is 5 Vdc, 2.5 A (nominal). Power to the EUT is furnished by a third-party bench-top laboratory power supply, via a cable with a maximum length of 3 m.

2.1.7. Temperature

The rated operational ambient temperature range is -20 deg C to +60 deg C.

2.1.8. Performance Criterion:

The EUT shall indicate the distance of the target within 20 cm of the distance reported prior to the application of unwanted and/or interference signal(s) as specified by applicable standards.

2.2. Description of Model Differences

Manufacturer's detailed description of model differences will be included in the TDF supplied to the Notified Body.

2.3. Block Diagram / Schematic

Block diagrams and schematics will be included in the TDF supplied to the Notified Body.

2.4. EUT Photographs

Photographs of the EUT will be included in the TDF supplied to the Notified Body.

2.5. Facilities and Personnel

All testing called for in this document shall be carried out by trained test personnel following published procedures and utilizing calibrated test equipment.

2.6. Equipment Configuration

During radiated testing, the EUT shall be set up on a tabletop in a normal configuration.

Any auxiliary equipment required to perform the tests shall be located outside the influence of the test environment. All input/output data cables will be terminated with a representative load if they are not connected to the equipment that normally forms the output for the product. Layout of power cables and I/O cables shall be in accordance with the manufacturer's requirements and as required by the standards.

Variation to the layout and orientation of cables and other items external to the enclosure port will be permitted between tests depending only on the limitations imposed by the test site.

A note and photographic record of the layout, including the positioning of test instrumentation and auxiliary equipment location, where relevant, shall be made and presented with the test report.

3. SUMMARY OF APPLICABLE STANDARDS AND TESTS

3.1. Summary of Radio Tests

3.1.1. General

Radio Spectral Matters per EN 301 091-1 v2.1.1, EN 301 091-2 v2.1.1, Final Draft EN 302 264 v2.1.1 and EN 302 264 v2.1.1 using normative measurement techniques per EN 303 396 v1.1.1.

The limits and procedures are essentially the same among EN 301 091-1 v2.1.1 and EN 301 091-2 v2.1.1. The scopes and associated end product applications are different, as follows:

Part 1: Ground based vehicular radar
Part 2: Fixed infrastructure radar equipment

For the purpose of this Test Plan and associated Test Reports EN 301 091-1 v2.1.1 and EN 301 091-2 v2.1.1 may be collectively identified as “EN 301 091”.

EN 301 091 covers the 76-77 GHz band.

EN 302 264 covers the 77-81 GHz band.

EN 303 396 is a normative reference from all the above standards and provides common measurement techniques.

Required tests are summarized in tables below. The test configurations and the number of operating modes shall be as called out by the referenced standard, unless otherwise noted.

3.1.2. Test Frequencies and Modulation Bandwidths

Each operating bandwidth is operated on one nominal frequency.

OPERATING BANDWIDTH	NOMINAL CENTER FREQUENCY
300 MHz	76.65 GHz
1300 MHz	77.78 GHz
4 GHz	79.07 GHz

3.1.3. Modulation

The device modulation is Frequency Modulated Continuous Wave (FMCW).

3.1.4. Transmitter Designations

Model 1642

- The two transmitters are identified as TX1 and TX2
- Simultaneous transmission on both transmitters is identified as TX1-2

Model 1243/1443/1843

- The three transmitters are identified as TX1, TX2 and TX3
- TX1 and TX3 are the outer antennas
- TX2 is the central antenna
- Simultaneous transmission on the two transmitters feeding an outer antenna and the central antenna, is identified as TX1-2
- Simultaneous transmission on the two transmitters feeding the two outer antennas, is identified as TX1-3
- Simultaneous transmission on all three transmitters is identified as TX1-2-3, and is supported only on the 1843

3.1.5. Antenna Scanning

The antennas do not scan.

3.1.6. Extreme Temperature Conditions

Temperature extremes for Extreme Temperature Conditions are -20 deg C and +60 deg C.

3.1.7. Summary of Transmitting Requirements for 1TX and 2TX operating configurations with ES2 silicon

Radio Spectral Matters per EN 301 091, unless otherwise noted

Requirement	Reference Clauses	Test Condition	Notes
Duty Cycle	EN 303 396 Clause 6.3.6	Reporting Only Normal	Any Model / TX# 300 MHz BW
Operating Frequency Range	4.3.1 EN 303 396 Clause 6.3.2	U Normal Extreme	Measure -23 dBc BW Worst-case Model / TX# from Mean Power Baseline: Normal & Extreme 300 MHz BW
Mean Power	4.3.2 EN 303 396 Clause 6.3.4	U Normal Extreme	Baseline on all Models / TX#s: Model 1642, TX1-2 Model 1443, TX1-2 Model 1443, TX1-3 Normal Only 300 MHz BW _____ Worst-case Model / TX# from Mean Power Baseline: Extreme 300 MHz BW
Peak Power	4.3.3 EN 303 396 Clause 6.3.3	U Normal Extreme	Apply Sweep Rate Correction Factor Worst-case Model / TX# from Mean Power Baseline: Normal & Extreme 300 MHz BW
Unwanted emissions in the out-of-band domain	4.3.4 EN 303 396 Clause 6.3.10	U Normal	All Models / TX#s: Model 1642, TX1-2 Model 1443, TX1-2 Model 1443, TX1-3 300 MHz BW
Unwanted emissions in the spurious domain	4.3.5 EN 303 396 Clause 6.3.10	U Normal	Model 1642, TX1-2 300 MHz BW

Radio Spectral Matters per Final Draft EN 302 264 v2.1.1, unless otherwise noted

Requirement	Reference Clauses	Test Condition	Notes
Duty Cycle	EN 303 396 Clause 6.3.6	Reporting Only Normal	Any Model / TX# 1300 MHz & 4 GHz BW
Operating Frequency Range	4.3.1 EN 303 396 Clause 6.3.2	U Normal Extreme	Measure -23 dBc BW Worst-case Model / TX# from Mean PSD Baseline: Normal & Extreme 1300 MHz & 4 GHz BW
Mean Power Spectral Density	4.3.2 EN 303 396 Clause 6.3.4	U Normal Extreme	Apply Duty Cycle Correction Factor Baseline on all Models / TX#s: Model 1642, TX1 Model 1642, TX2 Model 1443, TX1 Model 1443, TX2 Model 1443, TX3 Normal Only 1300 MHz & 4 GHz BW _____ Worst-case Model / TX# from Mean PSD Baseline: Extreme 1300 MHz & 4 GHz BW
Peak Power	4.3.3 EN 303 396 Clause 6.3.3	U Normal Extreme	Apply Sweep Rate Correction Factor Worst-case Model / TX# from Mean PSD Baseline: Normal & Extreme 1300 MHz & 4 GHz BW
Unwanted emissions in the out-of-band domain	4.3.4 EN 303 396 Clause 6.3.10	U Normal	All Models / TX#s: Model 1642, TX1 Model 1642, TX2 Model 1443, TX1 Model 1443, TX2 Model 1443, TX3 1300 MHz & 4 GHz BW
Unwanted emissions in the spurious domain	4.3.5 EN 303 396 Clause 6.3.10	U Normal	Model 1443, TX1-2 4 GHz BW only

3.1.8. Summary of Additional Transmitting Requirements for 3TX operating configuration with ES2 silicon

Radio Spectral Matters per EN 301 091, unless otherwise noted

Requirement	Reference Clauses	Test Condition	Notes
Duty Cycle	EN 303 396 Clause 6.3.6	Reporting Only Normal	Model 1843 Rev B 300 MHz BW
Operating Frequency Range	4.3.1 EN 303 396 Clause 6.3.2	U Normal Extreme	Measure -23 dBc BW Model 1843 Rev B TX1-2-3 Normal & Extreme 300 MHz BW
Mean Power	4.3.2 EN 303 396 Clause 6.3.4	U Normal Extreme	Model 1843 Rev B TX1-2-3 Normal & Extreme 300 MHz BW
Peak Power	4.3.3 EN 303 396 Clause 6.3.3	U Normal Extreme	Apply Sweep Rate Correction Factor Model 1843 Rev B TX1-2-3 Normal & Extreme 300 MHz BW
Unwanted emissions in the out-of-band domain	4.3.4 EN 303 396 Clause 6.3.10	U Normal	Model 1843 Rev B TX1-2-3 300 MHz BW
Unwanted emissions in the spurious domain	4.3.5 EN 303 396 Clause 6.3.10	U Normal	Model 1843 Rev B TX1-2-3 300 MHz BW Model 1843 Rev C TX1-2-3 300 MHz BW Measure emissions only from 30-1000 MHz

Radio Spectral Matters per EN 302 264 v2.1.1, unless otherwise noted

Requirement	Reference Clauses	Test Condition	Notes
Duty Cycle	EN 303 396 Clause 6.3.6	Reporting Only Normal	Model 1843 Rev B 1300 MHz & 4 GHz BW
Operating Frequency Range	4.3.1 EN 303 396 Clause 6.3.2	U Normal Extreme	Measure -23 dBc BW Model 1843 Rev B TX1-2-3 Normal & Extreme 1300 MHz & 4 GHz BW
Mean Power Spectral Density	4.3.2 EN 303 396 Clause 6.3.4	U Normal Extreme	Apply Duty Cycle Correction Factor Model 1843 Rev B TX1-2-3 Normal & Extreme 1300 MHz & 4 GHz BW
Peak Power	4.3.3 EN 303 396 Clause 6.3.3	U Normal Extreme	Apply Sweep Rate Correction Factor Model 1843 Rev B TX1-2-3 Normal & Extreme 1300 MHz & 4 GHz BW
Unwanted emissions in the out-of-band domain	4.3.4 EN 303 396 Clause 6.3.10	U Normal	Model 1843 Rev B TX1-2-3 1300 MHz & 4 GHz BW
Unwanted emissions in the spurious domain	4.3.5 EN 303 396 Clause 6.3.10	U Normal	Model 1843 Rev B TX1-2-3 1300 MHz & 4 GHz BW Model 1843 Rev C TX1-2-3 1300 MHz & 4 GHz BW Measure emissions only from 30-1000 MHz

3.1.9. Summary of Additional Transmitting Requirements for 1TX and 2TX operating configurations with ES3 silicon

Radio Spectral Matters per EN 301 091, unless otherwise noted

Requirement	Reference Clauses	Test Condition	Notes
Duty Cycle	EN 303 396 Clause 6.3.6	Reporting Only Normal	Model 1443 Rev B Worst-case 1-2TX# from Initial tests, Normal only, 300 MHz BW
Operating Frequency Range	4.3.1 EN 303 396 Clause 6.3.2	U Normal Extreme*	Measure -23 dBc BW Model 1443 Rev B Worst-case 1-2TX# from Initial tests, Normal only, 300 MHz BW
Mean Power	4.3.2 EN 303 396 Clause 6.3.4	U Normal Extreme*	Model 1443 Rev B Worst-case 1-2TX# from Initial tests, Normal only, 300 MHz BW
Peak Power	4.3.3 EN 303 396 Clause 6.3.3	U Normal Extreme*	Apply Sweep Rate Correction Factor Model 1443 Rev B Worst-case 1-2TX# from Initial tests, Normal only, 300 MHz BW
Unwanted emissions in the out-of-band domain	4.3.4 EN 303 396 Clause 6.3.10	U Normal	Model 1443 Rev B Worst-case 1-2TX# from Initial tests 300 MHz BW
Unwanted emissions in the spurious domain	4.3.5 EN 303 396 Clause 6.3.10	U Normal	N/A

* Engineering justification for performing tests only under Normal conditions provided below.

Radio Spectral Matters per Final Draft EN 302 264 v2.1.1, unless otherwise noted

Requirement	Reference Clauses	Test Condition	Notes
Duty Cycle	EN 303 396 Clause 6.3.6	Reporting Only Normal	Model 1443 Rev B Worst-case 1-2TX# from Initial tests, 1300 MHz & 4 GHz BW
Operating Frequency Range	4.3.1 EN 303 396 Clause 6.3.2	U Normal Extreme*	Measure -23 dBc BW Model 1443 Rev B Worst-case 1-2TX# from Initial tests, 1300 MHz & 4 GHz BW
Mean Power Spectral Density	4.3.2 EN 303 396 Clause 6.3.4	U Normal Extreme*	Apply Duty Cycle Correction Factor Model 1443 Rev B Worst-case 1-2TX# from Initial tests, 1300 MHz & 4 GHz BW
Peak Power	4.3.3 EN 303 396 Clause 6.3.3	U Normal Extreme*	Apply Sweep Rate Correction Factor Model 1443 Rev B Worst-case 1-2TX# from Initial tests, 1300 MHz & 4 GHz BW
Unwanted emissions in the out-of-band domain	4.3.4 EN 303 396 Clause 6.3.10	U Normal	Model 1443 Rev B Worst-case 1-2TX# from Initial tests 1300 MHz & 4 GHz BW
Unwanted emissions in the spurious domain	4.3.5 EN 303 396 Clause 6.3.10	U Normal	Model 1443 Rev B Worst-case 1-2TX# from Initial tests 4 GHz BW

* Engineering justification for performing tests only under Normal conditions provided below.

3.1.10. Summary of Receiving Requirements for 1TX and 2TX operating configurations with ES2 silicon

Radio Spectral Matters per EN 301 091, unless otherwise noted

Requirement	Reference Clauses	Test Condition	Notes
Receiver spurious emissions	4.4.2 EN 303 396 Clause 6.3.11	C Normal	N/A Receiver is co-located and operates simultaneously with Transmitter
Receiver in-band, out-of-band and remote-band signal handling	4.4.3 EN 303 396 Clause 6.3.12	U Normal	Model 1642 (with Dummy RX Antennas) Model 1443, without Dummy RX Antennas 300 MHz BW
Receiver sensitivity	4.4.4	Not Specified	N/A

Radio Spectral Matters per Final Draft EN 302 264 v2.1.1, unless otherwise noted

Requirement	Reference Clauses	Test Condition	Notes
Receiver spurious emissions	4.4.2 EN 303 396 Clause 6.3.11	C Normal	N/A Receiver is co-located and operates simultaneously with Transmitter
Receiver in-band, out-of-band and remote-band signal handling	4.4.3 EN 303 396 Clause 6.3.12	U Normal	Model 1642 (with Dummy RX Antennas) Model 1443, without Dummy RX Antennas 1300 MHz & 4 GHz BW
Receiver sensitivity	4.4.4	Not Specified	N/A

3.1.11. Summary of Additional Receiving Requirements for 3TX operating configuration with ES2 silicon

Radio Spectral Matters per EN 301 091, unless otherwise noted

Requirement	Reference Clauses	Test Condition	Notes
Receiver spurious emissions	4.4.2 EN 303 396 Clause 6.3.11	C Normal	N/A Receiver is co-located and operates simultaneously with Transmitter
Receiver in-band, out-of-band and remote-band signal handling	4.4.3 EN 303 396 Clause 6.3.12	U Normal	Model 1843 Rev B 300 MHz BW
Receiver sensitivity	4.4.4	Not Specified	N/A

Radio Spectral Matters per EN 302 264 v2.1.1, unless otherwise noted

Requirement	Reference Clauses	Test Condition	Notes
Receiver spurious emissions	4.4.2 EN 303 396 Clause 6.3.11	C Normal	N/A Receiver is co-located and operates simultaneously with Transmitter
Receiver in-band, out-of-band and remote-band signal handling	4.4.3 EN 303 396 Clause 6.3.12	U Normal	Model 1843 Rev B 4 GHz BW only
Receiver sensitivity	4.4.4	Not Specified	N/A

3.1.12. Summary of Additional Receiving Requirements for 1TX and 2TX operating configurations with ES3 silicon

Radio Spectral Matters per EN 301 091, unless otherwise noted

Requirement	Reference Clauses	Test Condition	Notes
Receiver spurious emissions	4.4.2 EN 303 396 Clause 6.3.11	C Normal	N/A Receiver is co-located and operates simultaneously with Transmitter
Receiver in-band, out-of-band and remote-band signal handling	4.4.3 EN 303 396 Clause 6.3.12	U Normal	N/A
Receiver sensitivity	4.4.4	Not Specified	N/A

Radio Spectral Matters per EN 302 264 v2.1.1, unless otherwise noted

Requirement	Reference Clauses	Test Condition	Notes
Receiver spurious emissions	4.4.2 EN 303 396 Clause 6.3.11	C Normal	N/A Receiver is co-located and operates simultaneously with Transmitter
Receiver in-band, out-of-band and remote-band signal handling	4.4.3 EN 303 396 Clause 6.3.12	U Normal	Model 1443 Rev B 4 GHz BW
Receiver sensitivity	4.4.4	Not Specified	N/A

3.2. Summary of RF Exposure (RF Safety) Evaluation

RF safety evaluation per General Public Limits from Table 2 Reference Levels of (1999/519/EC) and EN 62311:2008.

3.3. Summary of Electrical Safety Tests

Electrical safety tests per EN 60950-1:2006 + A11:2009 + A1:2010 + A12:2011 + A2:2013

3.4. Summary of EMC Tests

3.4.1. Summary of EMC Emissions Tests

Electromagnetic Compatibility Emissions per Draft EN 301 489-51 v2.1.0 and Draft EN 301 489-1 v2.2.0

Requirement	Test Method	Notes
Radiated Emission		N/A EUT has no ancillary equipment
Conducted Emission AC Mains Port		N/A EUT has no AC supply
Conducted Emission DC Power Port		N/A DC Power Cable <= 3m length EUT has no dedicated AC/DC supply EUT is not (yet*) vehicular
Harmonic Current Emissions		N/A EUT has no AC supply
Voltage Fluctuations and Flicker		N/A EUT has no AC supply
Conducted Emission Wired Network Port		N/A EUT has no wired network ports

* NOTE: End-products utilizing the chipset(s) will most likely be used in vehicular applications; such end-products will be subject to vehicular related EMC requirements.

3.4.2. Summary of EMC Immunity tests for 1TX and 2TX configurations with ES2 silicon

Electromagnetic Compatibility Immunity per Draft EN 301 489-51 v2.1.0 and Draft EN 301 489-1 v2.2.0

Requirement	Test Method	Notes
RF Electromagnetic Field (80 MHz to 6,000 MHz)	EN 61000-4-3:2006 + A1:2008 + A2:2010	Enclosure Model 1642 (with Dummy RX Antennas), 300 MHz BW Model 1443, without Dummy RX Antennas, 4 GHz BW
Electrostatic Discharge	EN 61000-4-2:2009	HCP and VCP Tests Only Model 1642 (with Dummy RX Antennas), 300 MHz BW Model 1443, without Dummy RX Antennas, 4 GHz BW
Fast Transients Common Mode		N/A DC Power Cable <= 3m length EUT has no dedicated AC/DC supply EUT has no AC supply EUT has no Wired Network Port
RF Common Mode 0,15 MHz to 80 MHz		N/A DC Power Cable <= 3m length EUT has no dedicated AC/DC supply EUT has no AC supply EUT has no Wired Network Port EUT is not (yet*) vehicular
Transients and surges in the vehicular environment		N/A EUT is not (yet*) vehicular
Voltage Dips and Interruptions		N/A EUT has no AC supply
Surges, Line to Line and Line to Ground		N/A EUT has no AC supply EUT has no Wired Network Port

* NOTE: End-products utilizing the chipset(s) will most likely be used in vehicular applications; such end-products will be subject to vehicular related EMC requirements.

3.4.3. Summary of Additional EMC Immunity tests for 3TX configuration with ES2 silicon

Electromagnetic Compatibility Immunity per EN 301 489-51 v2.1.0 and Draft EN 301 489-1 v2.2.0

Requirement	Test Method	Notes
RF Electromagnetic Field (80 MHz to 6,000 MHz)	N/A	N/A
Electrostatic Discharge	N/A	N/A

3.4.4. Summary of Additional EMC Immunity tests for 1 TX and 2TX configurations with ES3 silicon

Electromagnetic Compatibility Immunity per EN 301 489-51 v2.1.1 and Draft EN 301 489-1 v2.2.1

Requirement	Test Method	Notes
RF Electromagnetic Field (80 MHz to 6,000 MHz)	EN 61000-4-3:2006 + A1:2008 + A2:2010	Enclosure Model 1443 Rev B (with Dummy RX Antennas), 4 GHz BW
Electrostatic Discharge	EN 61000-4-2:2009	HCP and VCP Tests Only Model 1443 Rev B (with Dummy RX Antennas), 4 GHz BW

4. APPLICATION OF RADIO SPECTRAL MATTERS STANDARDS

4.1. Tests for 1TX and 2TX operating configurations with ES2 silicon

4.1.1. Duty Cycle

Test Samples:

Testing is performed in each operating bandwidth using any Model and any TX#.

Engineering rationale:

Minor variations in Duty Cycle that might be expected across different model numbers and/or TX chains will have an insignificant impact on parameters subject to regulatory limitations.

4.1.2. Operating Frequency Range

Test Samples:

Testing is performed on each operating bandwidth using the Model and TX# that showed the worst-case during Baseline tests.

Additional Model and /or TX# samples may be tested at Normal environmental conditions as needed to support Out-Of-Band (OOB) emissions testing.

Engineering rationale:

The worst-case sample from Baseline tests will yield representative performance of the Operating Frequency Range, particularly over temperature extremes.

Minor variations in Bandwidth that might be expected across different Model numbers and/or TX chains could have a significant impact on the OOB emissions performance at the sideband skirts of the fundamental spectral envelope. OOB emissions are only measured under Normal environmental conditions therefore any Bandwidth measurements required to support such OOB tests need only be performed at Normal environmental conditions.

Any minor variations due to chipset efuse differences are expected to be insignificant, therefore tests on the worst-case Model / TX# from Baseline tests are deemed to be representative of all efuse variants of models 1642 and 1243/1443.

Non-harmonized Measurement Procedure:

The -23 dBc Bandwidth is measured instead of the 99% Power Bandwidth.

Engineering rationale:

Applying the 99% BW to an FMCW radar, and simultaneously specifying that the OOB emissions domain begins at the Flow and Fhigh frequencies of the 99% BW, would require that the in-band Power Spectral Density comply with the Power Spectral Density OOB Limits.

Reference OOB Issue V2 attachment to email Correspondence Thread with ETSI ERM TG SRR Working Group Chair pertaining to impact of BW measurement procedure on OOB Compliance showing the impact of the change of the definition of the OOB domain from the R&TTE Directive to the Radio Equipment Directive.

This is unrealistic.

Correspondence plus a Conference Call with the ETSI ERM/TG SRR Working Group Chair indicates that measuring the -23 dBc BW instead of the 99% Power BW provides a reasonable solution, that the working group had considered the -23 dBc BW, that perhaps some members of the working group believed that the -23 dBc BW would be specified as an alternative definition in the published standards, and that the working group will very likely adopt the use of the -23 dBc BW in future revisions of the standards.

Reference Email Correspondence Thread with ETSI ERM TG SRR Working Group Chair pertaining to impact of BW measurement procedure on OOB Compliance.

4.1.3. Mean Power (76-77 GHz Band)

Test Samples for Baseline Measurements:

Testing is performed at Normal environmental conditions on the 300 MHz operating bandwidth using all three combinations of Model and TX# that comprise simultaneous operation of 2 transmitters. These combinations are:

Model 1642, TX1-2
Model 1443, TX1-2
Model 1443, TX1-3

Engineering rationale:

All transmitters among the chipsets are identically designed, however minor variations across different Model numbers and among the specific transmitter locations on the integrated circuit die are expected.

Potentially significant variations may arise due to the transmit antenna design and the transmit antenna locations on the circuit board; these vary on a Model/TX# by Model/TX# basis.

The selected combinations include both antenna designs and all antenna locations, as well as all integrated circuit die locations.

Any minor variations due to chipset efuse differences are expected to be insignificant, therefore tests on any 1642 and 1443 are deemed to be representative of all effuse variants of models 1642 and 1243/1443.

Test Samples for Extreme environmental conditions:

Testing is performed at on the 300 MHz operating bandwidth using the Model and TX# that showed the worst-case during Baseline tests.

Engineering rationale:

The worst-case sample from Baseline tests will yield representative performance of the variation of Mean Power over temperature extremes. Furthermore the worst-case sample from Baseline tests is expected to exhibit the worst-case Mean Power over temperature extremes.

Any minor variations due to chipset efuse differences are expected to be insignificant, therefore tests on the worst-case Model / TX# from Baseline tests are deemed to be representative of all efuse variants of models 1642 and 1243/1443.

4.1.4. Mean Power Spectral Density (77-81 GHz Band)

Test Samples for Baseline Measurements:

Testing is performed at Normal environmental conditions on the 1300 MHz and 4 GHz operating bandwidths using all five combinations of Model and TX#. These combinations are:

Model 1642, TX1
Model 1642, TX2
Model 1443, TX1
Model 1443, TX2
Model 1443, TX3

Engineering rationale:

All transmitters among the chipsets are identically designed, however minor variations across different Model numbers and among the specific transmitter locations on the integrated circuit die are expected.

Potentially significant variations may arise due to the transmit antenna design and the transmit antenna locations on the circuit board; these vary on a Model/TX# by Model/TX# basis.

The selected combinations include both antenna designs and all antenna locations, as well as all integrated circuit die locations.

Any minor variations due to chipset efuse differences are expected to be insignificant, therefore tests on any 1642 and 1443 are deemed to be representative of all effuse variants of models 1642 and 1243/1443.

Test Samples for Extreme environmental conditions:

Testing is performed at on the 1300 MHz and 4 GHz operating bandwidths using the Model and TX# that showed the worst-case during Baseline tests.

Engineering rationale:

The worst-case sample from Baseline tests will yield representative performance of the variation of Mean PSD over temperature extremes. Furthermore the worst-case sample from Baseline tests is expected to exhibit the worst-case Mean PSD over temperature extremes.

Any minor variations due to chipset efuse differences are expected to be insignificant, therefore tests on the worst-case Model / TX# from Baseline tests are deemed to be representative of all efuse variants of models 1642 and 1243/1443.

Measurement Procedure:

Apply Duty Cycle Correction Factor to Power Spectral Density measurements to show PSD during the ON time burst of the transmission.

Engineering rationale:

Neither Final Draft EN 302 264 v2.1.1 nor EN 303 396 v1.1.1 provide guidance as to whether PSD is to measured across the entire period (including ON and OFF times) or only during the ON time.

Measurements of PSD during the ON time burst of the transmission is consistent with other ETSI radio standards.

Correspondence with the ETSI ERM/TG SRR Working Group Chair confirms that PSD is intended to be measured during the ON time burst of the transmission.

4.1.5. Peak Power

Test Samples:

Testing is performed on each operating bandwidth using the Model and TX# that showed the worst-case during Baseline tests.

Engineering rationale:

The worst-case sample from Baseline tests will yield representative performance of the Peak Power, particularly over temperature extremes. Furthermore the worst-case sample from Baseline tests is expected to exhibit the worst-case Peak Power over temperature extremes.

Any minor variations due to chipset efuse differences are expected to be insignificant, therefore tests on the worst-case Model / TX# from Baseline tests are deemed to be representative of all efuse variants of models 1642 and 1243/1443.

Application of Normalized Sweep Rate Correction Factor:

EN 303 396 v1.1.1 clause 6.3.3.2 states

> "NOTE: For EUT with a higher frequency sweep rate, the RBW has to be increased until a stable peak power reading is obtained."

Stepping to the highest available RBW on the Test Laboratory's spectrum analyzer will not necessarily provide a stable peak power reading due to the frequency sweep rates utilized by the EUT.

Agilent Technologies, Inc. Application Note 150-2, Appendix B. IF Amplifier Response and Distortion, provides equation B-10 to compensate for this condition.

Normalized sweep rate = F_s / (T_s * B^2)
Where
F_s= Sweep Width
T_s = Sweep Time
B= 3 dB IF Bandwidth = RBW

Equation B-10 is excerpted below

$$\alpha = \frac{1}{\sqrt[4]{1+\left(\frac{2\ln(2)}{\pi}\right)^2\left(\frac{F_s}{T_s B^2}\right)^2}} \qquad \text{(B-10)}$$

Where α is the reduction in amplitude

4.1.6. Unwanted Emissions in the Out-Of-Band Domain

Test Samples:

Testing is performed on the 300 MHz operating bandwidth using all three combinations of Model and TX# that comprise simultaneous operation of 2 transmitters. These combinations are:

Model 1642, TX1-2
Model 1443, TX1-2
Model 1443, TX1-3

Testing is performed on the 1300 MHz and 4 GHz operating bandwidths using all five combinations of Model and TX#. These combinations are:

Model 1642, TX1
Model 1642, TX2
Model 1443, TX1
Model 1443, TX2
Model 1443, TX3

Engineering rationale:

All transmitters among the chipsets are identically designed, however minor variations across different Model numbers and among the specific transmitter locations on the integrated circuit die are expected.

Potentially significant variations may arise due to the transmit antenna design and the transmit antenna locations on the circuit board; these vary on a Model/TX# by Model/TX# basis.

The selected combinations include both antenna designs and all antenna locations, as well as all integrated circuit die locations.

Any minor variations due to chipset efuse differences are expected to be insignificant, therefore tests on any 1642 and 1443 are deemed to be representative of all effuse variants of models 1642 and 1243/1443.

4.1.7. Unwanted Emissions in the Spurious Domain

Test Samples:

Testing is performed on the 300 MHz operating bandwidth using Model 1642 transmitting on TX1-2.

Testing is performed on the 4 GHz operating bandwidth using Model 1443 transmitting on TX1-2.

Engineering rationale:

Spurious emissions arise from Clocks, Local Oscillators, Mixing Products and the rising and falling edges of data transitions.

The 1642 chipset has additional Digital Signal Processing (DSP) circuitry, compared to the 1443. This can lead to a different spurious emissions profile.

Although the 1443 chipset has three transmitters, at most only two transmitters can transmit simultaneously. The specific transmitter locations on the integrated circuit die will not have a significant impact on spurious emissions, thus testing any two of the three transmitters will provide representative performance.

Although only single-transmitter operation in the 77-81 GHz band is within the scope of this Test Plan, testing spurious with two transmitters operating simultaneously provides worst-case results and reduces the burden on end users that desire to show compliance under simultaneous two-transmitter operation in this band.

The selected combinations include both chipset designs, both RF Bands, and the lowest and highest operating bandwidths. The frequency range of the spectral envelope of the 1300 MHz BW lies completely within the frequency range of the spectral envelope of the 4 GHz BW.

Any minor variations due to chipset efuse differences are expected to be insignificant, therefore tests on any 1642 and 1443 are deemed to be representative of all effuse variants of models 1642 and 1243/1443.

4.1.8. Receiver Spurious Emissions

Applicability:

Not Applicable

Engineering rationale:

All Receivers are co-located with, and operate simultaneously with, the Transmitter(s).

4.1.9. Receiver in-band, out-of-band and remote-band signal handling

Test Samples:

Model 1642 (4-element Antennas / with Dummy RX Antennas), operating in the 300 MHz BW mode.

Model 1443, with 3-element Antennas / without Dummy RX Antennas, operating in the 4 GHz BW mode.

Test conditions:

The unwanted signal source is positioned within the 3 dB beamwidth at the operating centre frequency of the RX boresight.

A suitable Radar Cross Section (RCS) target shall be placed within the detection area of the EUT antenna.

Performance Criterion:

During and after the application of the unwanted signal, the EUT shall indicate the distance to the target within 20 cm of the distance indicated prior to the application of the unwanted signal.

Engineering rationale:

All receivers among the chipsets are identically designed, however minor variations across different Model numbers and among the specific receiver locations on the integrated circuit die are expected.

All four receivers on the integrated circuit chips operate simultaneously therefore any minor variations among the specific receiver locations on the integrated circuit die are inherently tested as a group.

Development boards for Model 1642 incorporate 4-element antennas. Development boards for Model 1443 incorporate 3-element antennas.

All development boards for Model 1642 incorporate two additional dummy receive antennas to provide better symmetry for the 4 active receive antennas.

Rev. E1 development boards for Model 1443 only have active receive antennas, while Rev. A development boards for Model 1443 incorporate two additional dummy receive antennas to provide better symmetry for the 4 active receive antennas.

The selected test samples include the combinations of Receive Antenna Design / Receive Antenna Array Designs that exhibit the lowest and highest available receive antenna gains.

The associated co-located transmitter PSD in the 4 GHz mode is lower than the PSD in the 1300 MHz mode, therefore the 4 GHz mode represents the worst-case operating bandwidth in the 77-81 GHz band.

Any minor variations due to chipset efuse differences are expected to be insignificant, therefore tests on any 1642 and 1443 are deemed to be representative of all effuse variants of models 1642 and 1243/1443.

Unwanted Signals Specification:

Test the 300 MHz BW mode using unwanted signals per EN 301 091 Clause 4.4.3.3 Table 8.

Test the 4 GHz BW mode using unwanted signals per Final Draft EN 302 264 v2.1.1 Clause 4.4.3.3 Table 7.

Engineering rationale:

The associated co-located transmitter PSD in the 4 GHz mode is lower than the PSD in the 1300 MHz mode, therefore the 4 GHz mode represents the worst-case operating bandwidth in the 77-81 GHz band.

4.1.10. Receiver Sensitivity

Applicability:

Not Applicable

Rationale:

Per EN 301 091 clause 4.4.4 and Final Draft EN 302 264 v2.1.1 Clause 4.4.4,

> "receiver sensitivity is not specified in the present document in order to allow manufacturers the freedom to tailor equipment to specific circumstances.
>
> For instance, equipment covered by the present document may be intended to detect a target at maximum range or may be intended to discriminate features such as size, shape or velocity at shorter range. The level of minimum usable signal would be different in each case."

4.2. Additional tests for 3TX operating configuration with ES2 silicon

Test Sample:

Model 1843

Rev. B EVM, unless otherwise specified

Rationale:

Model 1843 enables simulataneous transmission on all three transmitters.

The differences between the 1843 Rev. B EVM and 1843 Rev. C EVM are covered in the spurious emissions from 30-1000 MHz

4.2.1. Duty Cycle, Operating Frequency Range, Mean Power / Mean PSD, Peak Power, OOB emissions

Applicability:

Test Fundamental characteristics and Unwanted emissions in the out-of-band domain, Normal and Extreme conditions as applicable per relevant standard, for all three operating bandwidths (300 MHz, 1300 MHz and 4 GHz)

Rationale:

The addition of the third transmitter impacts Mean Power / Mean PSD (as applicable to each band), Peak Power, and Unwanted emissions in the out-of-band domain.

Operating frequency range impacts the boundaries of OOB domain.

Duty cycle impacts various correction factors.

4.2.2. Spurious emissions

Applicability:

1. **Rev B EVM**

Test Unwanted emissions in the spurious domain

2. **Rev C EVM**

Test Unwanted emissions in the spurious domain from 30 to 1000 MHz

Rationale:

1. **Rev B EVM**

The addition of the third transmitter impacts Unwanted emissions in the spurious domain.

2. **Rev C EVM**

Rev C EVM consists of power supply board layout and filtering changes, compared to Rev B EVM.

The operating frequencies associated with these component changes are below 108 MHz therefore the impact of such circuit changes can be readily evaluated by measuring emissions up to 1000 MHz.

NOTE: As this circuitry is not ancillary equipment such tests are performed under EN 301 091 and EN 302 264 rather than EN 301 489.

4.2.3. Receiver in-band, out-of-band and remote-band signal handling

Applicability:

Perform Receiver in-band, out-of-band and remote-band signal handling tests for two operating bandwidths (300 MHz and 4 GHz).

Engineering rationale:

The addition of the third co-located transmitter can impact receiver performance characteristics due to potential overloading the front end of the receiver. The peak power is highest in the 300 MHz BW mode therefore the 300 MHz BW mode represents the worst-case operating bandwidth from the perspective of potential receiver overload.

The associated co-located transmitter PSD in the 4 GHz mode is lower than the PSD in the 1300 MHz mode, therefore the 4 GHz mode represents the worst-case operating bandwidth in the 77-81 GHz band from the perspective of the wanted receive signal level.

The two selected BW's cover both the EN 301 091 and EN 302 264 standards.

Test conditions:

The unwanted signal source is positioned within the 3 dB beamwidth at the operating centre frequency of the RX boresight.

A suitable Radar Cross Section (RCS) target shall be placed within the detection area of the EUT antenna.

Performance Criterion:

During and after the application of the unwanted signal, the EUT shall indicate the distance to the target within 20 cm of the distance indicated prior to the application of the unwanted signal.

Unwanted Signals Specification:

Test the 300 MHz BW mode using unwanted signals per EN 301 091 Clause 4.4.3.3 Table 8.

Test the 4 GHz BW mode using unwanted signals per EN 302 264 v2.1.1 (2017-05) Clause 4.4.3.3 Table 7.

Engineering rationale:

The cited standards represent the state-of-the-art from the perspective of measurement procedures.

4.3. Additional tests for 1TX and 2TX operating configurations with ES3 silicon

Sample Configuration

Perform all tests using the TX1-3 antenna configuration.

Rationale:

The silicon changes between ES2 and ES3 optimize the existing design to improve RF performance. During the initial tests either the TX1-3 antenna configuration was worst-case or the difference between the TX1-3 results and the worst-case results was much less than the margin to the limit.

4.3.1. Duty Cycle, Operating Frequency Range, Mean Power / Mean PSD, Peak Power

Applicability:

Test Fundamental characteristics, Normal conditions only, for all three operating bandwidths (300 MHz, 1300 MHz and 4 GHz).

Rationale:

The silicon changes between ES2 and ES3 optimize the existing design to improve RF performance. During the initial tests either these fundamental parameters were worst-case at Normal conditions or the differences between Normal and Extreme conditions was much less than the margin to the limit.

4.3.2. OOB emissions

Applicability:

Test unwanted emissions in the out-of-band domain, for all three operating bandwidths (300 MHz, 1300 MHz and 4 GHz).

Rationale:

No deviation from harmonized procedures.

4.3.3. Spurious emissions

Applicability:

Measure Unwanted emissions in the spurious domain on the 4 GHz operating BW.

Rationale:

Spurious emissions arise from Clocks, Local Oscillators, Mixing Products and the rising and falling edges of data transitions. Spurious emissions levels in the 4 GHz operating BW are expected to be representative of all three operating BWs.

4.3.4. Receiver in-band, out-of-band and remote-band signal handling

Applicability:

Perform Receiver in-band, out-of-band and remote-band signal handling tests in the 4 GHz BW mode.

Engineering rationale:

Initial tests of the 1TX and 2TX operating configurations with ES2 silicon demonstrated similar performance across all three BW's and across various antenna configurations (3-element and 4-element antennas, with and without dummy RX antennas), therefore the performance of any one BW is expected to be representative of the performance of all BW's.

The associated co-located transmitter PSD is lowest in the 4 GHz mode, therefore the 4 GHz mode represents the worst-case operating bandwidth from the perspective of the wanted receive signal level.

Test conditions:

The unwanted signal source is positioned within the 3 dB beamwidth at the operating centre frequency of the RX boresight.

A suitable Radar Cross Section (RCS) target shall be placed within the detection area of the EUT antenna.

Performance Criterion:

During and after the application of the unwanted signal, the EUT shall indicate the distance to the target within 20 cm of the distance indicated prior to the application of the unwanted signal.

Unwanted Signals Specification:

Test the 4 GHz BW mode using unwanted signals per EN 302 264 v2.1.1 (2017-05) Clause 4.4.3.3 Table 7.

Engineering rationale:

The cited standard represents the state-of-the-art from the perspective of measurement procedures.

5. APPLICATION OF RF EXPOSURE STANDARDS

RF Exposure evaluation is performed in accordance with EN 62311:2008.

Engineering rationale for the application of EN 62311:2008

EN 62311 applies to electrical and electronic equipment for which no dedicated product or product family standard regarding human exposure to electromagnetic fields applies. The frequency range covered is 0 Hz to 300 GHz.

Evaluation method:

Perform RF Exposure Evaluation per EN 62311 Clause 7.2 (1) and (2).

Perform calculations of Power Density using the far field equations given in EN 62311 Annex A.2. Calculate minimum separation distance at which fields comply with the relevant Reference Levels.

6. APPLICATION OF ELECTRICAL PRODUCT SAFETY STANDARDS

Electrical safety testing is performed in accordance with the requirements of EN 60950-1:2006 + A11:2009 + A1:2010 + A12:2011 + A2:2013

Engineering rationale for the application of EN 60950-1:2006 + A11:2009 + A1:2010 + A12:2011 + A2:2013

The scope of EN 60950 + Amendments, as cited, is applicable to the EUT.

7. APPLICATION OF EMC STANDARDS

7.1. General

ElectroMagnetic Compatibility testing is performed in accordance with Draft EN 301-489-51 v2.1.0 and Draft EN 301-489-1 v2.2.0.

Engineering rationale for the application of Draft EN 301 489-51 v2.1.0

The scope of Draft EN 301-489-51 v2.1.0 is applicable to the EUT.

Engineering rationale for the application of Draft EN 301 489-1 v2.2.0

Draft EN 301-489-1 v2.2.0 is referenced by Draft EN 301 489-51 v2.1.0.

7.2. Application of EMC Emissions Tests

The equipment test requirement is given in the fixed use column of Table 1 in Clause 7.1 of Draft EN 301 489-1 v2.2.0.

7.2.1. Radiated Emissions

Not Applicable. This requirement is satisfied by Radio Spectral Matters requirements as the EUT has no ancillary equipment.

7.2.1. Conducted Emissions, AC Power Input Port

Not Applicable. The EUT has no AC supply.

7.2.2. Conducted Emissions, DC Power Input Port

Not Applicable. The manufacturer declares that the DC Power Input Port is not intended to be used with cables longer than 3 m, the EUT has no dedicated AC/DC supply and the EUT is not (yet*) vehicular.

The EUT User Manual shall include instructions to the end user to limit the length of the DC power connection to a maximum of 3 m.

7.2.3. Harmonics

Not Applicable. The EUT has no AC supply.

7.2.4. Flicker

Not Applicable. The EUT has no AC supply.

7.2.5. Conducted Emission, Wired Network Port

Not Applicable. The EUT has no wired network port.

7.3. Application of EMC Immunity Tests for 1TX and 2TX operating configurations with ES2 silicon

The equipment test requirement is given in the fixed use column of Table 2 in Clause 7.2 of Draft EN 301 489-1 v2.2.0.

7.3.1. RF Electromagnetic Field

Test Method: EN 61000-4-3:2006 + A1:2008 + A2:2010

Test level: 3 V/m (measured unmodulated). The test signal shall be amplitude modulated to a depth of 80% depth by a sinusoidal audio signal of 1000 Hz. The test signal frequency range shall be 80 to 6000 MHz. There are no exclusion bands within this range.

Performance criterion A applies for immunity tests with a phenomena of a continuous nature.

During the test the performance shall be

- Operate as intended
- No loss of function
- No unintentional responses

After the test the performance shall be

- Operate as intended
- No loss of function
- No unintentional responses

Test samples:

Model 1642 (4-element Antennas / with Dummy RX Antennas), operating in the 300 MHz BW mode.

Model 1443, with 3-element Antennas / without Dummy RX Antennas, operating in the 4 GHz BW mode.

Engineering rationale:

The selected test samples include the combinations of Receive Antenna Design / Receive Antenna Array Designs that exhibit the lowest and highest available receive antenna gains.

The associated co-located transmitter PSD in the 4 GHz mode is lower than the PSD in the 1300 MHz mode, therefore the 4 GHz mode represents the worst-case operating bandwidth in the 77-81 GHz band.

Furthermore, as the frequency range of the immunity signals are well below the EUT operating frequency the selected test samples and operating bandwidths will provide an adequate evaluation that is representative of all combinations of receiver antenna configurations and operating bandwidth modes.

Test conditions:

A suitable Radar Cross Section (RCS) target shall be placed within the detection area of the EUT antenna.

Performance Criterion:

During and after the application of the immunity field, the EUT shall indicate the distance to the target within 20 cm of the distance indicated prior to the application of the immunity field.

Test Protocol:

Expose Front and Back sides of the EUT Printed Circuit Board to both polarizations, Vertcal and Horizontal, of the Uniform Electric Field.

Engineering rationale:

The EUT is small therefore exposure of both sides of the PCB is sufficient to evaluate the performance with an applied uniform electric field.

7.3.2. Electrostatic Discharge

EN 61000-4-2:2009

Test Severity Levels: Up to +/- 4kV indirect contact discharge to Horizontal Coupling Plane and Vertical Coupling Plane.

Performance criterion B applies for immunity tests with a phenomena of a transient nature.

During the test the performance shall be
- No unintentional responses

After the test the performance shall be
- Operate as intended
- Loss of function(s) shall be self-recoverable
- No degradation of performance

Test samples:

Model 1642 (4-element Antennas / with Dummy RX Antennas), operating in the 300 MHz BW mode.

Model 1443, with 3-element Antennas / without Dummy RX Antennas, operating in the 4 GHz BW mode.

Engineering rationale:

The selected test samples include the combinations of Receive Antenna Design / Receive Antenna Array Designs that exhibit the lowest and highest available receive antenna gains.

The associated co-located transmitter PSD in the 4 GHz mode is lower than the PSD in the 1300 MHz mode, therefore the 4 GHz mode represents the worst-case operating bandwidth in the 77-81 GHz band.

Furthermore, as the frequency range of the immunity signals are well below the EUT operating frequency the selected test samples and operating bandwidths will provide an adequate evaluation that is representative of all combinations of receiver antenna configurations and operating bandwidth modes.

Test conditions:

A suitable Radar Cross Section (RCS) target shall be placed within the detection area of the EUT antenna.

Performance Criterion:

After the application of ESD discharges, the EUT shall indicate the distance to the target within 20 cm of the distance indicated prior to the application of ESD discharges.

Test Protocol:

Apply indirect contact discharges to the Horizontal Coupling Plane and the Vertical Coupling Plane.

Direct contact or direct air discharges shall not be applied to the EUT.

Engineering rationale:

The EUT is a development board. It is not contained within an enclosure as end users need access to the circuitry in order to make measurements during the R&D process. Only indirect discharges are appropriate for this construction.

Direct contact and direct air discharges are not appropriate for this construction. As the EUT is intended to be used in a laboratory setting these requirements are mitigated by placing the EUT on an ESD-protective mat and the end user wearing an ESD-protective wrist strap connected to the ESD-protective mat.

The EUT User Manual shall include instructions to the end user to place the EUT on an ESD-protective mat and to wear an ESD-protective wrist strap connected to the ESD-protective mat.

7.3.3. Fast Transients Common Mode

Not Applicable. The manufacturer declares that the DC Power Input Port is not intended to be used with cables longer than 3 m, the EUT has no dedicated AC/DC supply, the EUT has no AC supply and the EUT has no wired network port.

The EUT User Manual shall include instructions to the end user to limit the length of the DC power connection to a maximum of 3 m.

7.3.4. Radio Frequency, Common Mode

Not Applicable. The manufacturer declares that the DC Power Input Port is not intended to be used with cables longer than 3 m, the EUT has no dedicated AC/DC supply, the EUT has no AC supply, the EUT has no wired network port and the EUT is not (yet*) vehicular.

The EUT User Manual shall include instructions to the end user to limit the length of the DC power connection to a maximum of 3 m.

7.3.5. Trasients and surges in the vehicular environment

Not Applicable. The EUT is not intended for vehicular applications.

7.3.6. Voltage Dips, Fluctuations, Interrupts

Not Applicable. The EUT has no AC supply.

7.3.7. Surges, Line to Line and Line to Ground

Not Applicable. The EUT has no AC supply or wired network port.

7.4. Application of EMC Immunity Tests for 3TX operating configuration with ES2 silicon

The equipment test requirement is given in the fixed use column of Table 2 in Clause 7.2 of Draft EN 301 489-1 v2.2.1.

7.4.1. RF Electromagnetic Field

Applicability:

No test is specified.

Rationale:

All three transmitters were present on the 1243 and 1443 chipsets during the initial tests of the 1-2TX configurations. Enabling all three transmitters for simultaneous operation is not expected to introduce any additional immunity coupling mechanisms.

7.4.2. Electrostatic Discharge

Applicability:

No test is specified.

Rationale:

All three transmitters were present on the 1243 and 1443 chipsets during the initial tests of the 1-2TX configurations. Enabling all three transmitters for simultaneous operation is not expected to introduce any additional immunity coupling mechanisms.

7.5. Application of EMC Immunity Tests for 1TX and 2TX operating configurations with ES3 silicon

The equipment test requirement is given in the fixed use column of Table 2 in Clause 7.2 of Draft EN 301 489-1 v2.2.1.

7.5.1. RF Electromagnetic Field

Test Method: EN 61000-4-3:2006 + A1:2008 + A2:2010

Test level: 3 V/m (measured unmodulated). The test signal shall be amplitude modulated to a depth of 80% depth by a sinusoidal audio signal of 1000 Hz. The test signal frequency range shall be 80 to 6000 MHz. There are no exclusion bands within this range.

Performance criterion A applies for immunity tests with a phenomena of a continuous nature.

During the test the performance shall be

- Operate as intended
- No loss of function
- No unintentional responses

After the test the performance shall be

- Operate as intended
- No loss of function
- No unintentional responses

Test samples:

Model 1443 Rev. B operating in the 4 GHz BW mode.

Engineering rationale:

The associated co-located transmitter PSD is lowest in the 4 GHz mode therefore the 4 GHz mode represents the worst-case operating bandwidth from the perspective of the wanted receive signal level.

Furthermore, as the frequency range of the immunity signals are well below the EUT operating frequency the selected operating bandwidth will provide an adequate evaluation that is representative of all operating bandwidth modes.

Test conditions:

A suitable Radar Cross Section (RCS) target shall be placed within the detection area of the EUT antenna.

Performance Criterion:

During and after the application of the immunity field, the EUT shall indicate the distance to the target within 20 cm of the distance indicated prior to the application of the immunity field.

Test Protocol:

Expose Front Side and One Edge of the EUT Printed Circuit Board to both polarizations, Vertcal and Horizontal, of the Uniform Electric Field.

Engineering rationale:

The EUT is small therefore exposure of two orthogonal sides of the PCB is sufficient to evaluate the performance with an applied uniform electric field.

7.5.2. Electrostatic Discharge

EN 61000-4-2:2009

Test Severity Levels: Up to +/- 4kV indirect contact discharge to Horizontal Coupling Plane and Vertical Coupling Plane.

Performance criterion B applies for immunity tests with a phenomena of a transient nature.

During the test the performance shall be

- No unintentional responses

After the test the performance shall be

- Operate as intended
- No loss of function
- No degradation of performance

Test samples and Configurations:

Model 1443 Rev B operating in the 4 GHz BW mode.

Engineering rationale for Test samples and Configurations:

The associated co-located transmitter PSD is lowest in the 4 GHz mode therefore the 4 GHz mode represents the worst-case operating bandwidth from the perspective of the wanted receive signal level.

Furthermore, as the frequency range of the immunity signals are well below the EUT operating frequency the selected operating bandwidth will provide an adequate evaluation that is representative of all operating bandwidth modes.

Test conditions:

A suitable Radar Cross Section (RCS) target shall be placed within the detection area of the EUT antenna.

Performance Criterion:

After the application of ESD discharges, the EUT shall indicate the distance to the target within 20 cm of the distance indicated prior to the application of ESD discharges.

Test Protocol:

Apply indirect contact discharges to the Horizontal Coupling Plane and the Vertical Coupling Plane.

Direct contact or direct air discharges shall not be applied to the EUT.

Engineering rationale for Test Protocol:

The EUT is a development board. It is not contained within an enclosure as end users need access to the circuitry in order to make measurements during the R&D process. Only indirect discharges are appropriate for this construction.

Direct contact and direct air discharges are not appropriate for this construction. As the EUT is intended to be used in a laboratory setting these requirements are mitigated by placing the EUT on an ESD-protective mat and the end user wearing an ESD-protective wrist strap connected to the ESD-protective mat.

The EUT User Manual shall include instructions to the end user to place the EUT on an ESD-protective mat and to wear an ESD-protective wrist strap connected to the ESD-protective mat.

8. RELATED AND REFERENCED DOCUMENTS

DIRECTIVE 2014/53/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC

COUNCIL RECOMMENDATION of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (1999/519/EC)

DIRECTIVE 2014/30/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility (recast)

DIRECTIVE 2014/35/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits (recast)

EN 301 091-1 v2.1.1, Short Range Devices; Transport and Traffic Telematics (TTT); Radar equipment operating in the 76 GHz to 77 GHz range; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU; Part 1: Ground based vehicular radar

EN 301 091-2 v2.1.1, Short Range Devices; Transport and Traffic Telematics (TTT); Radar equipment operating in the 76 GHz to 77 GHz range; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU; Part 2: Fixed infrastructure radar equipment

Final Draft EN 302 264 v2.1.1 (2017-02), Short Range Devices; Transport and Traffic Telematics (TTT); Short Range Radar equipment operating in the 77 GHz to 81 GHz band; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU

EN 302 264 v2.1.1 (2017-05), Short Range Devices; Transport and Traffic Telematics (TTT); Short Range Radar equipment operating in the 77 GHz to 81 GHz band; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU

ETSI EN 303 396 v1.1.1, Short Range Devices; Measurement Techniques for Automotive and Surveillance Radar Equipment

Draft ETSI EN 301 489-1 v2.2.0, 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

Draft ETSI EN 301 489-1 v2.2.1, ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements; Harmonised Standard for ElectroMagnetic Compatibility

Draft EN 301 489-51 v2.1.0, ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 51: Specific conditions for Automotive, Ground based Vehicles and Surveillance Radar Devices using 24,05 GHz to 24,25 GHz, 24,05 GHz to 24,5 GHz, 76 GHz to

77 GHz and 77 GHz to 81 GHz; Harmonised Standard covering the essential requirements of article 3.1b of Directive 2014/53/EU

EN 301 489-51 v2.1.1, ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 51: Specific conditions for Automotive, Ground based Vehicles and Surveillance Radar Devices using 24,05 GHz to 24,25 GHz, 24,05 GHz to 24,5 GHz, 76 GHz to 77 GHz and 77 GHz to 81 GHz; Harmonised Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU

EN 61000-4-2:2009, Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement techniques - Section 2: Electrostatic discharge immunity test

EN 61000-4-3:2006 + A1:2008 + A2:2010, Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques – Section 3: Radiated, radio-frequency, electromagnetic field immunity test

EN 62311:2008, Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz – 300 GHz)

EN 60950-1:2006 + A11:2009 + A1:2010 + A12:2011 + A2:2013, Safety of Information Technology Equipment

Email Correspondence Thread with ETSI ERM TG SRR Working Group Chair pertaining to impact of BW measurement procedure on OOB Compliance

OOB Issue V2 attachment to email Correspondence Thread with ETSI ERM TG SRR Working Group Chair pertaining to impact of BW measurement procedure on OOB Compliance

Email Correspondence Thread with ETSI ERM TG SRR Working Group Chair pertaining to PSD interpretation

Agilent Technologies, Inc. 5952-1039, Spectrum and Signal Analysis…Pulsed RF Application Note 150-2

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