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## TEST REPORT

Test report no.: 1-3116/16-01-21



### Testing Laboratory

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#### Accredited Testing Laboratory:

The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2005) by the Deutsche Akkreditierungsstelle GmbH (DAkkS)

The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate with the registration number: D-PL-12076-01-01

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### Manufacturer

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### Test Standard/s

47 CFR Part 15

Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices

RSS - 247 Issue 2

Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSS) and Licence - Exempt Local Area Network (LE-LAN) Devices

For further applied test standards please refer to section 3 of this test report.

### Test Item

**Kind of test item:** Embedded ARM Module

**Model name:** ConnectCore i.MX6UL

Frequency: 5150 MHz to 5350 MHz & 5470 MHz to 5850MHz

Technology tested: WLAN (DFS Client only)

Antenna: Integrated antenna

Power supply: 5.0V DC

Temperature range: -40°C to +80°C



This test report is electronically signed and valid without handwriting signature. For verification of the electronic signatures, the public keys can be requested at the testing laboratory.

### Test report authorized:

René Oelmann  
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### Test performed:

David Lang  
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## 2 General Information

### 2.1 Notes and disclaimer

The test results of this test report relate exclusively to the test item specified in this test report. CTC advanced GmbH does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item.

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### 2.2 Application details

Date of receipt of order:	2017-01-16
Date of receipt of test item:	2017-01-16
Start of test:	2017-03-03
End of test:	2017-03-03
Person(s) present during the test:	-/-

### 2.3 Test Laboratories sub-contracted

None

### 3 Test standard/s

Test Standard	Date	Test Standard Description
47 CFR Part 15		Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices
RSS - 247 Issue 2	February 2017	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSS) and Licence - Exempt Local Area Network (LE-LAN) Devices

#### 3.1 Measurement guidance

Guidance	Version	Description
UNII: KDB 789033 D02	v01	Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices - Part 15, Subpart E
UNII: KDB 905462 D04	v01	Operational Modes suggested for DFS Testing
UNII: KDB 905462 D02	v01r01	Compliance measurement procedures for unlicensed - national information infrastructure devices operating in the 5250 - 5350 MHz and 5470 - 5725 MHz bands incorporating dynamic frequency selection
UNII: KDB 905462 D02	v01r02	Compliance measurement procedures for unlicensed - national information infrastructure devices operating in the 5250 - 5350 MHz and 5470 - 5725 MHz bands incorporating dynamic frequency selection
KDB 662911 D01	V02r01	Emissions Testing of Transmitters with Multiple Outputs in the Same Band

## 4 Test Environment

Temperature:	$T_{nom}$	+22 °C during room temperature tests
	$T_{max}$	+80 °C not tested
	$T_{min}$	-40 °C not tested
Relative humidity:		55 %
Air pressure:		not relevant for this kind of testing
Power supply:	$V_{nom}$	5.0 V DC
	$V_{max}$	5.5 V DC not tested
	$V_{min}$	3.7 V DC not tested

## 5 Test item

### 5.1 General description

Kind of test item	:	Embedded ARM Module
Type identification	:	ConnectCore i.MX6UL
HMN	:	-/-
PMN	:	CC IMX6UL
HVIN	:	55001944-xx
FVIN	:	82004060
S/N serial number	:	UL-SBC 018
HW hardware status	:	55001944-01 rev 1P
SW software status	:	82004060 rev 1P
Frequency band	:	5150 MHz to 5350 MHz & 5470 MHz to 5850MHz
Type of modulation	:	OFDM
Antenna	:	Integrated antenna
Power supply	:	5.0 V DC
Temperature range	:	-40°C to +80°C

### 5.2 Additional information

The content of the following annexes is defined in the QA. It may be that not all of the listed annexes are necessary for this report, thus some values in between may be missing.

Test setup- and EUT-photos are included in test report: 1-3116/16-01-01\_AnnexA  
 1-3116/16-01-01\_AnnexB

## 6 Measurement uncertainty

Measurement uncertainty	
Test case	Uncertainty
Frequency accuracy (radar burst)	0.1 Hz
Level accuracy (radar burst)	± 0.8 dB

## 7 Summary of measurement results

<input checked="" type="checkbox"/>	No deviations from the technical specifications were ascertained
<input type="checkbox"/>	There were deviations from the technical specifications ascertained
<input checked="" type="checkbox"/>	This test report is only a partial test report. The content and verdict of the performed test cases are listed below.

TC Identifier	Description	Verdict	Date	Remark
DFS-Testing	CFR Part 15, FCC 06-96	Pass	2017-03-13	DFS only

Test Standard Clause	Test Case	Bandwidth	C	NC	NA	NP	Remark
7.8.1*3	U-NII Detection Bandwidth	-/-	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	*1*2*3
§15.407 (h)(2)	DFS Detection Threshold	-/-	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	*1*2*3
§15.407 (h)(2) (ii) & 7.8.2*3	Channel Availability Check Time	-/-	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	*1*3
§15.407 (h)(2) (iv) & 7.8.3*3	Non-Occupancy Period	80 MHz	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	*1
§15.407 (h)(2) (iii) & 7.8.2*3	Channel Move Time / Channel Closing Transmission Time	80 MHz	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	*2
7.8.3 & 7.8.4*3	In-Service Monitoring / Statistical Performance Check	-/-	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	*2*3

### Abbreviations/References:

- C Compliant
- NC Not compliant
- NA Not applicable
- NP Not performed
- \*1 Prior to use of a channel
- \*2 During normal operation
- \*3 Not applicable for Client Devices without radar detection.

## 8 Additional comments

Reference documents: None

Special test descriptions: All tests except the In-Service Monitoring are conducted with Pulse Type 0.  
A sample with temporary antenna connector was provided to perform the measurements in a conducted way.

Configuration descriptions: Iperf was used to generate the required channel load (duty cycle grater 17 percent).

DFS functionality:

- Master device
- Client with radar detection
- Client without radar detection

## 9 RF measurements

### 9.1 Description of test setup

#### 9.1.1 Conducted measurements

##### Setup

Figure 1 shows a setup whereby the UUT is a RLAN device operating in slave mode, without Radar Interference Detection function. This setup also contains a RLAN device operating in master mode. The radar test signals are injected into the master device. The UUT (slave device) is associated with the master device.

Figure 1 shows an example

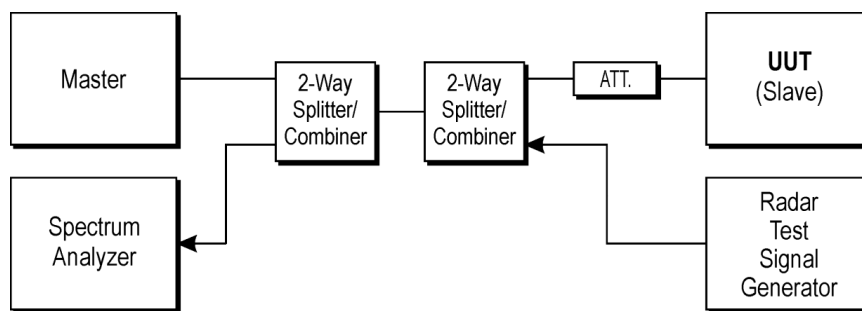


Figure 1: Setup

RPP = SG - CA  
 (RPP-radar pulse power; SG-signal generator power; CA-loss signal path)

Example calculation:

$$RPP \text{ [dBm]} = -30.0 \text{ [dBm]} - 33.0 \text{ [dB]} = -63.0 \text{ [dBm]}$$

##### Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No Cetecom	Kind of Calibration	Last Calibration	Next Calibration
1	A	Vektor Signal Generator	SMU200A	R&S	101633	300003496	k	07.04.2014	07.04.2017
2	A	Spectrum Analyzer 9kHz to 30GHz - 140..+30dBm	FSP30	R&S	100886	300003575	k	27.01.2016	27.01.2018
3	A	DFS-test site	div. Splitter, Cables, Attenuators	Mini-Circuits	na	300004557	ev	-/-	-/-
4	A	Dual Band Gigabit Router*	RT-AC68U	Asus	F11MOH056666	400001244	ne	-/-	-/-
5	A	PC	ExOne	F+W	2890296v001	300005102	ne	-/-	-/-
6	A	RF-Cable DFS-Tester No. 1	Enviroflex 316 D	Huber & Suhner	Batch no. 1560522	400001257	ev	-/-	-/-
7	A	RF-Cable DFS-Tester No. 6	Enviroflex 316 D	Huber & Suhner	Batch no. 1560522	-/-	-/-	-/-	-/-

\* FCC ID: MSQ-RTAC68U

##### Agenda: Kind of Calibration

k	calibration / calibrated	EK	limited calibration
ne	not required (k, ev, izw, zw not required)	zw	cyclical maintenance (external cyclical maintenance)
ev	periodic self verification	izw	internal cyclical maintenance
Ve	long-term stability recognized	g	blocked for accredited testing
vkl!	Attention: extended calibration interval	*)	next calibration ordered / currently in progress
NK!	Attention: not calibrated		



## 9.2 Parameters of DFS test signals

### 9.2.1 DFS Detection Thresholds for Master Devices as well as Client Devices With Radar Detection

Maximum Transmit Power EIRP	Value (see note)
≥ 200 mW	-64 dBm
< 200 mW and power spectral density < 10 dBm/MHz	-62 dBm
< 200 mW and That do not meet the power spectral density < 10 dBm/MHz	-64 dBm

Note 1: This is the level at the input of the receiver assuming a 0 dBi receive antenna.  
 Note 2: Throughout these test procedures an additional 1 dB has been added to the amplitude of the test transmission waveforms to account for variations in measurement equipment. This will ensure that the test signal is at or above the detection threshold level to trigger a DFS response.  
 Note3: EIRP is based on the highest antenna gain. For MIMO devices refer to KDB Publication 662911 D01.

### 9.2.2 DFS Response Requirement Values

Parameter	Value
Non-occupancy period	minimum 30 minutes
Channel Availability Check Time	60 seconds
Channel Move Time	10 seconds See Note 1.
Channel Closing Transmission Time	200 milliseconds + an aggregate of 60 milliseconds over remaining 10 second period. See Notes 1 and 2.
U-NII Detection Bandwidth	Minimum 100% of the U-NII 99% transmission power bandwidth. See Note 3.

Note 1: Channel Move Time and the Channel Closing Transmission Time should be performed with Radar Type 0. The measurement timing begins at the end of the Radar Type 0 burst.  
 Note 2: The Channel Closing Transmission Time is comprised of 200 milliseconds starting at the beginning of the Channel Move Time plus any additional intermittent control signals required to facilitate a Channel move (an aggregate of 60 milliseconds) during the remainder of the 10 second period. The aggregate duration of control signals will not count quiet periods in between transmissions.  
 Note 3: During the U-NII Detection Bandwidth detection test, radar type 0 should be used. For each frequency step the minimum percentage of detection is 90 percent. Measurements are performed with no data traffic.

### 9.2.3 Radar Test Waveforms

This section provides the parameters for required test waveforms, minimum percentage of successful detections, and the minimum number of trials that must be used for determining DFS conformance.

#### Short Pulse Radar Test Waveforms

Radar Type	Pulse Width (µsec)	PRI (µsec)	Number of Pulses	Minimum Percentage of Successful Detection	Minimum Number of Trials
0	1	1428	18	See Note 1	See Note 1
1	1	Test A: 15 unique PRI values randomly selected from the list of 23 PRI values in Table 5a	Roundup $\left\{ \left( \frac{1}{360} \right) \cdot \left( \frac{19 \cdot 10^6}{PRI_{\mu sec}} \right) \right\}$	60%	30
		Test B: 15 unique PRI values randomly selected within the range of 518-3066 µsec, with a minimum increment of 1 µsec, excluding PRI values selected in Test A			
2	1-5	150-230	23-29	60%	30
3	6-10	200-500	16-18	60%	30
4	11-20	200-500	12-16	60%	30
Aggregate (Radar Types 1-4)				80%	120
Note 1: Short Pulse Radar Type 0 should be used for the detection bandwidth test, channel move time, and channel closing time tests.					

A minimum of 30 unique waveforms are required for each of the Short Pulse Radar Types 2 through 4.

**Pulse Repetition Intervals Values for Test A**

Pulse Repetition Frequency Number	Pulse Repetition Frequency (Pulses Per Second)	Pulse Repetition Interval (Microseconds)
1	1930.5	518
2	1858.7	538
3	1792.1	558
4	1730.1	578
5	1672.2	598
6	1618.1	618
7	1567.4	638
8	1519.8	658
9	1474.9	678
10	1432.7	698
11	1392.8	718
12	1355	738
13	1319.3	758
14	1285.3	778
15	1253.1	798
16	1222.5	818
17	1193.3	838
18	1165.6	858
19	1139	878
20	1113.6	898
21	1089.3	918
22	1066.1	938
23	326.2	3066

**Long Pulse Radar Test Waveform**

Radar Type	Pulse Width (µsec)	Chirp Width (MHz)	PRI (µsec)	Number of Pulses per Burst	Number of Bursts	Minimum Percentage of Successful Detection	Minimum Number of Trails
5	50-100	5-20	1000-2000	1-3	8-20	80%	30

The parameters for this waveform are randomly chosen. Thirty unique waveforms are required for the Long Pulse Radar Type waveforms.

**Frequency Hopping Radar Test Waveform**

Radar Type	Pulse Width (µsec)	Chirp Width (MHz)	Pulses per Hop	Hopping Rate (kHz)	Hopping Sequence Length (msec)	Minimum Percentage of Successful Detection	Minimum Number of Trails
6	1	333	9	0.333	300	70%	30

For the Frequency Hopping Radar Type, the same Burst parameters are used for each waveform. The hopping sequence is different for each waveform and a 100-length segment is selected from the hopping sequence defined.

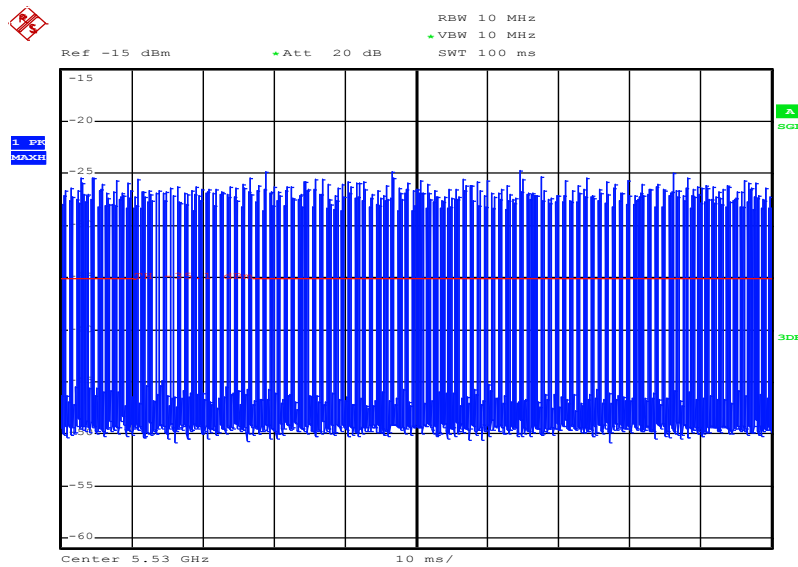
The first frequency in a hopping sequence is selected randomly from the group of 475 integer frequencies from 5250 – 5724 MHz. Next, the frequency that was just chosen is removed from the group and a frequency is randomly selected from the remaining 474 frequencies in the group. This process continues until all 475 frequencies are chosen for the set.

### 9.3 Test preparation

#### 9.3.1 Channel loading

Timing plots are required with calculations demonstrating a minimum channel loading of approximately 17% or greater. For example, channel loading can be estimated by setting the spectrum analyzer for zero span and approximate the Time On/ (Time On + Off Time). This can be done with any appropriate channel BW and modulation type.

HT80-Mode: Calculated duty cycle = 17.5%

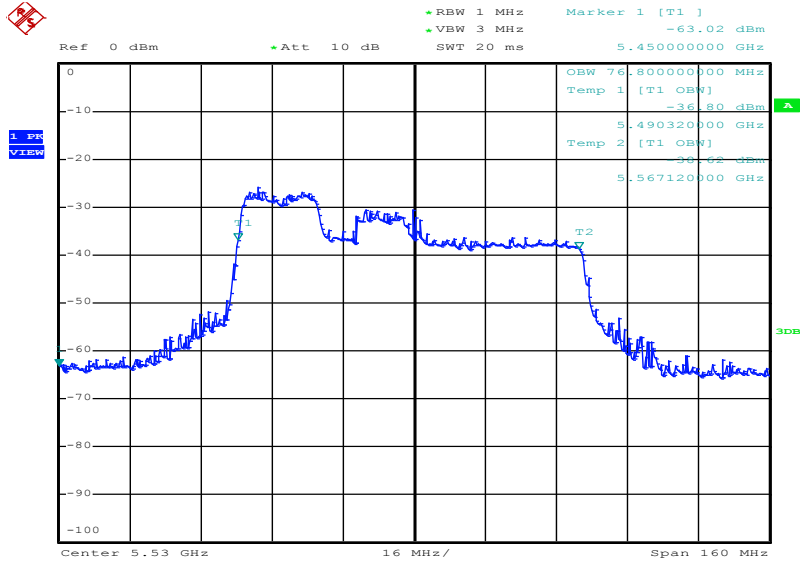


Date: 3.MAR.2017 11:02:50

Plot 1

### 9.3.2 99% Bandwidth to determine the U-NII-bandwidth

HT80-Mode: 76.8 MHz



Date: 3.MAR.2017 10:34:51

Plot 2

## 9.4 Test results (prior to use of a channel)

Not applicable.

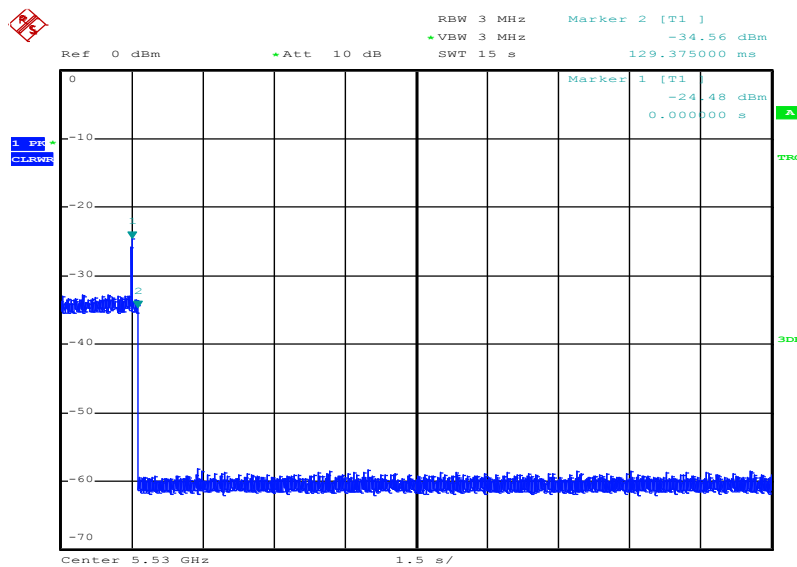
## 9.5 Test results (during normal operation)

### 9.5.1 Channel move time / channel closing transmission time

After a radar's presence is detected, all transmissions shall cease on the operating channel within 10 seconds. Transmissions during this period shall consist of normal traffic for a maximum of 200 ms after detection of the radar signal. In addition, intermittent management and control signals can be sent during the remaining time to facilitate vacating the operating channel not exceeding 60ms.

The test is performed during normal operation with the highest bandwidth supported by the DUT.

#### Channel Closing Time

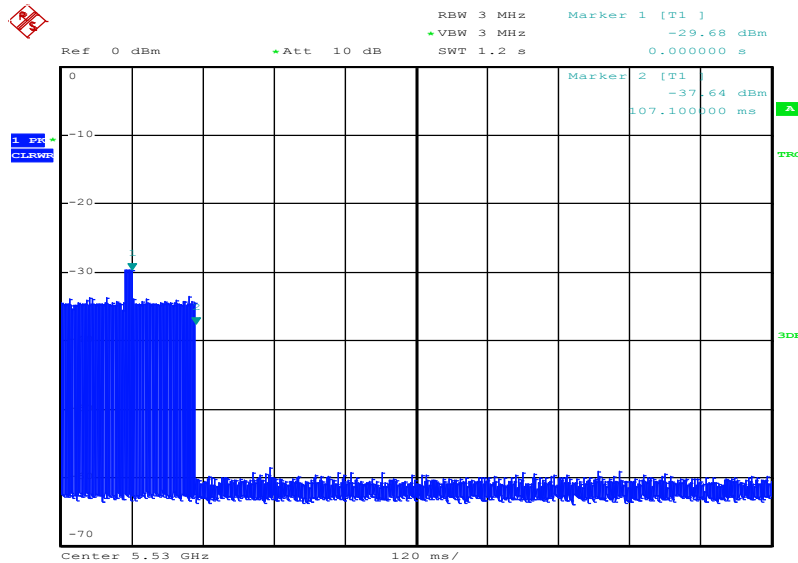


Date: 3.MAR.2017 11:04:11

**Plot 3**

Note: With Marker 1 at the end of the radar pulse ( $t = 0$ ms) the Channel Closing Time is determined by setting Marker 2 to the point where the last transmission occurred. The Channel Closing Time is 129.4ms.

**Channel Closing Transmission Time**



Date: 3.MAR.2017 11:43:02

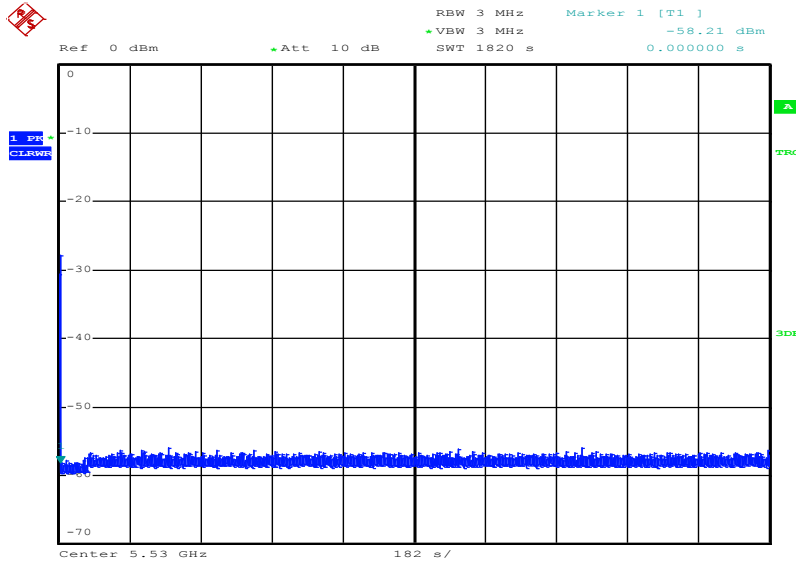
**Plot 4**

Note: The accumulated transmission time is calculated by the number of bins occurring after  $t = 200\text{ms}$  multiplied with the Time-per-sweep point-factor resulting from the Sweep Time and number of Sweep Points of the Spectrum Analyser.  
 The Channel Closing Transmission Time is 0.0ms.



### 9.5.2 Non-Occupancy Period

A channel that has been flagged as containing a radar system, either by a channel availability check or in-service monitoring, is subject to a non-occupancy period of at least 30 minutes. The non occupancy period starts at the time when the radar system is detected.



Date: 3.MAR.2017 13:56:36

Plot 5

## 10 Observations

No observations except those reported with the single test cases have been made.

## Annex A Document history

Version	Applied changes	Date of release
	Initial release	2017-03-13

## Annex B Further information

### Glossary

AVG	-	Average
DUT	-	Device under test
EMC	-	Electromagnetic Compatibility
EN	-	European Standard
EUT	-	Equipment under test
ETSI	-	European Telecommunications Standard Institute
FCC	-	Federal Communication Commission
FCC ID	-	Company Identifier at FCC
HW	-	Hardware
IC	-	Industry Canada
Inv. No.	-	Inventory number
N/A	-	Not applicable
PP	-	Positive peak
QP	-	Quasi peak
S/N	-	Serial number
SW	-	Software
PMN	-	Product marketing name
HMN	-	Host marketing name
HVIN	-	Hardware version identification number
FVIN	-	Firmware version identification number
OBW		Occupied Bandwidth
OC		Operating Channel
OCW		Operating Channel Bandwidth
OOB		Out Of Band

## Annex C Accreditation Certificate

first page

last page



Deutsche Akkreditierungsstelle GmbH

Befehlens gemäß § 8 Absatz 1 AkkStelleG i.V.m. § 1 Absatz 1 AkkStelleGBV  
Unterzeichnerin der Multilateralen Abkommen  
von EA, ILAC und IAF zur gegenseitigen Anerkennung

### Akkreditierung



Die Deutsche Akkreditierungsstelle GmbH bestätigt hiermit, dass das Prüflaboratorium

**CTC advanced GmbH**  
Untertürkheimer Straße 6-10, 66117 Saarbrücken

die Kompetenz nach DIN EN ISO/IEC 17025:2005 besitzt, Prüfungen in folgenden Bereichen durchzuführen:

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Kanaidische Anforderungen  
US-Anforderungen  
Akustik  
Near Field Communication (NFC)

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Registrierungsnummer der Urkunde: D-PL-12076-01-01

Frankfurt, 25.11.2016

Stelle Minister auf der Rückseite

Im Auftrag Dipl.-Ing. Ralf Eigner  
Abteilungsleiter

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38116 Braunschweig

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**Note:**  
The current certificate including annex can be received on request.