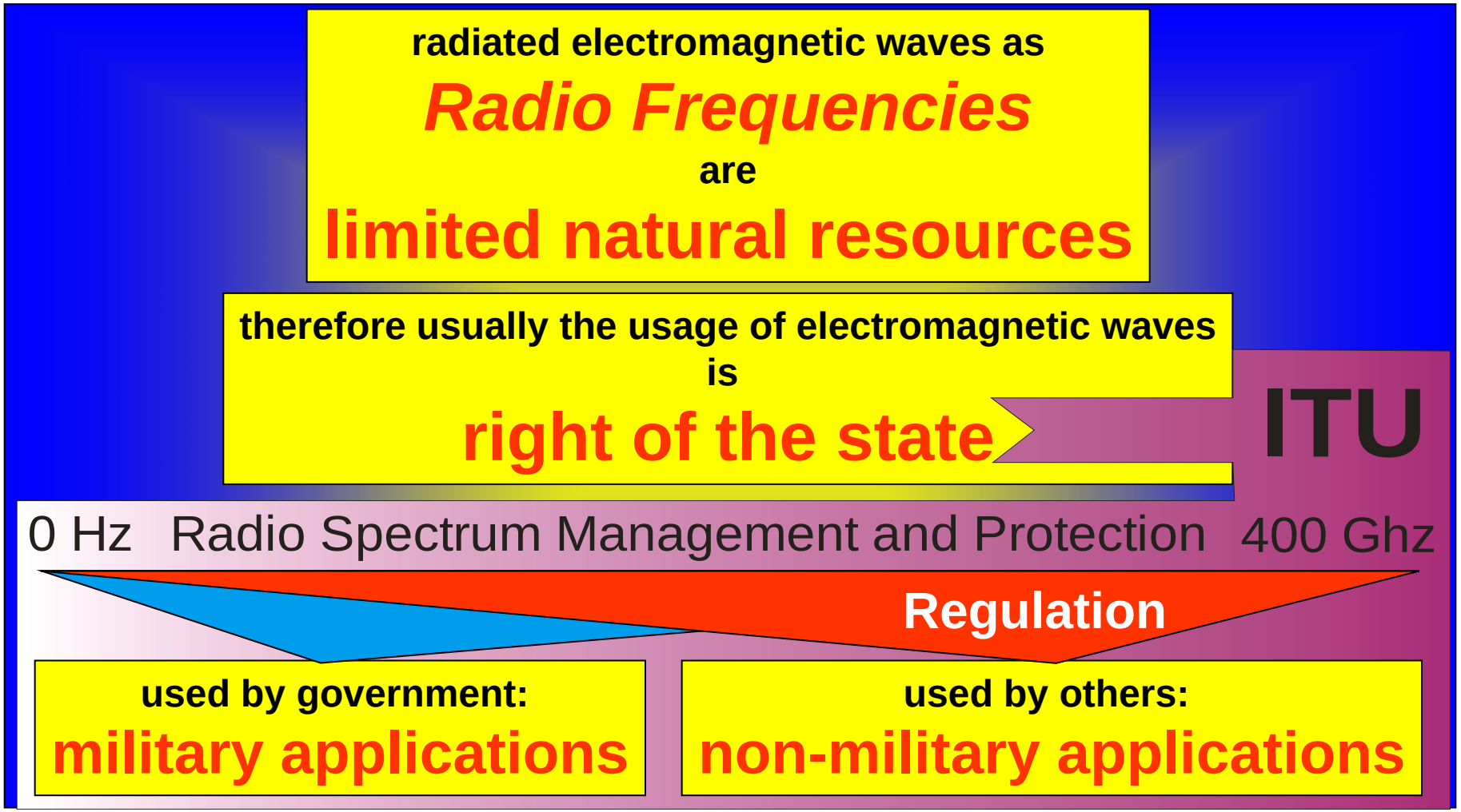
ETSI EN Standards Update

ISM band wireless devices
2.4 GHz and 5 GHz band

Harmonized Standards:
ETSI EN 300 328 v1.8.1 and
ETSI EN 301 893 v1.7.1

ROHDE&SCHWARZ

Why is Regulation necessary?



Regulation of the Internal Market by European Directives

72/245/EEC	Motor vehicles
73/23/EEC	"Low voltage directive"
78/404/EEC	Simple pressure containers
88/378/EEC	Toy safety
89/106/EEC	Building products
89/336/EEC, 92/31/EEC 2004/108/EEC	**Electromagnetic compatibility**
89/392/EEC, 91/368/EEC	Machines
89/686/EEC	Personal protective equipment
90/384/EEC	Non-automatic scales
90/385/EEC	Active implantable medical devices
90/396/EEC	Gas regulating devices
92/61/EEC	two- or three-wheel motor vehicles
1999/5/EEC	**R&TTE directive** (Radio Equipment and Telecommunications terminal equipment)
92/42/EEC	Efficiency of hot water boilers
93/42/EEC	Medical devices
93/97/EEC	Satellite radio devices

R & TTE Directive Article 3(2)

Article 3

Essential requirements

1. The following essential requirements are applicable to all apparatus:

(a) the protection of the health and the safety of the user and any other person, including the objectives with respect to safety requirements contained in Directive 73/23/EEC, but with no voltage limit applying;

(b) the protection requirements with respect to electromagnetic compatibility contained in Directive 89/336/EEC.

EMC

2. In addition, radio equipment shall be so constructed that it effectively uses the spectrum allocated to terrestrial/space radio communication and orbital resources so as to avoid harmful interference.

3. In accordance with the procedure laid down in

Manufacturers' responsibilities under the R&TTE Directive

2. In addition, radio equipment shall be so constructed that it effectively uses the spectrum allocated to terrestrial/space radio communication and orbital resources so as to avoid harmful interference.

Key Words
- Effective use of spectrum
- Avoidance of harmful interference

Essential Radio Tests for "effective use of spectrum"
- Modulation accuracy
- Data transfer rates
- Robustness inside use environment

Essential Radio Tests for "avoiding harmful interference"
- Power restrictions
- Spectrum restrictions (BW and "leakage")
- Sharing of the resource

Tests to achieve the aims of Article 3.2

- Space
  - Distance covered by a certain power level
  - Antenna assembly gain
  - Beamforming gain
- Time
  - Duty Cycle, Dwell time
  - TxOn times, TxOff time
  - Tx-sequence
  - Tx-gap
- Frequency
  - Power Spectral Density
  - Frequency occupation / timing / accuracy (frequency hopping radios)
- Organizational
  - R&TTE Directive references the List of Harmonised Standards

European Harmonized Standards

ETSI	EN 300 328 V1.8.1 **(new)** Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz ISM band and using wide band modulation techniques; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive	EN 300 328 V1.7.1 Note 2.1	31/12/2014	Article 3(2)

This version of the standard gives presumption of conformity with the requirements of Article 3(2) of Directive 1999/5/EC under the following condition: The equipment shall implement an adequate spectrum sharing mechanism, e.g. LBT (Listen Before Talk), DAA (Detect And Avoid), etc., in order to comply with the requirement specified in clause 4.3.5 of this version. Such a mechanism shall facilitate sharing between the various technologies and applications which currently exist and in case of congestion, users will be ensured equal access (and as a consequence a graceful degradation of service to all users). The efficiency of the various sharing mechanisms can be assessed using the appropriate clauses of EN 300 328 version 1.8.1.

Specific Standards Issued

ETSI EN 300 328 V1.8.1 (2012-06)

Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz ISM band and using wide band modulation techniques; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive

ETSI EN 301 893 V1.7.1 (2012-06)

Broadband Radio Access Networks (BRAN); 5 GHz high performance RLAN; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive

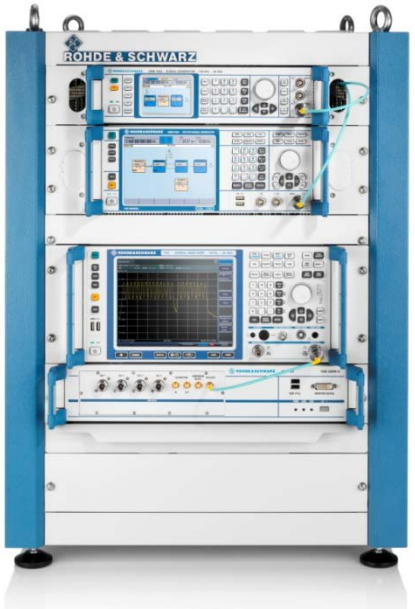
Version Turn – Effective Date January 1, 2015

Version Turn with major changes to conformance tests

Old Version
equipment required

+

New Version
equipment required



New Version requires testing for “Adaptivity” (LBT, DAA)
and summation of MIMO transmission power

ETSI EN 300 328

ETSI EN 300 328 V1.8.1 (2012-06)

Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz ISM band and using wide band modulation techniques; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive

ETSI EN 300 328 – Wide Band Data Transmission

Examples of Wide Band Data Transmission equipment are:

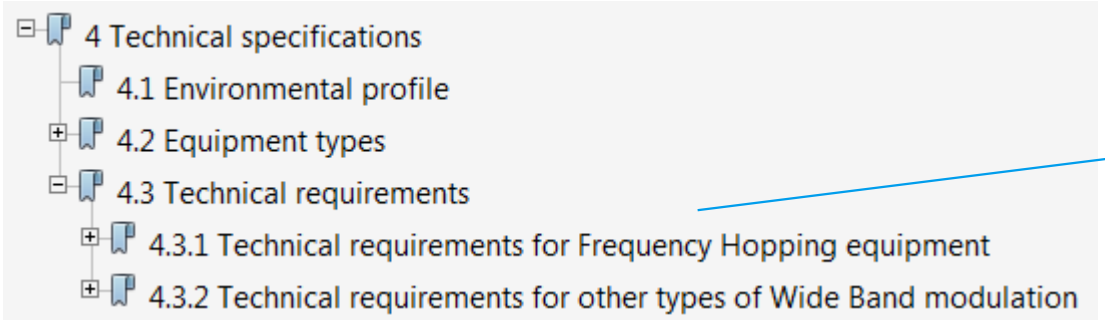
- IEEE 802.11™ RLANs [i.3],
- Bluetooth® wireless technologies,
- Zigbee™, etc.

This equipment can be used in fixed, mobile or nomadic applications, e.g.:

- stand-alone radio equipment with or without their own control provisions;
- plug-in radio devices intended for use with or within a variety of host systems, e.g. personal computers, hand-held terminals, etc.;
- plug-in radio devices intended for use within combined equipment, e.g. cable modems, set-top boxes, access points, etc.;
- combined equipment or a combination of a plug-in radio device and a specific type of host equipment.

Radio equipment operating in the band 2.4 GHz to 2.4835 GHz

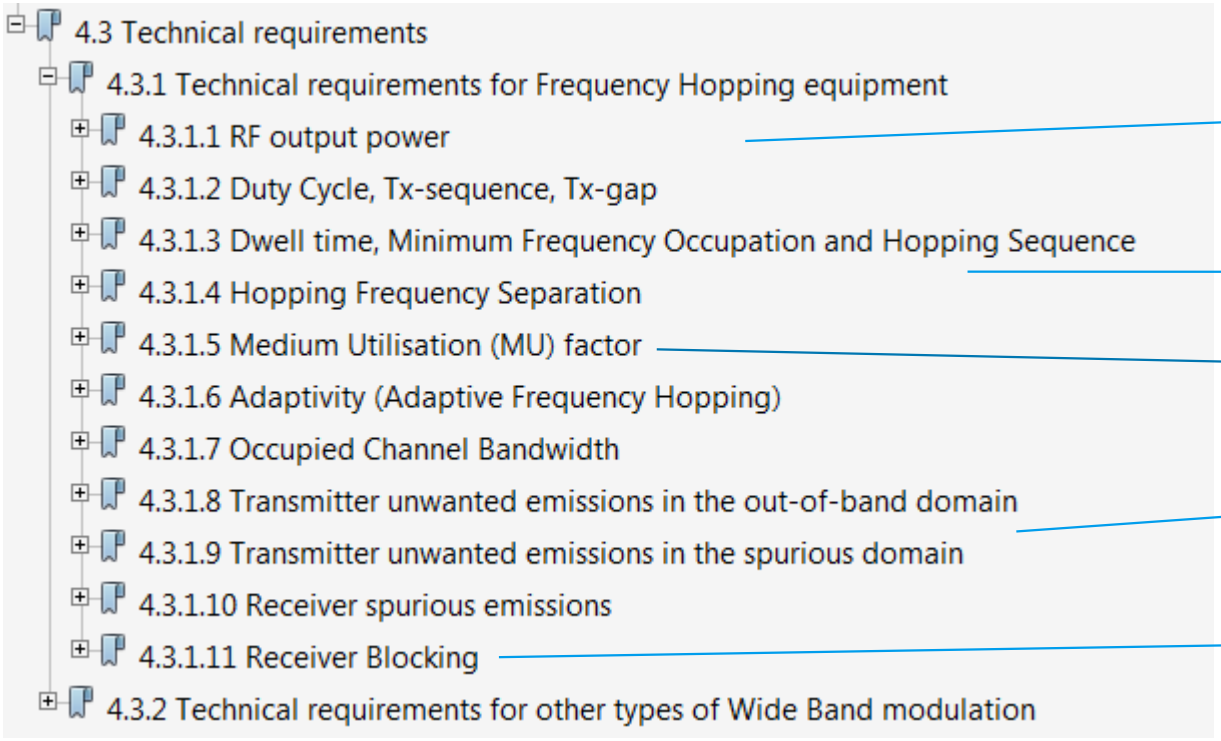
Structure of ETSI EN 300 328



Frequency Hopping

Everything Else (fixed frequency)

Frequency Hopping Radio Tests



Power Control Tests

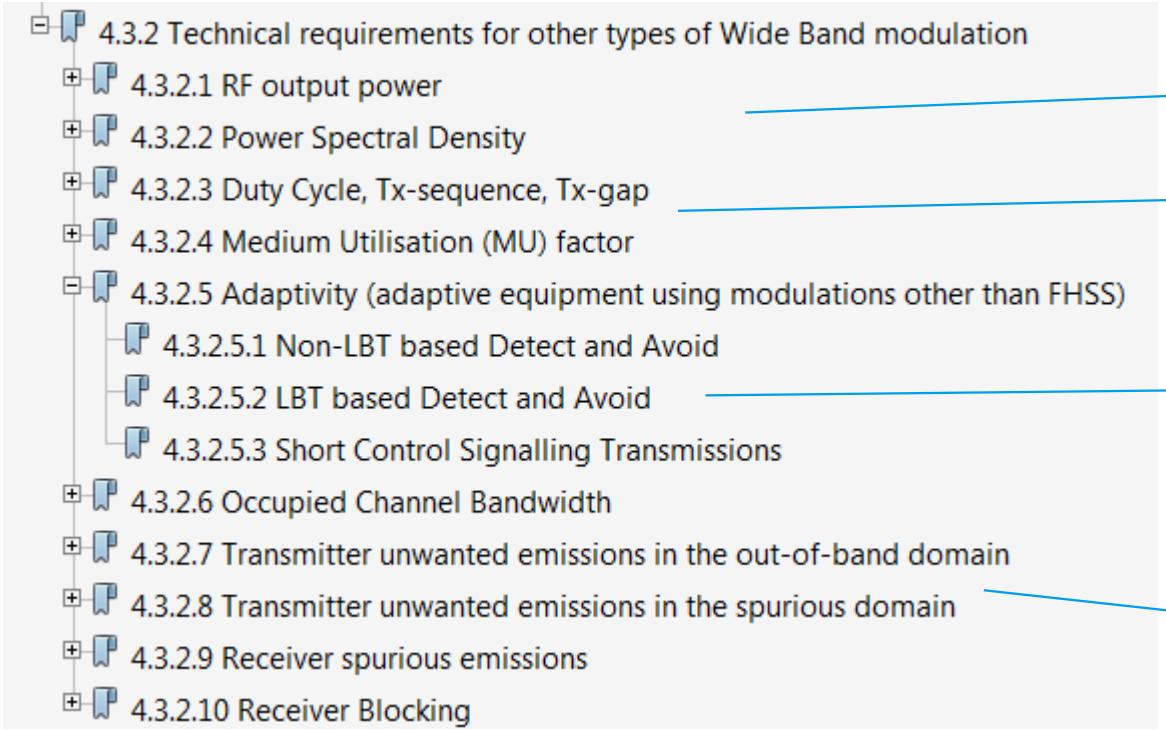
Frequency Control Tests

Interoperability Tests

Spurious Tests

Adaptive – Coexistence Tests

Fixed Frequency Radio Tests



Power Control Tests

Interoperability Tests

Adaptive – Coexistence Tests

Spurious Tests

Test Definitions – Power and Frequency Tests

- **RF output power** is mean equivalent isotropic radiated power (EIRP) during a transmission burst on all antennas (including gain, beam-forming and MIMO can't exceed 20 dBm)

RF output power

DUT Frequency (MHz)	Max Burst RMS Power (dBm)	Max EIRP (dBm)	Temperature (°C)	Result	Comment
2412.000000	10.6	10.6	21	PASS	
2441.750000	10.3	10.3	21	PASS	
2483.500000	10.8	10.8	21	PASS	

- **Duty Cycle** is the total transmitter 'on'-time inside a 1 second observation time (burst duty cycle for fixed and hopping frequency cycle for hoppers)
- **Tx-sequence** is the period during which a single or multiple transmissions may occur and which shall be followed by a Tx-gap
- **Tx-gap** is a period in time during which no transmissions occur.

Duty Cycle, Tx-sequence, Tx-gap

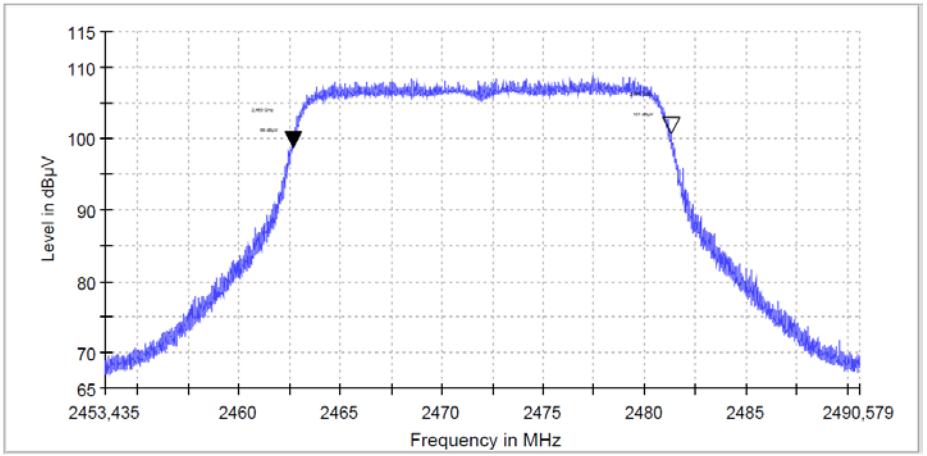
DUT Frequency (MHz)	Duty Cycle (%)	Number of Bursts	Number of Gaps	Maximum Tx-sequence (ms)	Minimum Tx-gap (ms)	Minimum Tx-On (ms)	Maximum Tx-On (ms)	Minimum Tx-Off (ms)
2412.000000	57.758	2019	0	---	---	0.027	2.320	0.027
2441.750000	58.573	1952	0	---	---	0.027	2.320	0.026
2483.500000	59.702	1532	0	---	---	0.027	2.320	0.038

(continuation of the "Duty Cycle, Tx-sequence, Tx-gap" table from column 9 ...)

DUT Frequency (MHz)	Maximum Tx-Off (ms)	Measurement Time (ms)	DC Result	Tx-Seq Result	Tx-Gap Result	Comment
2412.000000	2.859	1001.698	FAIL	FAIL (no gap)	FAIL	DC > 50 %; Seq. > 5 ms; no Gap
2441.750000	3.348	1000.122	FAIL	FAIL (no gap)	FAIL	DC > 50 %; Seq. > 5 ms; no Gap
2483.500000	3.435	1002.019	FAIL	FAIL (no gap)	FAIL	DC > 50 %; Seq. > 5 ms; no Gap

Test Definitions – Power and Frequency Tests

- **Occupied Channel Bandwidth** is the bandwidth that contains 99 % of the power



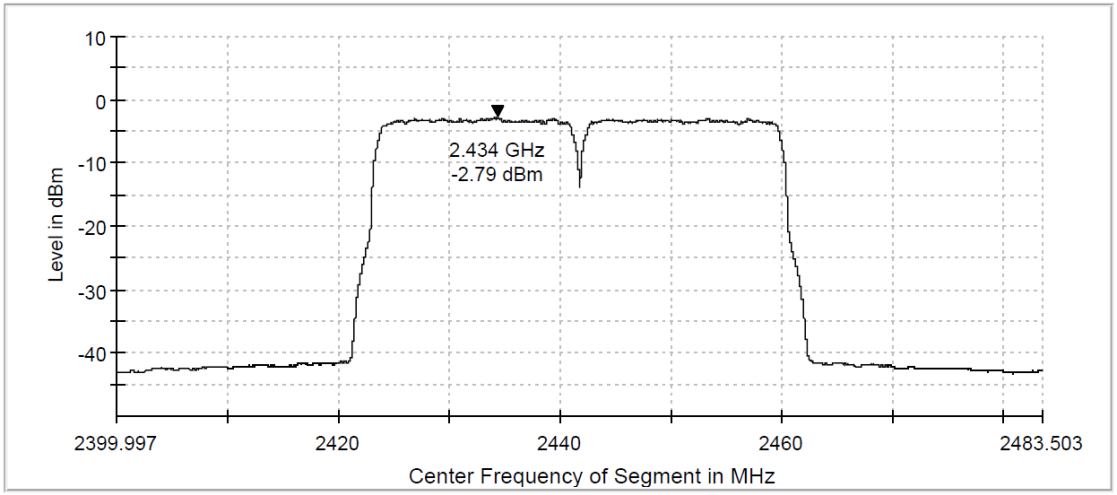
Occupied Channel Bandwidth

DUT Frequency (MHz)	DUT Bandwidth (MHz)	Channel Center Frequency (MHz)	Occupied Channel Bandwidth (MHz)	Result
2440.000000	20.000000	2472.013715	18.567268	PASS
2485.000000	20.000000	2472.013760	18.563543	PASS

- **Power Spectral Density** is mean equivalent EIRP spectral density during the burst (maximum PSD is limited to 10 dBm per MHz)

Power Spectral Density

DUT Frequency (MHz)	Center Frequency of Segment (MHz)	Level (dBm)	Result
2400.000000	2402.602316	0.1	PASS
2441.750000	2434.370436	-2.8	PASS
2483.500000	2476.117966	0.1	PASS



Additional Tests for Frequency Hopping Radios

- **Dwell Time** that a hopping frequency is occupied during a single hop
- **Minimum Frequency Occupation Time** is the minimum time each hopping frequency shall be occupied within a given period.
- **Hopping Sequence** is the unrepeated pattern of the hopping frequencies
- **Hopping Frequency Separation** is the frequency separation between 2 adjacent hop frequencies.

Dwell Time

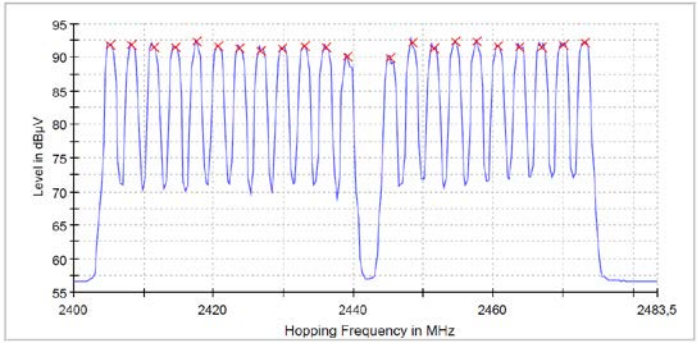
Dwell Time (ms)	Measurement Time (ms)	Frequency (MHz)	Result
1.441	330.000	2405.235670	PASS
1.595	330.000	2473.067588	PASS

Minimum Frequency Occupation

Minimum Frequency Occupation (ms)	Measurement Time (ms)	Frequency (MHz)	Result
5.852	1320.000	2405.235670	PASS
5.940	1320.000	2473.067588	PASS

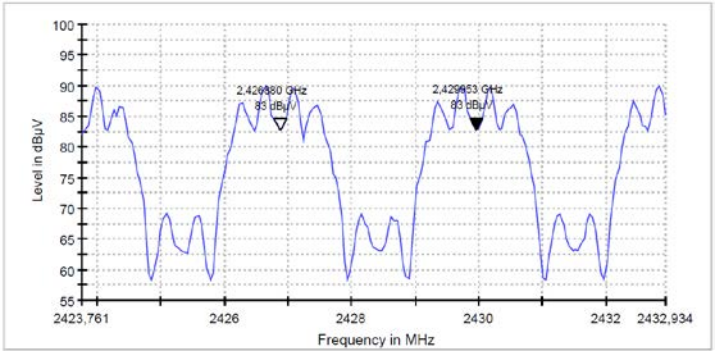
Hopping Sequence

Number of Hopping Frequencies	Result
22	PASS



Hopping Frequency Separation

Hopping Frequency Separation (MHz)	Center Frequency of Separation (MHz)	Result
3.084746	2428.433246	PASS



Medium Utilization – must play nice with the other kids

- The **Medium Utilization (MU) factor** is a measure to quantify the amount of resources (Power and Time) used by non-adaptive equipment. The Medium Utilization factor is defined by the formula:

$$MU = (P/100\ mW) \times DC$$

where:

MU is Medium Utilization factor in %.

P is the RF output power expressed in mW.

DC is the Duty Cycle expressed in %.

  - NOTE: The equipment may have dynamic behavior with regard to duty cycle and corresponding power level. See clause (5.3.1 e).

Medium Utilisation (MU) factor

DUT Frequency (MHz)	Medium Utilisation (MU) (%)	Result	Comment
2400.000000	12.315	FAIL	> 10%
2441.750000	12.307	FAIL	> 10%
2483.500000	12.135	FAIL	> 10%

Medium Utilisation (MU) factor

Medium Utilisation (MU) (%)	Result
2.284	PASS

Annex A: Crib Notes for EN 300 328

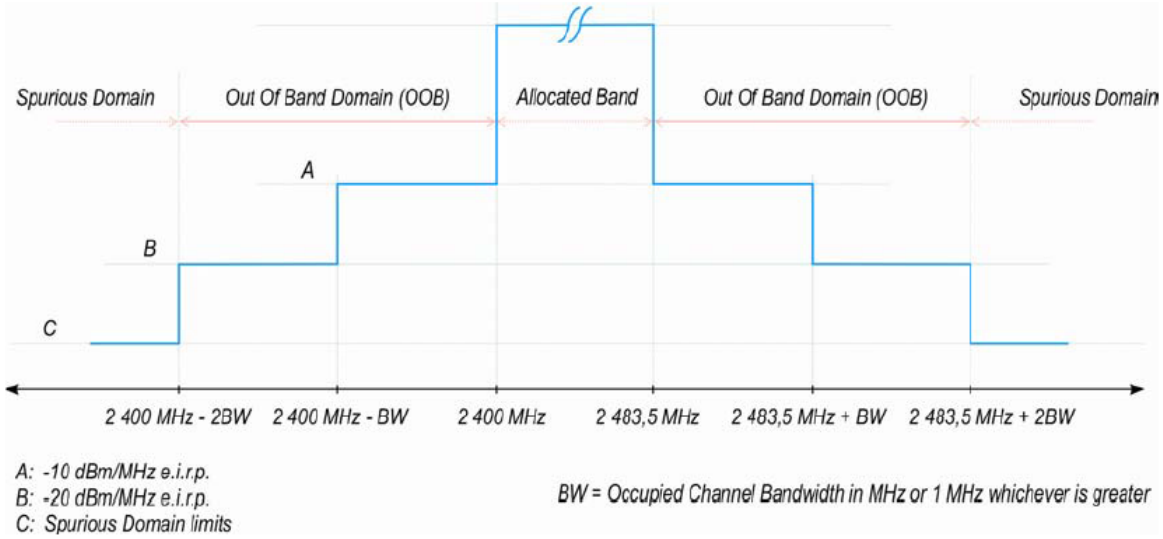
Table A.1: HS Requirements and conformance Test specifications Table (HS-RTT)

Harmonized Standard EN 300 328 The following requirements and test specifications are relevant to the presumption of conformity under the article 3.2 of the R&TTE Directive [i.1]						
Requirement			**Requirement Conditionality**		**Test Specification**	
No	**Description**	**Reference: Clause No**	**U/C**	**Condition**	**E/O**	**Reference: Clause No**
1	RF Output Power	4.3.1.1 or 4.3.2.1	U		E	5.3.2
2	Power Spectral Density	4.3.2.2	C	Only for modulations other than FHSS	E	5.3.3
3	Duty cycle, Tx-Sequence, Tx-gap	4.3.1.2 or 4.3.2.3	C	Only for non-adaptive equipment	E	5.3.2
4	Dwell time, Minimum Frequency Occupation & Hopping Sequence	4.3.1.3	C	Only for FHSS	E	5.3.4
5	Hopping Frequency Separation	4.3.1.4	C	Only for FHSS	E	5.3.5
6	Medium Utilisation	4.3.1.5 or 4.3.2.4	C	Only for non-adaptive equipment	E	5.3.2
7	Adaptivity	4.3.1.6 or 4.3.2.5	C	Only for adaptive equipment	E	5.3.7
8	Occupied Channel Bandwidth	4.3.1.7 or 4.3.2.6	U		E	5.3.8
9	Transmitter unwanted emissions in the OOB domain	4.3.1.8 or 4.3.2.7	U		E	5.3.9
10	Transmitter unwanted emissions in the spurious domain	4.3.1.9 or 4.3.2.8	U		E	5.3.10
11	Receiver spurious emissions	4.3.1.10 or 4.3.2.9	U		E	5.3.11
12	Receiver Blocking	4.3.1.11 or 4.3.2.10	C	Only for adaptive equipment	E	5.3.7

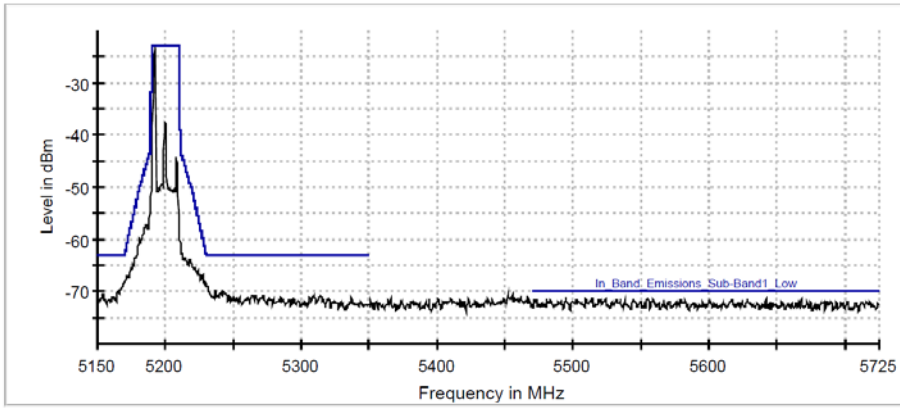
Frequency
Time
BW

Spurious
Emissions
Test

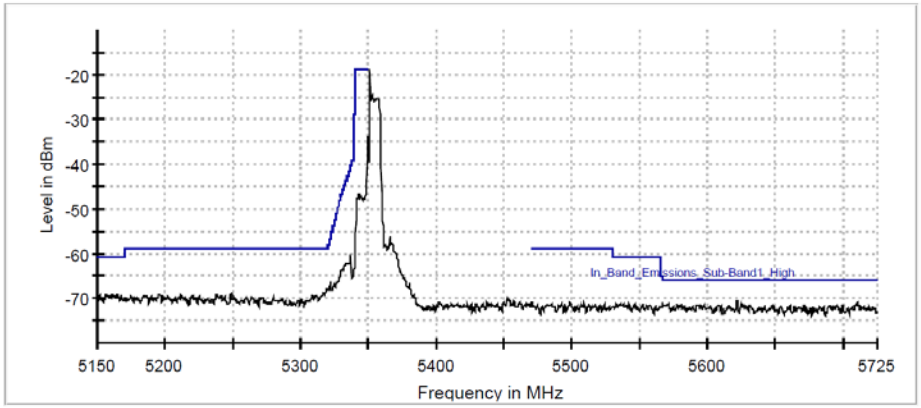
Transmitter Spurious Emissions Test



5150 MHz



5350 MHz



Receiver spurious emissions

- Receiver spurious emissions are emissions at any frequency when the equipment is in receive mode (transmitter is turned off during test).

Table 2: Spurious emission limits for receivers

Frequency range	Maximum power e.r.p. (≤ 1 GHz) e.i.r.p. (> 1 GHz)	Measurement bandwidth
30 MHz to 1 GHz	-57 dBm	100 kHz
1 GHz to 12,75 GHz	-47 dBm	1 MHz

Adaptivity / Coexistence Tests

Table A.1: HS Requirements and conformance Test specifications Table (HS-RTT)

Harmonized Standard EN 300 328 The following requirements and test specifications are relevant to the presumption of conformity under the article 3.2 of the R&TTE Directive [i.1]						
Requirement			**Requirement Conditionality**		**Test Specification**	
No	**Description**	**Reference: Clause No**	**U/C**	**Condition**	**E/O**	**Reference: Clause No**
1	RF Output Power	4.3.1.1 or 4.3.2.1	U		E	5.3.2
2	Power Spectral Density	4.3.2.2	C	Only for modulations other than FHSS	E	5.3.3
3	Duty cycle, Tx-Sequence, Tx-gap	4.3.1.2 or 4.3.2.3	C	Only for non-adaptive equipment	E	5.3.2
4	Dwell time, Minimum Frequency Occupation & Hopping Sequence	4.3.1.3	C	Only for FHSS	E	5.3.4
5	Hopping Frequency Separation	4.3.1.4	C	Only for FHSS	E	5.3.5
6	Medium Utilisation	4.3.1.5 or 4.3.2.4	C	Only for non-adaptive equipment	E	5.3.2
7	Adaptivity	4.3.1.6 or 4.3.2.5	C	Only for adaptive equipment	E	5.3.7
8	Occupied Channel Bandwidth	4.3.1.7 or 4.3.2.6	U		E	5.3.8
9	Transmitter unwanted emissions in the OOB domain	4.3.1.8 or 4.3.2.7	U		E	5.3.9
10	Transmitter unwanted emissions in the spurious domain	4.3.1.9 or 4.3.2.8	U		E	5.3.10
11	Receiver spurious emissions	4.3.1.10 or 4.3.2.9	U		E	5.3.11
12	Receiver Blocking	4.3.1.11 or 4.3.2.10	C	Only for adaptive equipment	E	5.3.7

Adaptivity / Coexistence

EN 300 328 Technical requirements for Adaptivity

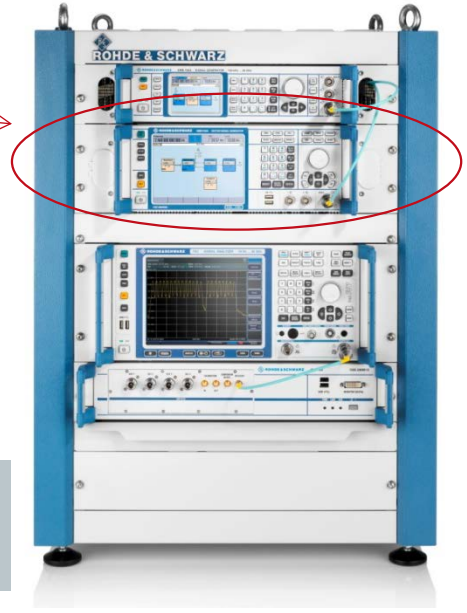
A Device must adapt to is operating environment if:

- The EIRP is higher than 10 dBm (violates space restriction) and / or
- The MU is higher than 10% (violates time restriction)
  - Other tests may still fail, but are often caused by the test mode of the DUT

Devices adapt by detect(ing) and avoid(ing) (DAA) other transmitters

The access point (AP) will use energy detection to “look” for competing signals

- Called Clear Channel Assessment (CCA)
- Must switch to adaptive mode if finds energy
- Must command clients to deal with switch to adaptive mode
- Must keep checking, and adjust again as needed



EN 300 328 Technical requirements for Adaptivity

Buzzword and Acronym Review (Bostonian version)
EIRP = equivalent isotropic radiated power (don't hog my space, bro)
MU = medium utilization (don't hog my time, yo)
CCA = clear channel assessment (hello, do yous guys see me out here)
DAA = detect and avoid (then do something already)

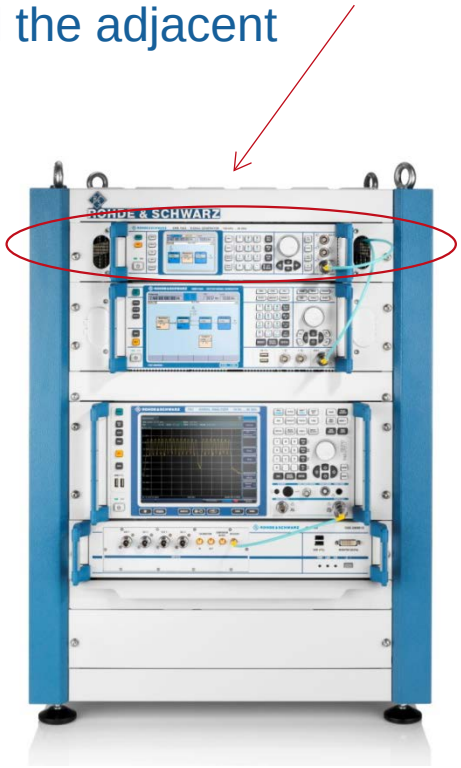
LBT = Listen before talk
Full process of playing nice in the ISM band. Standard wants devices to listen, and make spectrum or transmission time slots unavailable when other signals are present

OEMs can call it something else, but either you restrict your transmission rates or power all the time, or must be adaptive and restrict them when another transmitter is detectable

Receiver Blocking Test

Definition:

- Receiver blocking is a measure of the capability of the Adaptivity mechanism to **operate as intended** in the presence of an unwanted signal (**blocking signal**) on frequencies other than those of the operating channel and the adjacent channels.



ETSI EN 300 328 Annexes

- Annex A (normative): HS Requirements and conformance Test specifications Table (HS-RTT)
- Annex B (normative): Test sites and arrangements for radiated measurement
- Annex C (normative): Measurement procedures for radiated measurement
- Annex D (informative): Guidance for testing IEEE 802.11nŽ Equipment
  - D.1 Introduction
  - D.2 Possible Modulations
    - D.2.1 Guidance for Testing
  - D.3 Possible Operating Modes
    - D.3.1 Guidance for Testing
- Annex E (informative): Application form for testing

- Annex E (informative): Application form for testing
  - E.1 Information as required by EN 300 328 V1.8.1, clause 5.3.1
  - E.2 Combination for testing (see clause 5.1.3.3 of EN 300 328 V1.8.1)
  - E.3 Additional information provided by the applicant
    - E.3.1 Modulation:
    - E.3.2 Duty Cycle
    - E.3.3 About the UUT
    - E.3.4 Additional items and/or supporting equipment provided

ETSI EN 300 328 Annex E
Application form for testing

Annex E (informative): Application form for testing

Notwithstanding the provisions of the copyright clause related to the text of the present document, ETSI grants that users of the present document may freely reproduce the application form in this annex so that it can be used for its intended purposes and may further publish the completed application form.

The form contained in this annex may be used by the supplier to comply with the requirement contained in clause 5.3.1 to provide the necessary information about the equipment to the test laboratory prior to the testing. It contains product information as well as other information which might be required to define which configurations are to be tested, which tests are to be performed as well the test conditions.

This application form should form an integral part of the test report.

E.1 Information as required by EN 300 328 V1.8.1, clause 5.3.1

In accordance with EN 300 328, clause 5.3.1, the following information is provided by the supplier.

a) The type of modulation used by the equipment:

☐ FHSS

☐ other forms of modulation

b) In case of FHSS modulation:

- In case of non-Adaptive Frequency Hopping equipment:
  The number of Hopping Frequencies: ……
- In case of Adaptive Frequency Hopping Equipment:
  The maximum number of Hopping Frequencies: ……
  The minimum number of Hopping Frequencies: ……
- The Dwell Time: ……
- The Minimum Channel Occupation Time: ……

c) Adaptive / non-adaptive equipment:

☐ non-adaptive Equipment

☐ adaptive Equipment without the possibility to switch to a non-adaptive mode

☐ adaptive Equipment which can also operate in a non-adaptive mode

d) In case of adaptive equipment:

The Channel Occupancy Time implemented by the equipment: ..... ms

☐ The equipment has implemented an LBT based DAA mechanism

- In case of equipment using modulation different from FHSS:
  ☐ The equipment is Frame Based equipment
  ☐ The equipment is Load Based equipment

☐ The equipment can switch dynamically between Frame Based and Load Based equipment

The CCA time implemented by the equipment: ..... µs

The value q as referred to in clause 4.3.2.5.2.2.2 .....

☐ The equipment has implemented an non-LBT based DAA mechanism

☐ The equipment can operate in more than one adaptive mode

e) In case of non-adaptive Equipment:

The maximum RF Output Power (e.i.r.p.): ..... dBm

The maximum (corresponding) Duty Cycle: ..... %

Equipment with dynamic behaviour, that behaviour is described here. (e.g. the different combinations of duty cycle and corresponding power levels to be declared):

.....

.....

.....

f) The worst case operational mode for each of the following tests:

- RF Output Power
  .....
- Power Spectral Density
  .....
- Duty cycle, Tx-Sequence, Tx-gap
  .....
- Dwell time, Minimum Frequency Occupation & Hopping Sequence (only for FHSS equipment)
  .....
- Hopping Frequency Separation (only for FHSS equipment)
  .....
- Medium Utilisation
  .....
- Adaptivity & Receiver Blocking
  .....
- Occupied Channel Bandwidth
  .....
- Transmitter unwanted emissions in the OOB domain
  .....
- Transmitter unwanted emissions in the spurious domain
  .....

- Receiver spurious emissions
  .....

g) The different transmit operating modes (tick all that apply):

☐ Operating mode 1: Single Antenna Equipment

☐ Equipment with only 1 antenna

☐ Equipment with 2 diversity antennas but only 1 antenna active at any moment in time

☐ Smart Antenna Systems with 2 or more antennas, but operating in a (legacy) mode where only 1 antenna is used. (e.g. IEEE 802.11™ [i.3] legacy mode in smart antenna systems)

☐ Operating mode 2: Smart Antenna Systems - Multiple Antennas without beam forming

☐ Single spatial stream / Standard throughput / (e.g. IEEE 802.11™ [i.3] legacy mode)

☐ High Throughput (> 1 spatial stream) using Occupied Channel Bandwidth 1

☐ High Throughput (> 1 spatial stream) using Occupied Channel Bandwidth 2

NOTE: Add more lines if more channel bandwidths are supported.

☐ Operating mode 3: Smart Antenna Systems - Multiple Antennas with beam forming

☐ Single spatial stream / Standard throughput (e.g. IEEE 802.11™ [i.3] legacy mode)

☐ High Throughput (> 1 spatial stream) using Occupied Channel Bandwidth 1

☐ High Throughput (> 1 spatial stream) using Occupied Channel Bandwidth 2

NOTE: Add more lines if more channel bandwidths are supported.

h) In case of Smart Antenna Systems:

- The number of Receive chains: .....
- The number of Transmit chains: .....

☐ symetrical power distribution

☐ asymmetrical power distribution

In case of beam forming, the maximum beam forming gain: .....

NOTE: Beam forming gain does not include the basic gain of a single antenna.

i) Operating Frequency Range(s) of the equipment:

- Operating Frequency Range 1: ..... MHz to ..... MHz
- Operating Frequency Range 2: ..... MHz to ..... MHz

NOTE: Add more lines if more Frequency Ranges are supported.

j) Occupied Channel Bandwidth(s):

- Occupied Channel Bandwidth 1: ..... MHz
- Occupied Channel Bandwidth 2: ..... MHz

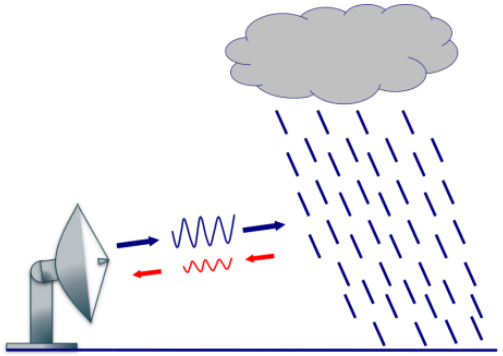
NOTE: Add more lines if more channel bandwidths are supported.

k) Type of Equipment (stand-alone, combined, plug-in radio device, etc.):

☐ Stand-alone

EN 301 893 v 1.7.1 For 5 GHz Band

- Same general tests but with different limits
- Implements Transmit Power Control for non-continuous bands
- Must use Dynamic Frequency Selection (DFS)
  - Sense and avoid Doppler weather radar
  - If sees 5 GHz signals must abandon channel
- Adaptivity reserved for other RLANs
  - Time delay to get clear channel



Channel Availability Check for Radar

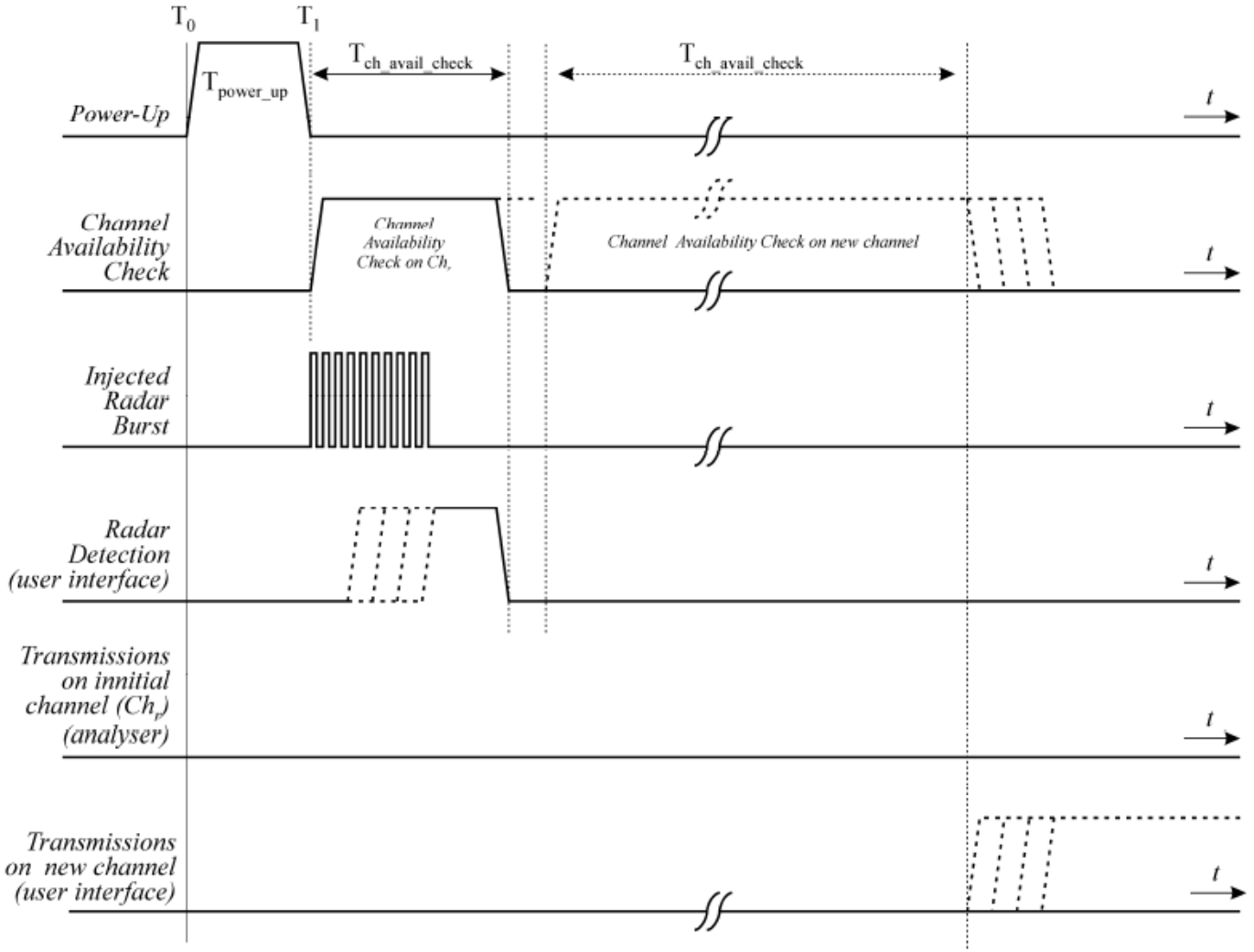


Figure 7: Example of timing for radar testing at the beginning of the Channel Availability Check Time

Clear Channel Assessment for other WLANs

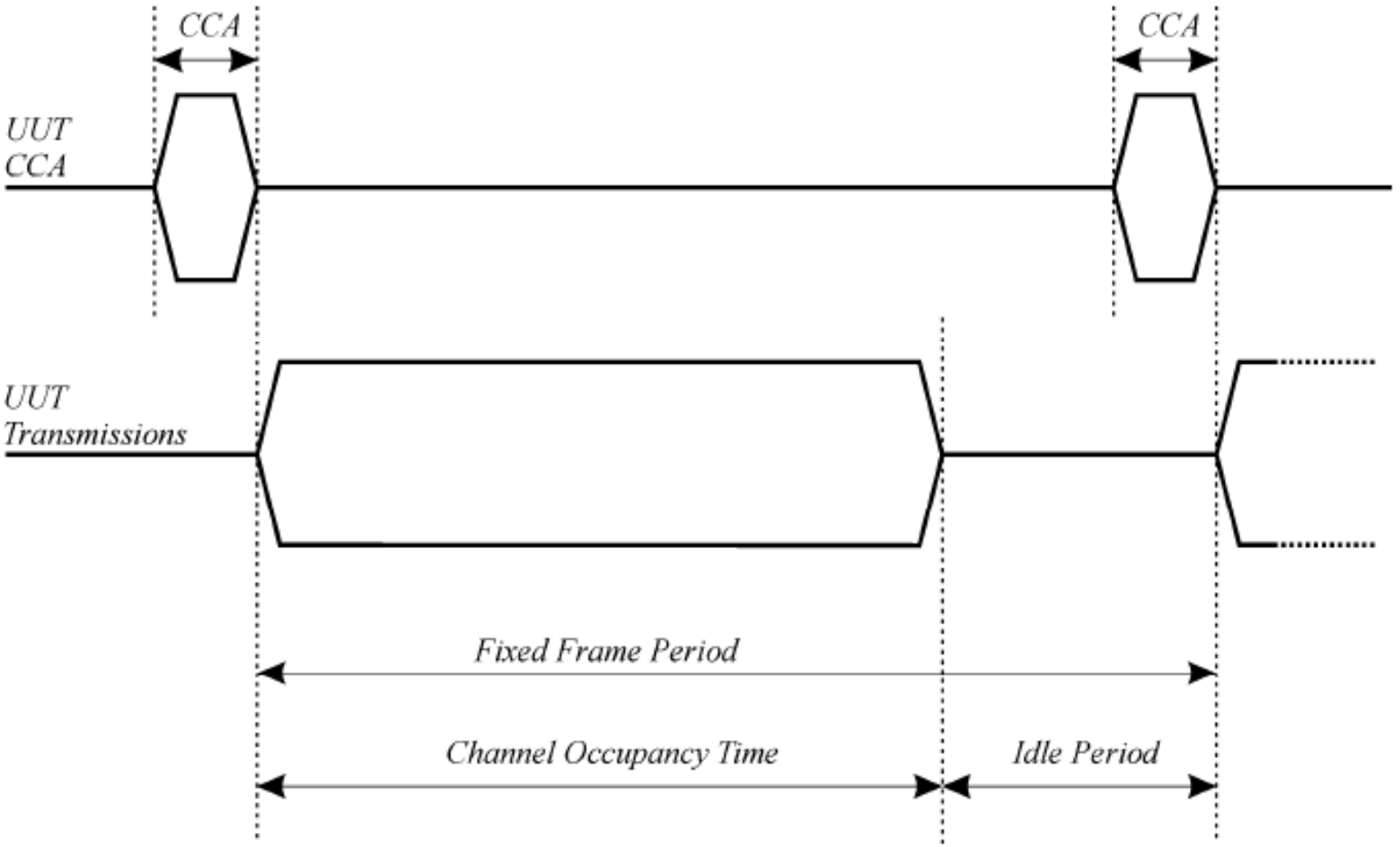
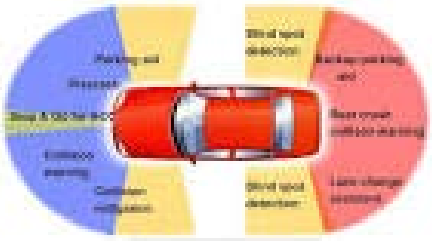


Figure 2: Example of timing for Frame Based Equipment

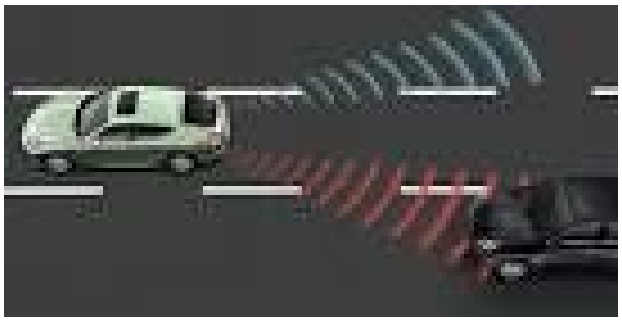
Insider Info: EN 300 328 V1.9.1

- Now the bad news
- WiFi OEM's aren't happy with changes
  - Didn't pay attention, industrial automation OEMs shaped the standard
- WiFi OEMs have "shaped" a version 1.9.1 up for vote that makes many of these tests "optional"
- Both versions could issue Jan 1, 2015 (V1.8.1 comes in force in 2015)
- So all this may not really matter if the WiFi OEMs have their way
- Will be interesting to see outcome

The Future? 802.11P Car-to-Car Communication



Collision Avoidance



Lane Change Assist