**3GPP TSG-RAN WG4 Meeting #116 R4-25xxxxx**

**Bengaluru, India, August 25th – 29th, 2025**

**Agenda item:** 7.22.1

**Source:** Moderator (CMCC)

**Title:** Topic summary for [116][134] A-IoT\_device

**Document for:** Information

# Introduction

This summary focuses on the R19 ambient IOT work item under agenda 7.22.2, 7.22.3.2, 7.22.5, including general, device and OTA requirements. The way forward agreed in RAN4#115 is R4-2508116.

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| --- | --- | --- | --- |
| **TDoc** | **Title** | **Source** | **Agenda item** |
| R4-2509062 | Topic summary for [116][219] Ambient\_IoT\_Solutions | Moderator (CMCC) | 7.22.1 |
| R4-2509101 | Topic summary for [116][134] A-IoT\_device | Moderator (CMCC) | 7.22.1 |
| R4-2509102 | Topic summary for [116][135] A-IoT\_BSCW | Moderator (Huawei) | 7.22.1 |
| R4-2509896 | big draft CR for TS 38.194 | Huawei, HiSilicon | 7.22.1 |
| R4-2509897 | draft TS 38.194 | Huawei, HiSilicon | 7.22.1 |
| R4-2511481 | Topic summary for [116][335] A-IoT\_demod | Moderator (CMCC) | 7.22.1 |
| [**R4-2509329**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509329.zip) | Discussion on system parameters for A-IoT | CATT | 7.22.2 |
| [**R4-2509713**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509713.zip) | Discussion on A-IoT System parameters | CMCC | 7.22.2 |
| [**R4-2509717**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509717.zip) | TP for TR 38.194 5.3 BS channel bandwidth and 5.4 Channel arrangement | CMCC | 7.22.2 |
| [**R4-2509719**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509719.zip) | TP for TR 38.191 section 3 Definitions, symbols and abbreviations | CMCC | 7.22.2 |
| [**R4-2509806**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509806.zip) | Discussion on AIoT system parameters | Xiaomi | 7.22.2 |
| [**R4-2509882**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509882.zip) | A-IoT general aspects | Huawei, HiSilicon | 7.22.2 |
| [**R4-2510118**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510118.zip) | Discussion on system parameters for ambient IoT | Spreadtrum,UNISOC | 7.22.2 |
| [**R4-2510246**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510246.zip) | Discussion on the system parameter of AIoT | vivo | 7.22.2 |
| [**R4-2510389**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510389.zip) | Work plan for R19 AIOT demodulation performance part | CMCC, Huawei, HiSilicon | 7.22.2 |
| [**R4-2510847**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510847.zip) | on system parameter | OPPO | 7.22.2 |
| [**R4-2511125**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2511125.zip) | Discussions on General aspect for A-IoT | ZTE Corporation, Sanechips | 7.22.2 |
| [**R4-2511435**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2511435.zip) | TP for 38.191 maximum output power and D2R channel bandwidth | Ericsson | 7.22.2 |
| [**R4-2511436**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2511436.zip) | A-IoT general overview | Ericsson | 7.22.2 |
| [**R4-2509358**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509358.zip) | Discussion on Ambient IoT device 1 RF requirements | CATT | 7.22.3.2 |
| [**R4-2509364**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509364.zip) | TP for TS 38.191 Clause 4 on General | CATT | 7.22.3.2 |
| [**R4-2509712**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509712.zip) | Discussion on A-IoT device requirements | CMCC | 7.22.3.2 |
| [**R4-2509720**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509720.zip) | TP for TR 38.191 section 5.3 Channel bandwidth and 5.4 Channel Arrangement | CMCC | 7.22.3.2 |
| [**R4-2509807**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509807.zip) | Discussion on AIoT device 1 RF requirements | Xiaomi | 7.22.3.2 |
| [**R4-2509809**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509809.zip) | TP for TS 38.191: General and Operating bands | Xiaomi | 7.22.3.2 |
| [**R4-2509935**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509935.zip) | RF requirements of ambient IoT device 1 | Sony | 7.22.3.2 |
| [**R4-2510080**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510080.zip) | Discussion on RF requirement for A-IoT device 1 | LG Electronics UK | 7.22.3.2 |
| [**R4-2510119**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510119.zip) | Discussion on RF requirements for ambient IoT device 1 | Spreadtrum,UNISOC | 7.22.3.2 |
| R4-2510204 | draft TP for TS 38.191 Clause 7.3 Maximum input level | Spreadtrum,UNISOC | 7.22.3.2 |
| [**R4-2510210**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510210.zip) | TP for TS 38.191 Clause 7.3 Maximum input level | Spreadtrum,UNISOC | 7.22.3.2 |
| [**R4-2510248**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510248.zip) | Discussion on the RF requirement of AIoT device | vivo | 7.22.3.2 |
| [**R4-2510251**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510251.zip) | TP to TS 38.191 on device unwanted emssion | vivo | 7.22.3.2 |
| [**R4-2510845**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510845.zip) | on AIOT Device requirement | OPPO | 7.22.3.2 |
| [**R4-2510972**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510972.zip) | REFSENS procedure | Qualcomm Incorporated | 7.22.3.2 |
| [**R4-2511128**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2511128.zip) | Discussion on RF requirement of Ambient IoT device | ZTE Corporation, Sanechips | 7.22.3.2 |
| [**R4-2511129**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2511129.zip) | TP to TS38.191 FRC for device 1 REFSENS | ZTE Corporation, Sanechips | 7.22.3.2 |
| [**R4-2511420**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2511420.zip) | On the RF requirements for Ambient IoT Device | Huawei, HiSilicon | 7.22.3.2 |
| [**R4-2511421**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2511421.zip) | TP to TS38.191 Introduction of receiver sensitivity requirements for Ambient IoT devices | Huawei, HiSilicon | 7.22.3.2 |
| [**R4-2511434**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2511434.zip) | TP for 38.191 backscatter power loss | Ericsson, Sony | 7.22.3.2 |
| [**R4-2511437**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2511437.zip) | A-IoT device requirement overview | Ericsson | 7.22.3.2 |
| [**R4-2511601**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2511601.zip) | On the RF requirements for Ambient IoT Device | Huawei Technologies R&D UK | 7.22.3.2 |
| R4-2511651 | DraftCR to TS38.191 on ambient IoT device | LG Electronics UK | 7.22.3.2 |
| [**R4-2509036**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509036.zip) | on ambient device OTA tests | Huawei, HiSilicon | 7.22.5 |
| [**R4-2509106**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509106.zip) | Text Proposal for 39.191 clause 8.4 | Huawei, HiSilicon | 7.22.5 |
| [**R4-2509107**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509107.zip) | Text Proposal for 38.191 Annex A and Annex B | Huawei, HiSilicon | 7.22.5 |
| [**R4-2509716**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509716.zip) | Discussion on A-IoT device testing | CMCC | 7.22.5 |
| [**R4-2509721**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509721.zip) | TP for TR 38.191 section 8.3 device positioning guidelines | CMCC | 7.22.5 |
| [**R4-2509936**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2509936.zip) | Consideration on the OTA test of ambient IoT device 1 | Sony | 7.22.5 |
| [**R4-2510235**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510235.zip) | Discussion on Ambient IoT Device Testability | Qualcomm Incorporated | 7.22.5 |
| [**R4-2510250**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510250.zip) | Discussion on the AIoT device test method | vivo | 7.22.5 |
| [**R4-2510253**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510253.zip) | TP to TS 38.191 on OTA performance metric | vivo | 7.22.5 |
| [**R4-2510254**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510254.zip) | CR to TR 38.870 on AIoT test method | vivo | 7.22.5 |
| [**R4-2510320**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510320.zip) | Discussion on OTA testing for A-IoT device 1 | Ericsson Korea Partners Co Ltd | 7.22.5 |
| [**R4-2510846**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116/Docs/R4-2510846.zip) | on OTA test aspect | OPPO | 7.22.5 |

# System parameters

## Topic 2-1: R2D bandwidth

**Issue 2-1-1: R2D transmission bandwidth**

|  |
| --- |
| **Agreement in RAN4#115:*** Define symmetric guard band as 10kHz, 20kHz, 30kHz and 40kHz for 1PRB, 2PRB, 3PRB and 4PRB channel bandwidth configuration
 |

Proposal 1 (HW):

Remove the agreement in previous meeting on symmetric guard band for R2D CBW.

Use the minimum guardband requirements for R2D CBW in Table 8.

**Table 8: Minimum guardband (kHz)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **R2D CBW** | **200kHz** | **400kHz** | **600kHz** | **800kHz** |
| Minimum guardband(kHz) | 2.5 | 12.5 | 22.5 | 32.5 |

Proposal 2 (OPPO):

Define the A-IoT R2D channel bandwidth as figure 1 above.



Figure 1 A-IOT R2D channel bandwidth

**Recommended WF:**

Define asymmetric guard band as below.

**Table : Minimum guardband (kHz)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **R2D CBW** | **200kHz** | **400kHz** | **600kHz** | **800kHz** |
| Minimum guardband(kHz) | 2.5 | 12.5 | 22.5 | 32.5 |

## Topic 2-2: D2R bandwidth

**Issue 2-2-1: D2R bandwidth**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Agreement:*** Define D2R CBW based on all Tb, Tc, R combinations as finally approved in RAN1.
	+ Assumed 10% SFO for device
	+ For Reader, [90%] filter spectrum utility ([10%] guard band) is considered.
* The value of transmission BW and channel BW will be explicitly listed.
* Using following equation for BS as starting point:

D2R CBW for BS (KHz)=(2SB Transmission BW\*(1/2)+2\* Small frequency shift)/0.9=(2000\*(1+R)/Tb)\* (1+∣SFO∣)/0.9=(1000\*(R+1)/(Tc\*R)) \* (1+∣SFO∣)/0.9* + Define [200kHz]，[3.54MHz] D2R CBW for AIoT BS. Other D2R CBWs for BS are FFS
* Using following equation for device as starting point:

D2R CBW for device (KHz)=2SB Transmission BW\*(1/2)+2\* Small frequency shift=(2000\*(1+R)/Tb)\* (1+∣SFO∣)=(1000\*(R+1)/(Tc\*R)) \* (1+∣SFO∣)* The following are for information:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *
* Figure 1-1 Small frequency shift diagram of FDMA without SFO
*
* Figure 1-2. SFO impact of transmission bandwidth and small frequency shift of FDMA
* As the figures above indicate, SFO not only affects the D2R transmission bandwidth but also scales the small frequency shift value .
* The 2SB transmission BW and small frequency shift \_both measured in kHz——with and without SFO are as follows:
* Note : BW and Small frequency shift are in kHz;Tc and Tb are in μs

|  |  |
| --- | --- |
| 2SB Transmission BW (kHz) | Small frequency shift (kHz) |
| Without SFO | With SFO | Without SFO | With SFO |
| Btx,D2R\_ without SFO= 4\*1000/Tb=2\*1000/(R\*Tc) | Btx,D2R\_ with SFO =Btx,D2R\_ without SFO×(1±∣SFO∣) | SFSwithout SFO=±1000\*R/Tb= ±1000/(2\*Tc) | SFSwith SFO =SFSwithout SFO×(1±∣SFO∣) |

 |

 |

Proposal 1 (Huawei):

* For A-IoT BS, 90% filter spectrum utility (10% guard band) is considered for D2R CBW.
* Using the following equation for BS D2R CBW:
	+ - D2R CBW for BS (kHz)
		- = (2SB Transmission BW\_without SFO× (1/2) +2× Small frequency shift\_without SFO)/0.9
		- =(2000×(1+R)/Tb) × (1+∣SFO∣)/0.9
		- =(1000×(R+1)/ (Tc ×R)) × (1+∣SFO∣)/0.9 (Eq. 4)
* The transmission bandwidth (BW) and small frequency shift are in kHz, while Tc and Tb are in μs.
* The 0.9 divisor presents the 90% BS filter spectrum utility (10% guard band).
* Using following equation for device D2R CBW
	+ - D2R CBW for device (kHz)
		- =2SB Transmission BW\_without SFO× (1/2) +2× Small frequency shift\_without SFO
		- =(2000×(1+R)/Tb) × (1+∣SFO∣)
		- =(1000×(R+1)/ (Tc ×R)) × (1+∣SFO∣) (Eq. 5)
* The transmission bandwidth (BW) and small frequency shift are in kHz, while Tc and Tb are in μs.
* Adopt Table 7's A-IoT D2R CBW values for BS and device.
* Transmission bandwidth configuration isn't needed for D2R.
* From A-IoT BS sides, define D2R CBW 200 kHz and 3.52MHz for testing. Other BS D2R CBWs for testing in future release is not excluded.

|  |  |  |
| --- | --- | --- |
|  | Chip duration:Tc=2/SCS/(1,2,4,8,16,32,64,192) (μs) | 2SB=4/Tb（kHz） |
| 133.33 | 66.67 | 33.33 | 16.67 | 8.33 | 4.17 | 2.08 | 1.04 | 0.69 |
| $$τ$$ | $${τ}/{2}$$ | $${τ}/{4}$$ | $${τ}/{8}$$ | $${τ}/{16}$$ | $${τ}/{32}$$ | $${τ}/{64}$$ | $${τ}/{128}$$ | $${τ}/{192}$$ |
| Small Frequency Shift：SFS=1/(2×Tc)= R/Tb (kHz) |
| 3.75 | 7.5 | 15 | 30 | 60 | 120 | 240 | 480 | 720 |
| Bit duration:Tb= Tc×2R(μs) |  |  |
| 266.67 |  | R=1 | R=2 | R=4 | R=8 | R=16 | R=32 | R=64 | R=128 |  | 15 |
| Device D2R CBW (kHz)  | 16.5 | 24.8 | 41.3 | 74.3 | 140.3 | 272.3 | 536.3 | 1064.3 |  |
| BS D2R CBW (kHz)  | 18.3 | 27.6 | 45.9 | 82.6 | 155.9 | 302.6 | 595.9 | 1182.6 |  |
| 133.33 |  |  | R=1 | R=2 | R=4 | R=8 | R=16 | R=32 | R=64 |  | 30 |
| Device D2R CBW (kHz)  |  | 33 | 49.5 | 82.5 | 148.5 | 280.5 | 544.5 | 1072.5 |  |
| BS D2R CBW (kHz)  |  | 36.7 | 55 | 91.7 | 165 | 311.7 | 605 | 1191.7 |  |
| 66.67 |  |  |  | R=1 | R=2 | R=4 | R=8 | R=16 | R=32 |  | 60 |
| Device D2R CBW (kHz)  |  |  | 66 | 99 | 165 | 297 | 561 | 1089 |  |
| BS D2R CBW (kHz)  |  |  | 73.3 | 110 | 183.3 | 330 | 623.3 | 1210 |  |
| 33.33 |  |  |  |  | R=1 | R=2 | R=4 | R=8 | R=16 |  | 120 |
| Device D2R CBW (kHz)  |  |  |  | 132 | 198 | 330 | 594 | 1122 |  |
| BS D2R CBW (kHz)  |  |  |  | 146.7 | 220 | 366.7 | 660 | 1246.7 |  |
| 16.667 |  |  |  |  |  | R=1 | R=2 | R=4 | R=8 |  | 240 |
| Device D2R CBW (kHz)  |  |  |  |  | 264 | 396 | 660 | 1188 |  |
| BS D2R CBW (kHz)  |  |  |  |  | 293.3 | 440 | 733.3 | 1320 |  |
| 8.333 |  |  |  |  |  |  | R=1 | R=2 | R=4 |  | 480 |
| Device D2R CBW (kHz)  |  |  |  |  |  | 528 | 792 | 1320 |  |
| BS D2R CBW (kHz)  |  |  |  |  |  | 586.7 | 880 | 1466.7 |  |
| 4.167 |  |  |  |  |  |  |  | R=1 | R=2 |  | 960 |
| Device D2R CBW (kHz)  |  |  |  |  |  |  | 1056 | 1584 |  |
| BS D2R CBW (kHz)  |  |  |  |  |  |  | 1173.3 | 1760 |  |
| 1.389 |  |  |  |  |  |  |  |  |  | R=1 | 2880 |
| Device D2R CBW (kHz)  |  |  |  |  |  |  |  |  | 3168 |
| BS D2R CBW (kHz)  |  |  |  |  |  |  |  |  | 3520 |

Proposal 2 (CMCC):

* it’s suggested to define all D2R CBW values for AIoT BS and device as above.
* For BS, only using minimum 200kHz and maximum 3530MHz for testing.

|  |  |  |
| --- | --- | --- |
|  | ***DSB******/kHz*** | ***D2R CBW at BS side*** |
| ***T***b (μs) |  | Tchip (μs) |
|  |  | 133.33 | 66.67 | 33.33 | 16.67 | 8.33 | 4.17 | 2.08 | 1.04 | 0.69 |
| 266.67 | 15 | *18* | *27* | *46* | *82* | *156* | *302* | *597* | *1184* |  |
| 133.33 | 30 |  | *37* | *55* | *92* | *165* | *311* | *606* | *1194* |  |
| 66.67 | 60 |  |  | *73* | *110* | *183* | *330* | *624* | *1212* |  |
| 33.33 | 120 |  |  |  | *147* | *220* | *366* | *661* | *1249* |  |
| 16.67 | 240 |  |  |  |  | *293* | *440* | *734* | *1322* |  |
| 8.33 | 480 |  |  |  |  |  | *587* | *881* | *1469* |  |
| 4.17 | 960 |  |  |  |  |  |  | *1174* | *1761* |  |
| 1.39 | 2880 |  |  |  |  |  |  |  |  | *3520* |

|  |  |  |
| --- | --- | --- |
|  | ***DSB******/kHz*** | ***D2R CBW at device side*** |
| ***T*b (*μs*)** |  | Tchip (μs) |
|  |  | 133.33 | 66.67 | 33.33 | 16.67 | 8.33 | 4.17 | 2.08 | 1.04 | 0.69 |
| 266.67 | 15  | *17*  | *25*  | *41*  | *74*  | *140*  | *272*  | *537*  | *1066*  |  |
| 133.33 | 30  |  | *33*  | *50*  | *82*  | *149*  | *280*  | *545*  | *1074*  |  |
| 66.67 | 60  |  |  | *66*  | *99*  | *165*  | *297*  | *562*  | *1091*  |  |
| 33.33 | 120  |  |  |  | *132*  | *198*  | *330*  | *595*  | *1124*  |  |
| 16.67 | 240  |  |  |  |  | *264*  | *396*  | *661*  | *1190*  |  |
| 8.33 | 480  |  |  |  |  |  | *528*  | *793*  | *1322*  |  |
| 4.17 | 960 |  |  |  |  |  |  | *1056*  | *1585*  |  |
| 1.39 | 2880 |  |  |  |  |  |  |  |  | *3168*  |

Proposal 3 (xiaomi):

The D2R CBW for device side is corrected to (2+2R)/Tb\*1.1= (1+R)/Tc\*1.1. The D2R CBW for BS side is corrected to (2+2R)/Tb\*1.1/0.9= (1+R)/Tc\*1.1/0.9.

Both the CBW equations and the final values are captured to the specs.

Proposal 4 (CATT):

* The D2R channel bandwidth for device with 10% SFO is shown in table 2.
* The D2R channel bandwidth for reader with 10% SFO and 0.9 filter spectrum utility is shown in table 3.

Table 2: D2R channel bandwidth for device with 10% SFO

|  |
| --- |
| **D2R channel bandwidth for device with 10% SFO (kHz)** |
| **Tb (μs)** | **Tchip (μs)** | **2SB BW=4/Tb(kHz)** |
| **133.33** | **66.67** | **33.33** | **16.67** | **8.33** | **4.17** | **2.08** | **1.04** | **0.69** | 　 |
| **266.67** | 16.50  | 24.75  | 41.25  | 74.25  | 140.25  | 272.25  | 536.25  | 1064.25  | 　 | 15  |
| **133.33** | 　 | 33.00  | 49.50  | 82.50  | 148.50  | 280.50  | 544.50  | 1072.50  | 　 | 30  |
| **66.67** | 　 | 　 | 66.00  | 99.00  | 165.00  | 297.00  | 561.00  | 1089.00  | 　 | 60  |
| **33.33** | 　 | 　 | 　 | 132.00  | 198.00  | 330.00  | 594.00  | 1122.00  | 　 | 120  |
| **16.67** | 　 | 　 | 　 | 　 | 264.00  | 396.00  | 660.00  | 1188.00  | 　 | 240  |
| **8.33** | 　 | 　 | 　 | 　 | 　 | 528.00  | 792.00  | 1320.00  | 　 | 480  |
| **4.17** | 　 | 　 | 　 | 　 | 　 | 　 | 1056.00  | 1584.00  | 　 | 960  |
| **1.39** | 　 | 　 | 　 | 　 | 　 | 　 | 　 | 　 | 3168.00  | 2880  |
| **SFS =R/Tb(kHz)** | 3.75  | 7.50  | 15.00  | 30.00  | 60.00  | 120.00  | 240.00  | 480.00  | 720.00  | 　 |

Table 3: D2R channel bandwidth for reader with 10% SFO and 0.9 filter spectrum utility

|  |
| --- |
| **D2R channel bandwidth for reader with 10% SFO and 0.9 filter spectrum utility (kHz)** |
| **Tb (μs)** | **Tchip (μs)** | **2SB BW=4/Tb(kHz)** |
| **133.33** | **66.67** | **33.33** | **16.67** | **8.33** | **4.17** | **2.08** | **1.04** | **0.69** | 　 |
| **266.67** | 18.33  | 27.50  | 45.84  | 82.50  | 155.83  | 302.50  | 595.83  | 1182.50  | 　 | 15  |
| **133.33** | 　 | 36.67  | 55.00  | 91.67  | 165.00  | 311.67  | 605.00  | 1191.67  | 　 | 30  |
| **66.67** | 　 | 　 | 73.34  | 110.00  | 183.33  | 330.00  | 623.33  | 1210.00  | 　 | 60  |
| **33.33** | 　 | 　 | 　 | 146.67  | 220.00  | 366.67  | 660.00  | 1246.67  | 　 | 120  |
| **16.67** | 　 | 　 | 　 | 　 | 293.33  | 440.00  | 733.33  | 1320.00  | 　 | 240  |
| **8.33** | 　 | 　 | 　 | 　 | 　 | 586.67  | 880.00  | 1466.67  | 　 | 480  |
| **4.17** | 　 | 　 | 　 | 　 | 　 | 　 | 1173.33  | 1760.00  | 　 | 960  |
| **1.39** | 　 | 　 | 　 | 　 | 　 | 　 | 　 | 　 | 3520.00  | 2880  |
| **SFS =R/Tb(kHz)** | 3.75  | 7.50  | 15.00  | 30.00  | 60.00  | 120.00  | 240.00  | 480.00  | 720.00  | 　 |

Proposal 5 (Spreadtrum, UNISOC):

* Use the following equations to define the CBW for D2R
* When R=1, Channel bandwidth=4/Tb\*(1+ SFO) =1.1\*4/ Tb
* When R>1, Channel bandwidth = 2\*[(R/Tb)\*(1+SFO)+ 1/2\*1.1\*4/ Tb]=2\*(1.1\*R/Tb+2\*1.1/Tb)=2\*1.1(R/Tb+2/Tb)
* Take the Table 2 to define the specific CBW for D2R.

**Table 2. The channel bandwidth of D2R**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***T*b (*μs*)** | **R value** | **DSB****(kHz)** | **CBW****(kHz)** | ***T*b (*μs*)** | **R value** | **DSB****(kHz)** | **CBW****(kHz)** | ***T*b (*μs*)** | **R value** | **DSB****(kHz)** | **CBW****(kHz)** |
| 266.67 | 1 | 15 | 16.5 | 133.33 | 1 | 30 | 33 | 66.67 | 1 | 60 | 66 |
| 266.67 | 2 | 15 | 33 | 133.33 | 2 | 30 | 66 | 66.67 | 2 | 60 | 132 |
| 266.67 | 4 | 15 | 49.5 | 133.33 | 4 | 30 | 99 | 66.67 | 4 | 60 | 198 |
| 266.67 | 8 | 15 | 82.5 | 133.33 | 8 | 30 | 165 | 66.67 | 8 | 60 | 330 |
| 266.67 | 16 | 15 | 148.5 | 133.33 | 16 | 30 | 297 | 66.67 | 16 | 60 | 594 |
| 266.67 | 32 | 15 | 280.5 | 133.33 | 32 | 30 | 561 | 66.67 | 32 | 60 | 1121.9 |
| 266.67 | 64 | 15 | 544.5 | 133.33 | 64 | 30 | 1089 | 66.67 | 64 | 60 | 2177.9 |
| 266.67 | 128 | 15 | 1072.5 | 16.67 | 1 | 240 | 263.9 | 8.33 | 1 | 480 | 528.2 |
| 33.33 | 1 | 120 | 132 | 16.67 | 2 | 240 | 527.9 | 8.33 | 2 | 480 | 1056.4 |
| 33.33 | 2 | 120 | 264 | 16.67 | 4 | 240 | 1055.8 | 8.33 | 4 | 480 | 1584.6 |
| 33.33 | 4 | 120 | 396 | 16.67 | 8 | 240 | 1319.7 | 1.39 | 1 | 2880 | 3165.5 |
| 33.33 | 8 | 120 | 660.1 | 4.17 | 1 | 960 | 1055.2 |  |  |  |  |
| 33.33 | 16 | 120 | 1188.1 | 4.17 | 2 | 960 | 2110.3 |  |  |  |  |

Proposal 6 (vivo):

The D2R channel bandwidth for device is translated as the relationship with center frequency and transmission bandwidth rather than R/Tb/Tc, as listed below:

|  |
| --- |
| **D2R channel bandwidth (kHz)** |
| **D2R transmission** **Bandwidth (kHz)** | **Small frequency shift (kHz)** |
| **3.75**  | **7.5**  | **15**  | **30**  | **60** | **120**  | **240** | **480** | **720**  |
| **15** | *16.5* | *24.75* | *41.25* | *74.25* | *140.25* | *272.25* | *536.25* | *1064.25* |  |
| **30** | 　 | *33* | *49.5* | *82.5* | *148.5* | *280.5* | *544.5* | *1072.5* |  |
| **60** | 　 | 　 | *66* | *99* | *165* | *297* | *561* | *1089* |  |
| **120** | 　 | 　 |  | *132* | *198* | *330* | *594* | *1122* |  |
| **240** | 　 | 　 | 　 |  | *264* | *396* | *660* | *1188* |  |
| **480** | 　 | 　 | 　 | 　 |  | *528* | *792* | *1320* |  |
| **960** | 　 | 　 | 　 | 　 | 　 |  | *1056* | *1584* |  |
| **2880** | 　 | 　 | 　 | 　 | 　 | 　 | 　 |  | *3168* |

The guard band for each D2R CBW for device can also be considered to be listed in the sepc:

|  |
| --- |
| **D2R guard band (kHz)** |
| **D2R transmission** **Bandwidth (kHz)** | **Small frequency shift (kHz)** |
| **3.75**  | **7.5**  | **15**  | **30**  | **60** | **120**  | **240** | **480** | **720**  |
| **15** | *1.5* | *2.25* | *3.75* | *6.75* | *12.75* | *24.75* | *48.75* | *96.75* |  |
| **30** | 　 | *3* | *4.5* | *7.5* | *13.5* | *25.5* | *49.5* | *97.5* |  |
| **60** | 　 | 　 | *6* | *9* | *15* | *27* | *51* | *99* |  |
| **120** | 　 | 　 |  | *12* | *18* | *30* | *54* | *102* |  |
| **240** | 　 | 　 | 　 |  | *24* | *36* | *60* | *108* |  |
| **480** | 　 | 　 | 　 | 　 |  | *48* | *72* | *120* |  |
| **960** | 　 | 　 | 　 | 　 | 　 |  | *96* | *144* |  |
| **2880** | 　 | 　 | 　 | 　 | 　 | 　 | 　 |  | *288* |

Proposal 7 (OPPO):

* The D2R channel bandwidth with its transmission bandwidth and corresponding feasible frequency shift is proposed as table 3.
* To define the D2R channel bandwidth as:

$$D2R channel bandwidth=\left\{\begin{array}{c}Transmission bandwidth\\2\*Small frequency shift+Transmission bandwidth\end{array}\genfrac{}{}{0pt}{}{R=1}{R>1}\right.$$

* The transmission bandwidth and small frequency shift both consider SFO.

**Table 3 Frequency shift and transmission bandwidth**

|  |  |
| --- | --- |
| ***Transmission bandwidth*** | **Frequency shift (kHz)** |
| **3.75 kHz** | **7.5 kHz** | **15 kHz** | **30 kHz** | **60 kHz** | **120 kHz** | **240 kHz** | **480 kHz** | **720 kHz** |
| **15 kHz** | **3.75**  | **7.5**  | **15**  | **30**  | **60** | **120**  | **240** | **480** |  |
| **30 kHz** |  | **7.5**  | **15**  | **30**  | **60** | **120**  | **240** | **480** |  |
| **60 kHz** |  |  | **15**  | **30**  | **60** | **120**  | **240** | **480** |  |
| **120 kHz** |  |  |  | **30**  | **60** | **120**  | **240** | **480** |  |
| **240 kHz** |  |  |  |  | **60** | **120**  | **240** | **480** |  |
| **480 kHz** |  |  |  |  |  | **120**  | **240** | **480** |  |
| **960 kHz** |  |  |  |  |  |  | **240** | **480** |  |
| **2880 kHz** |  |  |  |  |  |  |  |  | **720** |

Proposal 8 (ZTE):

for D2R bandwidth for device, propose to define the full set of bandwidth to accommodate all the device capability as following:

|  |  |  |
| --- | --- | --- |
| DSB[KHz] | Tb [us] | D2R bandwidth without SFO, GB [KHz] |
|  |  | *R*=1 | *R*=2 | *R*=4 | *R=8* | *R=16* | *R=32* | *R=64* | *R=128* |  |
| 15 | 266.67 | 15 | 22.5 | 37.5 | 67.5 | 127.5 | 247.5 | 487.5 | 967.5 |  |
|  |  |  | *R=1* | *R=2* | *R=4* | *R=8* | *R=16* | *R=32* | *R=64* |  |
| 30 | 133.33 |  | 30 | 45 | 75 | 135 | 255 | 495 | 975 |  |
|  |  |  |  | *R=1* | *R=2* | *R=4* | *R=8* | *R=16* | *R=32* |  |
| 60 | 66.67 |  |  | 60 | 90 | 150 | 270 | 510 | 990 |  |
|  |  |  |  |  | *R=1* | *R=2* | *R=4* | *R=8* | *R=16* |  |
| 120 | 33.33 |  |  |  | 120 | 180 | 300 | 540 | 1020 |  |
|  |  |  |  |  |  | *R=1* | *R=2* | *R=4* | *R=8* |  |
| 240 | 16.67 |  |  |  |  | 240 | 360 | 600 | 1080 |  |
|  |  |  |  |  |  |  | *R*=1 | *R*=2 | *R*=4 |  |
| 480 | 8.33 |  |  |  |  |  | 480 | 720 | 1200 |  |
|  |  |  |  |  |  |  |  | *R*=1 | *R*=2 |  |
| 960 | 4.17 |  |  |  |  |  |  | 960 | 1440 |  |
|  |  |  |  |  |  |  |  |  |  | *R*=1 |
| 2880 | 1.39 |  |  |  |  |  |  |  |  | 2880 |

for D2R bandwidth for BS, propose to define the full set of D2R bandwidth in Rel-19.

|  |  |  |
| --- | --- | --- |
| DSB [KHz] | Tb [us] | D2R bandwidth SFO, GB [KHz] |
|  |  | R=1 | R=2 | R=4 | R=8 | R=16 | R=32 | R=64 | R=128 |  |
| 15.0  | 266.67 | 18.3  | 27.5  | 45.8  | 82.5  | 155.8  | 302.5  | 595.8  | 1182.5  |  |
|  |  |  | R=1 | R=2 | R=4 | R=8 | R=16 | R=32 | R=64 |  |
| 30.0  | 133.33 |  | 36.7  | 55.0  | 91.7  | 165.0  | 311.7  | 605.0  | 1191.7  |  |
|  |  |  |  | R=1 | R=2 | R=4 | R=8 | R=16 | R=32 |  |
| 60.0  | 66.67 |  |  | 73.3  | 110.0  | 183.3  | 330.0  | 623.3  | 1210.0  |  |
|  |  |  |  |  | R=1 | R=2 | R=4 | R=8 | R=16 |  |
| 120.0  | 33.33 |  |  |  | 146.7  | 220.0  | 366.7  | 660.0  | 1246.7  |  |
|  |  |  |  |  |  | R=1 | R=2 | R=4 | R=8 |  |
| 240.0  | 16.67 |  |  |  |  | 293.3  | 440.0  | 733.3  | 1320.0  |  |
|  |  |  |  |  |  |  | R=1 | R=2 | R=4 |  |
| 480.0  | 8.33 |  |  |  |  |  | 586.7  | 880.0  | 1466.7  |  |
|  |  |  |  |  |  |  |  | R=1 | R=2 |  |
| 960.0  | 4.17 |  |  |  |  |  |  | 1173.3  | 1760.0  |  |
|  |  |  |  |  |  |  |  |  |  | R=1 |
| 2880.0  | 1.39 |  |  |  |  |  |  |  |  | 3520  |

Proposal 10 (Sony): RAN4 should decide if all the D2R channel BW value corresponding to transmission bandwidth and SFS shall be defined.

Proposal 11 (Ericsson):

Proposal:

* Introduce the D2R channel BW equals to OBW for spurious test.
* The requirements in this specification apply to the combination of channel bandwidths, data bit duration Tb, chip bit duration Tc, and operating bands shown in Table 5.3.2-1.

Table 5.3.2-1: D2R Channel bandwidths for n8 (kHz)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | Tc=133.33 | Tc=66.7 | Tc=33.33 | Tc=16.67 | Tc= 8.33 | Tc= 4.17 | Tc= 2.08 | Tc= 1.04, | Tc= 0.69 |
| Tb= 266.67 | 163.49 |  645.30 | 1370.35 |  2462.23  | 4997.19 |  9833.37 | 19653.92 | 37507.34 | 53652.42 |
| Tb=133.33 |   |  207.46 | 1539.63 | 2462.73 | 5188.09 | 9840.29 | 19662.69 | 37514.09 | 53654.72 |
| Tb= 66.67 |  |  | 359.83 | 2471.47  | 5490.93 |  9886.65 | 19677.76 |  37513.23 | 53663.66 |
| Tb= 33.33 |  |  |  | 604.68 |  6107.25 | 10328.16 | 19751.66 | 37540.43 | 53683.05 |
| Tb=16.7 |  |  |  |  | 1206.55 | 10722.37 |  20666.82 |  38802.00 |  53778.75 |
| Tb= 8.33 |  |  |  |  |  | 2468.70 | 21656.32 | 39436.84 | 56457.06 |
| Tb= 4.17 |  |  |  |  |  |  | 4667.25 | 41445.33 | 56712.04 |
| Tb= 1.39 |   |   |   |   |   |   |   | 14855.72 | 14933.20 |

**Recommended WF:**

* No maximum transmission bandwidth configuration for D2R.
* Both the D2R CBW equations and table based D2R CBW values are captured into the specs
	+ For equations:

|  |
| --- |
| Using the following equation for BS D2R CBW:D2R CBW for BS (kHz)= (2SB Transmission BW\_without SFO× (1/2) +2× Small frequency shift\_without SFO)/0.9=(2000×(1+R)/Tb) × (1+∣SFO∣)/0.9=(1000×(R+1)/ (Tc ×R)) × (1+∣SFO∣)/0.9 (Eq. 4)The transmission bandwidth (BW) and small frequency shift are in kHz, while Tc and Tb are in μs. The 0.9 divisor presents the 90% BS filter spectrum utility (10% guard band). |
| Using following equation for device D2R CBW D2R CBW for device (kHz)=2SB Transmission BW\_without SFO× (1/2) +2× Small frequency shift\_without SFO=(2000×(1+R)/Tb) × (1+∣SFO∣)=(1000×(R+1)/ (Tc ×R)) × (1+∣SFO∣) (Eq. 5)The transmission bandwidth (BW) and small frequency shift are in kHz, while Tc and Tb are in μs. |

* + For the channel bandwidth table:

|  |
| --- |
| **Device D2R channel bandwidth (kHz)**  |
| **Norminal D2R transmission** **Bandwidth without SFO(kHz)** | **Norminal Small frequency shift without SFO(kHz)** |
| **3.75**  | **7.5**  | **15**  | **30**  | **60** | **120**  | **240** | **480** | **720**  |
| **15** | 16.5 | 24.8 | 41.3 | 74.3 | 140.3 | 272.3 | 536.3 | 1064.3 |  |
| **30** | 　 | 33 | 49.5 | 82.5 | 148.5 | 280.5 | 544.5 | 1072.5 |  |
| **60** | 　 | 　 | 66 | 99 | 165 | 297 | 561 | 1089 |  |
| **120** | 　 | 　 |  | *132* | *198* | *330* | *594* | *1122* |  |
| **240** | 　 | 　 | 　 |  | *264* | *396* | *660* | *1188* |  |
| **480** | 　 | 　 | 　 | 　 |  | *528* | *792* | *1320* |  |
| **960** | 　 | 　 | 　 | 　 | 　 |  | *1056* | *1584* |  |
| **2880** | 　 | 　 | 　 | 　 | 　 | 　 | 　 |  | *3168* |

|  |
| --- |
| **BS D2R channel bandwidth (kHz)**  |
| **Norminal D2R transmission** **Bandwidth without SFO (kHz)** | **Norminal Small frequency shift without SFO(kHz)** |
| **3.75**  | **7.5**  | **15**  | **30**  | **60** | **120**  | **240** | **480** | **720**  |
| **15** | 18.3 | 27.6 | 45.9 | 82.6 | 155.9 | 302.6 | 595.9 | 1182.6 |  |
| **30** | 　 | 36.7 | 55 | 91.7 | 165 | 311.7 | 605 | 1191.7 |  |
| **60** | 　 | 　 | 73.3 | 110 | 183.3 | 330 | 623.3 | 1210 |  |
| **120** | 　 | 　 |  | 146.7 | 220 | 366.7 | 660 | 1246.7 |  |
| **240** | 　 | 　 | 　 |  | 293.3 | 440 | 733.3 | 1320 |  |
| **480** | 　 | 　 | 　 | 　 |  | 586.7 | 880 | 1466.7 |  |
| **960** | 　 | 　 | 　 | 　 | 　 |  | 1173.3 | 1760 |  |
| **2880** | 　 | 　 | 　 | 　 | 　 | 　 | 　 |  | 3520 |

* Only use 200kHz and 3.52MHz for BS D2R testing.

## Topic 2-3: Channel raster

**Issue 2-3-1: R2D channel raster**

|  |
| --- |
| **Agreement in RAN4#115:**- Define 10KHz channel raster- FFS on channel raster offset |

Proposal 1 (Huawei): No need to define R2D channel raster offset.

Proposal 2 (CMCC):

* no offset are required for channel raster to support symetric guard band.

Proposal 3 (xiaomi): No offset is needed for the AIoT channel raster compared with NR

Proposal 4 (CATT): mapping between the A-IoT RF reference frequency and the channel raster is the same as that of the NR system, and there is no channel raster offset between them

Proposal 5 (Spreadtrum, UNISOC): Define R2D channel raster as 10 kHz, there is no need to define R2D channel raster offset value.

Proposal 6 (vivo): For standalone operation, reuse same channel raster as NR in corresponding band, i.e., 100kHz in band n8. For in-band operation, the enhanced channel raster is used, i.e., 10kHz.

Proposal 7 (OPPO):

* 10kHz channel raster is used for NR bands with 100kHz channel raster for A-IOT.
* The channel raster to RE mapping of AIOT and NR are the same.
* For stand-alone AIOT deployment, no frequency offset is needed.

Proposal 8 (Ericsson):

* For in-band operation, reuse the 10kHz enhanced channel raster for A-IoT BS without a need of any raster offset.
* Reuse the DL channel raster for UL so the D2R channel can be configured with NR-ARFCN for testing.

Proposal 9 (ZTE):

for R2D transmission in Standalone operation mode, to define the channel raster as 10KHz; for R2D transmission in in-band operation mode, to define the channel raster as 100KHz\*N+delta\_offset where delta\_offset could be as [ -7.5, 0, 2.5]kHz.

**Recommended WF:**

* Define 10kHz channel raster for both D2R and R2D.
	+ Note: channel raster for D2R will only be captured into BS spec 38.194
* No channel raster offset

## Topic 2-4: Others

**Issue 2-4-1: whether channel spacing is needed or not**

Proposal 1 (CMCC): no since we only consider single CC operation.

Proposal 2 (OPPO): For in-band AIOT simultaneous NR transmission, channel spacing is used to keep the AIOT and NR centre frequency SCS level aligned

**Recommended WF:**

No channel spacing.

**Issue 2-4-2: maximum number of devices allowed to communicate simultaneously with one A-IoT BS**

Proposal 1 (CATT): The maximum number of devices allowed to communicate simultaneously with one A-IoT BS needs to be clarified.

**Recommended WF:**

No discussion is needed.

# Device RF requirements

## Topic 3-1: Transmit output power

**Issue 3-1-1: Transmit output power**

|  |
| --- |
| **Agreement in RAN4#115:*** Performance metric: EIRP
	+ FFS on how to determine device’s peak antenna gain direction
	+ FFS on whether to measure multiple directions
* Take [10] dB backscatter loss for OOK as starting point, based on the assumption that the incoming CW signal and the backscatter signal are aligned with the peak gain direction of the device antenna.
	+ FFS for BPSK
* The power of the backscattered signal shall include only the 1st lower sideband and the 1st upper sideband, excluding the carrier itself.
 |

Proposal 1 (Huawei):

* For OOK modulation, the backscatter power *Pbs* meet the following requirements:
* $P\_{back}\geq \left\{\begin{array}{c}P\_{cw}-10, -35dBm \leq P\_{cw}\leq -15dBm\\-25, -15dBm<P\_{cw}\leq -5dBm\end{array}\right.$
* For BPSK modulation, the minimum backscatter power is increased by [4] dB relative to the minimum requirement for OOK.
* The backscatter power/loss requirements do not include the loss caused by antenna orientation or polarization mismatch.
* For backscatter power measurement, the CW signal is transmitted in two orthogonal polarisation directions in separate steps. And for each CW stimulation, the backscattered power is measured in two orthogonal directions. The following equations are used for derive the backscatter power $p\_{back}$:

$$p\_{back,1}=p\_{back,1}\left(PolMeas=θ\right)+p\_{back,1}\left(PolMeas=φ\right)$$

$$p\_{back,2}=p\_{back,2}\left(PolMeas=θ\right)+p\_{back,2}\left(PolMeas=φ\right)$$

$p\_{back}= p\_{back,1}+p\_{back,2}$.

Proposal 2 (LGE): Ambient IoT device 1 backscattering loss used to define requirement is 14.3 dB

* Use 6dB as Modulation loss for Ambient IoT device1
* Use -4.3dB as antenna efficiency for Ambient IoT device 1
* Backscattering circuitry loss is treated as equivalent to modulation loss.
* Use 1dB as backscattering circuitry loss only for internal loss.

Proposal 3 (ZTE):

for the practical OOK backscattering loss, propose to define the minimum requirement 8dB (ideal 6+2dB margin) without considering antenna efficiency.

For the BPSK modulation, it is expected to be 6dB better than OOK backscattering loss in theory, therefore we propose to consider 2dB backscattering loss for BPSK.

for the practical BPSK backscattering loss, propose to define the minimum requirement 2dB without considering antenna efficiency.

Proposal 4 (Ericsson):

10 dB backscatter loss should be specified for backscatter loss.

The manufacturer declare the peak antenna gain direction using a reference plane.

Specify the backscatter loss using the text above.

*The maximum backscatter loss is defined as the ratio of the input CW power at the device antenna to the backscatter power at the device antenna. The backscatter power is defined as mean filtered power measured over the duration of the D2R signal at the UE declared directionand. The basckscatter loss shall be met in Table 6.2.1.1-1 with the test parameters set in Table 6.2.1.1-2.*

*Note: UE declare the test direction in a reference plane.*

*Table 6.2.1.1-1: Maximum backscatter loss*

|  |  |
| --- | --- |
| *Operating band* | *Maximum backscatter loss*  |
| *N8* | *[10]* |

*Table 6.2.1.1-2: Test configuraton*

|  |  |
| --- | --- |
| *Test parameter* | *value* |
| *D2R channel bandwidth (kHz)* | *(2000\*(1+Tb/(2Tc))/Tb)\* 1.1/0.9* |
| *CW frequency (MHz)* | *According to TS 38.192* |
| *Filter centre frequency* | *CW frequency* |
| *Filter frequency offset* | *1/Tc* |
| *Filter bandwidth* | *2/Tb \*1.1* |

Proposal 5 (OPPO):

* For the device peak antenna gain direction, vendor declaration is used
* Only test the peak gain direction of device for transmit output power
* For OOK, the backscattering loss is -9dB and for BPSK, the backscattering loss is -3dB.

Proposal 6 (Sony):

* It is proposed to define the maximum backscattering loss as 14 dB, which is applicable within a 45-degree partial sphere range with respect to the bore sight direction (or UE declared direction) of the AIoT device 1, when both angle to the reader and the CW are within this partial sphere for OOK.
* It is proposed that the input power level can be vendor-declared, and RAN4 can further discuss whether a range of input power levels should be defined to limit the allowed declared range.
* It is proposed that the backscattering loss of BPSK should be 5 dB less than that of OOK.
* RAN4 needs to take into account a 3 dB polarization mismatch loss if the backscattering loss is measured as the average value between two orthogonal polarized CW waves.

Proposal 7 (vivo):

* The peak antenna gain direction is declared by device.
* It is unnecessary to evaluate the device antenna pattern in both Tx requirement (backscatter loss from multiple direction) and Rx requirement (reference sensitivity from multiple direction).
* Only two backscatter loss with corresponding certain maximum incident CW power level as side condition will be defined in the spec..

Proposal 8 (Spreadtrum, UNISOC):

* Device declares the peak antenna gain direction.
* Define the backscatter loss as follows.
* -For OOK, 10 dB @input CW power= -25dBm and 25dB@input CW power= -10 dBm.
* -For BPSK, 6 dB @ input CW power= -25dBm and 21dB@input CW power= -10 dBm.

Proposal 9 (Qualcomm): Maximum output power is met with maximum CW power level. Output power is assumed to scale linearly with CW level until minimum CW level

Proposal 10 (CATT):

For Device Tx output power requirements, the peak antenna gain direction could be declaration based.

For Device Tx output power requirements, a range should be defined based on the different CW input power.

Proposal 11 (xiaomi):

Only peak direction requirement for transmit output power is defined.

Proposal 12 (CMCC):

it’s suggested to only define device’s peak antenna gain direction which is based on declaration.

it’s suggested to define two points for backscatter power into spec as below.

When input CW level is at -27dBm, the backscatter loss is 8dB and backscatter power is -35dBm

The maximum backscatter power is suggested to be larger than -25dBm

8dB backscatter loss for OOK and 4dB for BPSK.

**Recommended WF:**

* Define requirements at the peak antenna gain direction, which is based on declaration.
* Define RF requirement with input CW level/level range as side condition
	+ Option 1: backscatter power
	+ Option 2: backscatter loss
	+ Input CW level - loss = power
* Define backscatter power/loss with following options:
	+ Option 1: define two steps for backscatter power/loss
		- Option 1a: $P\_{back}\geq \left\{\begin{array}{c}P\_{cw}-10, -35dBm \leq P\_{cw}\leq -15dBm\\-25, -15dBm<P\_{cw}\leq -5dBm\end{array}\right.$
	+ Option 2: define two backscatter power/loss with related input CW level
		- Option 2a:
			* When input CW level is at -27dBm, the backscatter power is >= -35dBm
			* The maximum backscatter power is suggested to be larger than -25dBm
		- Option 2b:
			* -For OOK, [10 dB @input CW power= -25dBm] and [25dB@input CW power= -10 dBm].
			* -For BPSK, [6 dB @ input CW power= -25dBm] and [21dB@input CW power= -10 dBm].
	+ Option 3: define fixed backscatter loss at declared input CW level or level range
* For the fixed backscatter loss value
	+ OOK: [8, 9, 10]dB
	+ BPSK: BPSK is [4, 5, 6]dB less than OOK
	+ backscatter loss does not include the loss caused by antenna orientation or polarization mismatch

**Issue 3-1-2: Transmit output power**

Proposal :

* Introduce the maximum backscatter power of – 5.5 dBm (Ericsson)
* TP:
	+ The effective radiated power is the power radiated by its antenna in its direction of maximum gain under specified conditions of measurement. The radiated power shall not exceed -5 dBm within the configured channel bandwidth.

## Topic 3-2: Modulation quality

**Issue 3-2-1: SFO requirement**

|  |
| --- |
| **Agreement in RAN4#115:*** No need to directly test SFO if SFO can be indirectly verified via other test.
* FFS whether to explicitly define SFO requirements or not.
 |

Proposal 3 (Vivo): The 10% SFO can be explicitly captured in the spec.

Proposal 4 (Spreadtrum, UNISOC): No need to define SFO requirement explicitly.

Proposal 6 (xiaomi): Define SFO requirement for device 1

Proposal 7 (CMCC): no SFO

Proposal 8 (HW): The timing error caused by SFO can be discussed/defined in the RRM requirements.

**Recommended WF:**

Define SFO value in D2R CBW bandwidth calculation equations.

## Topic 3-3: Emission requirements

**Issue 3-3-1: SEM requirements**

|  |
| --- |
| **Agreement in RAN4#115:*** Use EIRP as performance metric
	+ Device’s peak antenna gain direction is based on declaration, i.e. same peak gain direction for backscattering loss testing
* The applicable frequency range for SEM: from the CBW edge to [OOB boundary]
* Define flat requirements for SEM as starting point, [9dBc~14dBc] based on achievable harmonic performance
* Define requirements applicable to all CBWs, FFS on how to reduce the test burden.
* Use the [maximum] CW input power level, FFS on the value.
 |

Proposal 1 (Huawei):

* Consider to define the SEM requirement for AIoT devices as in Table 6.
* Table 6: Spectrum emission mask for AIoT devices

|  |  |  |
| --- | --- | --- |
| * ΔfOOB
 | * Emission limit (dBc)
 | * Measurement bandwidth
 |
| * ± 0-FOOB
 | * [12.5+1.5]
 | * 1SB
 |
| * Note 1: The carrier power includes the two sidebands centred at +/-SFS, but excludes the spectrum around the carrier frequency.
 |

1SB=2/Tb, SFS=1/(2Tc)

ΔfOOB =0 is defined as the offset of ± (SFS+1SB/2)\*1.1 = (1+R)/Tb\*1.1 from the carrier frequency;

* + - * + FOOB is the OOB boundary frequency.
* Alternatively, the SEM can be defined as Table 7, assuming CBW=3MHz.
	+ - * Table 7: Spectrum emission mask for AIoT devices (option 2)

|  |  |  |
| --- | --- | --- |
| * ΔfOOB (MHz)
 | * Emission limit (dBm)
 | * Measurement bandwidth
 |
| * ± 0-1
 | * [-20]
 | * 30kHz
 |
| * ± 1-5
 | * [-25]
 | * 1MHz
 |
| * ± 5-6
 | * [-30]
 | * 1MHz
 |
| * Note 1: ΔfOOB =0 is defined as the offset of ±1.5MHz from the carrier frequency.
 |

Proposal 2 (Ericsson): No SEM is required.

Proposal 3 (OPPO):

* 10dBc is proposed to be the SEM requirement
* For the SEM requirement, the input CW power is the same as transmit output power test.

Proposal 4 (vivo): The flat requirement for SEM is set to 12 dBc with the measurement bandwidth equal to 0.5\*D2R transmission bandwidth..

Proposal 5 (Spreadtrum, UNISOC): Define flat 12dBc/1SB as SEM requirements.

Proposal 6 (Qualcomm): Emission are met with maximum CW input level

Proposal 7 (xiaomi): SEM requirement candidate for no SFS case is proposed in Figure 4.



Figure 4：SEM candidate for 7.5kHz Tb D2R signal without SFS

Proposal 8 (CMCC):

12dBc/1SB flat requirement is suggested for SEM. And can only test minimum and max CBW to reduce the test burden.

only test minimum and max CBW to reduce the test burden.

Proposal 9 (CATT):

For Device SEM requirements, the peak antenna gain direction could be defined as declaration based, and the SEM value should be defined as stricter than -9 dBc.

**Recommended WF:**

* Discuss with following two options:
	+ Option 1: Define flat SEM requirements, i.e. 12dBc-2 (margin), The RBW is 1SB
	+ Option 2: Alternatively, the SEM can be defined as Table 7, assuming CBW=3MHz.

Spectrum emission mask for AIoT devices (option 2)

|  |  |  |
| --- | --- | --- |
| * ΔfOOB (MHz)
 | * Emission limit (dBm)
 | * Measurement bandwidth
 |
| * ± 0-1
 | * [-20]
 | * 30kHz
 |
| * ± 1-5
 | * [-25]
 | * 1MHz
 |
| * ± 5-6
 | * [-30]
 | * 1MHz
 |
| * Note 1: ΔfOOB =0 is defined as the offsetof±1.5MHz from the carrier frequency.
 |

* Backscatter power for testing: align with spurious emission requirements.

**Issue 3-3-1: spurious emission requirements**

|  |
| --- |
| **Agreement in RAN4#115:*** Use EIRP as performance metric
	+ Device’s peak antenna gain direction is based on declaration, i.e. same peak gain direction for backscattering loss testing
* OOB boundary
	+ Option 1: D2R channel bandwidth plus minimum D2R channel bandwidth
	+ Option 2: max of 500kHz and 10 times NB where NB equals to D2R CBW
	+ Other options are not precluded
* Define requirements applicable to all CBWs, FFS on how to reduce the test burden.
* Use the [maximum] CW input power level, FFS on the value.
 |

Proposal 1 (Huawei):

The general spurious emission limits for AIoT devices are defined as in Table 3.

Table 3: Requirement for general spurious emissions limits

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range | Maximum Level | Measurement bandwidth | NOTE |
| 30 MHz ≤ f < 1000 MHz | -36 dBm | 100 kHz |  |
| 1 GHz ≤ f < 5 GHz | -30 dBm | 1 MHz |  |
| 5 GHz ≤ f < 12.75 GHz | -30 dBm | 1 MHz | 1 |
| NOTE 1: Applies for Band for which the upper frequency edge of the UL Band is greater than 1 GHz and less than or equal to 2.55 GHz. |

Define the OOB boundary frequency (FOOB) as 7.5MHz from the carrier frequency independent of the transmission BW, from which the general spurious emission limit applies.

-5dBm CW input power for testing

Proposal 2 (Ericsson):

* Introduce the D2R channel BW equals to OBW for spurious test.
* Introduce the D2R channel BW at device specification, exclude the Tc =1.04 and 0.69 case.
* OOB Boundary set to 250% OBW
* Introduce the maximum backscatter power of – 5.5 dBm (with 3 dB margin of -2.45 dBm)

Proposal 3 (OPPO): It is proposed to reuse the 10 times NB where NB equals to D2R CBW as the OOB boundary..

Proposal 4 (vivo):

* The OOB boundary is set at max of 500kHz and 10 times NB where NB equals to D2R CBW
* The CW power for spurious and SEM is set to -10 dBm, and only SFS = 480kHz with 15kHz 2SB transmission bandwidth need to be tested.

Proposal 5 (Spreadtrum, UNISOC): Define the maximum 500 kHz or 10 times NB as the boundary A-IoT out of band and general spurious emission domain and the NB (necessity bandwidth) is the CBW. We can assume the maximum backscatter power is -10dBm (the distance between CW and device is 1m)

Proposal 6 (xiaomi): NR UE general spurious emissions limits can be reused from Fc+24/Tb for no SFS case if absolute requirement needs to be defined.

Proposal 7 (CMCC): the OOB is defined as Fb as in ITU, i.e. max of 500kHz and 10 times NB where NB equals to D2R CBW. Note: the worst case is for minimum 2DB with R=1. for such CBW, to meet spurious emission requirment, it’s suggested to use -24dBm backscatter power for testing

Proposal 8 (CATT): For Device spurious emissions requirements, the OOB boundary could be defined as max of 500 kHz and 10 times NB, where NB equals to D2R CBW

**Recommended WF:**

* Spurious emission requirements
	+ Option 1: reuse UE requirements (previous meeting agreement)
	+ Option 2:

Table 3: Requirement for general spurious emissions limits

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range | Maximum Level | Measurement bandwidth | NOTE |
| 30 MHz ≤ f < 1000 MHz | -36 dBm | 100 kHz |  |
| 1 GHz ≤ f < 5 GHz | -30 dBm | 1 MHz |  |
| 5 GHz ≤ f < 12.75 GHz | -30 dBm | 1 MHz | 1 |
| NOTE 1: Applies for Band for which the upper frequency edge of the UL Band is greater than 1 GHz and less than or equal to 2.55 GHz. |

* OOB boundary:
	+ Option 1: max of 500kHz and 10 times NB where NB equals to D2R CBW
	+ Option 2: 7.5MHz assuming 3M CBW
* For testing:
	+ Only using limited DSB and SFS combination for testing with [ TBD dBm] CW input power.
		- SFS = 480kHz with [15kHz], 2SB transmission bandwidth need to be tested

## Topic 3-4: Reference sensitivity

**Issue 3-4-1: Reference sensitivity**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Agreement in RAN4#115:*** Using [-34dBm] as starting point to define REFSENS requirements, based on the peak gain direction of device antenna.
* Consider to define orientation requirements with following options:
	+ Option 1: min sensitivity at peak antenna gain direction and EIS spherical coverage requirements, XdBm at Xth percentage
	+ Option 2: spatial averaging EIS
	+ Option 3: EIS in the peak direction
* Testing metric: 10% miss detection rate, FFS on whether to consider false alarm
* FFS for the FRC, consider following as starting point:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS | 15 | 15 | 15 | 15 |
| PRB | 1 | 2 | 3 | 4 |
| TBS | 20 | 20 | 20 | 20 |
| CRC | 6 | 6 | 6 | 6 |
| M | 6 | 12 | 24 | 24 |

 |

Proposal 1 (Huawei):

* Define the minimum sensitivity requirement for the typical D1T1 indoor factory deployment scenario in Rel-19. Additional sensitivity levels can be added in the future if needed.
* Table 1: Device Sensitivity at peak antenna gain direction

|  |  |
| --- | --- |
| * Sensitivity Level
 | * Minimum requirement (dBm)
 |
| * L1
 | * -34
 |
| * Note: It’s assumed that the antenna polarisation of the reader and device are matched.
 |

* The EIS measurement is performed for both θ-polarization and ϕ-polarization. And the average EIS is calculated as:

EIS = [1/EIS(PolMeas= +1/EIS(PolMeas=]-1

* The peak antenna gain direction is declared by the device vendor.
* Consider to define the minimum EIS partial spherical coverage requirements for the typical D1T1 indoor factory deployment scenario in Rel-19. Additional coverage levels can be added in the future if needed.
* Table 2: EIS partial spherical coverage

|  |  |
| --- | --- |
| * Spherical Coverage Level
 | * EIS at 50th %-tile CCDF
 |
| * E1
 | * [-30+2] dBm
 |
| * Note: The EIS is measured in the upper hemisphere only.
 |

* Alternatively, the partial sphere coverage requirement can be defined as the max EIS measured over the partial sphere of an angular width of [+/-45] degrees.
* In order to reduce the test burden, the EIS partial sphere coverage requirement is only verified at the middle frequency of the supported band(s).
* The AIoT CFA (Contention-Free Access) procedure is used to evaluate the receiver sensitivity with success rate >=90%. There is no need to consider false alarm rate.
* Use the following parameters for the FRC for Rx sensitivity measurement.

|  |  |
| --- | --- |
| PRB | 1 |
| M | Down-select from [2 or 6] |
| SCS | 15 |
| TBS | Depending on the size of the MAC PDU of A-IoT paging message indicating CFA |
| CRC | 16 |

Proposal 2 (ZTE):

* propose to define the charging REFSENS requirement at the peak direction as -27dBm.
* propose to define the -34dBm with 99% inventory success rate as the decoding REFSENS requirement under the condition of device charged to enable the work.
* propose to define the spherical coverage requirement at the 48% coverage as -31dBm with 99% inventory success rate.
* propose to consider the following R2D FRC as starting point for further discussion.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | SCS | 15 | 15 | 15 | 15 |
|  | PRB | 1 | 2 | 3 | 4 |
| SIP | Bit length | 8 | 8 | 8 | 8 |
|  | M\_SIP | 4 | 4 | 4 | 4 |
|  | OOK |  |  |  |  |
|  | OFDM | 2 | 2 | 2 | 2 |
| CAP | Bit length | 4 | 4 | 4 | 4 |
|  | M | 2 | 2 | 2 | 2 |
|  | OOK |  |  |  |  |
|  | OFDM | 2  | 2  | 2  | 2  |
| PRDCH | TBS | 96Depend on the RAN2 conclusion. |
|  | CRC | 16 | 16 | 16 | 16 |
|  | Line encoding |  |  |  |  |
|  | OOK |  |  |  |  |
|  | M | 2 | 2 | 2 | 2 |
| postamble | Bit length | 4 | 4 | 4 | 4 |
|  | M | 6 | 12 | 2 | 2 |
| chip number except for SIP,padding |  | 228 | 228 | 228 | 228 |
| Padding |  | 6 | 12 | 2 | 2 |

Proposal 3 (Ericsson): Averaging EIS can be specified instead of the maximum EIS if a dipole antenna is assumed in device.

Proposal 4 (Sony):

* It is proposed to define a minimum -37 dBm REFSENS requirement, which is applicable within a 45° solid angle range partial sphere with respect to the bore sight direction (or UE declared direction) of the AIoT device 1.
* RAN4 needs to verify the FAR performance of the device either as part of the REFSENS test or under the Demod test.

Proposal 5 (Vivo):

* The false alarm is not considered as the performance metric.
* Use minimum sensitivity over partial sphere as the additional requirement, 45° sphere with 5.5 dB degradation compared to the peak EIS..

Proposal 5 (Spreadtrum, UNISOC):

* The reference sensitivity can be -29dBm
* The metric of reference sensitivity can be success rate (≥ 90%)

Proposal 6 (Qualcomm):

* Use known pagingID and CFRA for REFSENS test procedure
* Allow set time + SFO for the devices response time.
* Leave number of repeats to reach 10 % miss detection rate for the RAN5 to determine.
* The CW input level should be at least equal to the maximum input level of R2D for REFSENS testing.

Proposal 7 (xiaomi):

* The following two options can be considered for the REFSNES requirement.
* 1)EIS in the peak direction.
* 2)Several directions based on the declaration if the extra test burden and cost are endurable.
* 90% success rate of identifying the tag is used to test tag REFSENS for PRDCH channel. No FAR is needed.

Proposal 8 (CMCC):

* REFSENSE is suggested as -34dBm
* define min sensitivity at peak antenna gain direction and EIS spherical coverage requirements, XdBm at Y degree. Y is suggested to be +-60degree, X is suggested to be 3dB worse than REFSENSE.

Proposal 9 (OPPO): To test the 60° hemi-sphere REFSENS.

**Recommended WF:**

* Define peak EIS at declared peak antenna gain direction and EIS spherical coverage requirements,
	+ EIS at peak antenna gain direction is -34dBm. Additional peak EIS levels can be added in the future if needed
	+ EIS spherical coverage requirement is defined as sensitivity over partial sphere, i.e. XdBm at Y solid angle range partial sphere . Y is suggested to be [+-60 degree, +-45 degree] with respect to the bore sight direction (or UE declared direction), X is suggested to be [3dB, 5.5dB, 6dB] worse than peak EIS.



* **Figure I Illustration of additional test point for sensitivity**
* For testing metric:
	+ 90% success rate.
	+ Use CFRA for REFSENS test procedure
	+ Allow set time + SFO for the device response time.
	+ Leave number of repeats to reach 90% success rate for the RAN5 to determine.
* FRC is listed as below

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | SCS | 15 | 15 | 15 | 15 |
|  | PRB | 1 | 2 | 3 | 4 |
| SIP | Bit length | 8 | 8 | 8 | 8 |
|  | M\_SIP | 4 | 4 | 4 | 4 |
|  | OOK |  |  |  |  |
|  | OFDM | 2 | 2 | 2 | 2 |
| CAP | Bit length | 4 | 4 | 4 | 4 |
|  | M | 2 | 2 | 2 | 2 |
|  | OOK |  |  |  |  |
|  | OFDM | 2  | 2  | 2  | 2  |
| PRDCH | TBS | Depending on the size of the MAC PDU of A-IoT paging message indicating CFA |
|  | CRC | 16 | 16 | 16 | 16 |
|  | Line encoding |  |  |  |  |
|  | OOK |  |  |  |  |
|  | M | [2/6] | [2/6] | [2/6] | [2/6] |
| postamble | Bit length | 4 | 4 | 4 | 4 |
|  | M | 6 | 12 | 2 | 2 |
| chip number except for SIP, padding |  | 228 | 228 | 228 | 228 |
| Padding |  | 6 | 12 | 2 | 2 |

## Topic 3-5: Others

**Issue 3-5-1: Maximum input power**

|  |
| --- |
| **Agreement in RAN4#115:*** Define maximum input level at peak antenna direction, using [-4dBm] as starting point.
 |

Proposal 1 (Huawei): Set the maximum input level to -4 dBm for AIoT devices..

Proposal 3 (Sony):

* The maximum input level of R2D needs to be defined to ensure the RF-ED receiver operates in the square-law region of the diode and that the signal can be self-mixed to the DC.
* Consider a maximum input power level in the range between -20 and -10 dBm as starting point.
	+ typical square law region for a Schottky diode is below -20 dBm

Proposal 4 (vivo): The maximum input power of device is -20 dBm

Proposal 5 (Spreadtrum, UNISOC):

Using dynamic range of device receiver to define maximum input level. The maximum input level can be -4dBm..

Proposal 6 (Qualcomm): Define a range for CW input power for the device similarly as max input level

Proposal 7 (CATT): The MCL should be discussed first to check if maximum input power requirement is needed. If the MCL needs to be determined, the value of MCL in TR 38.769 could be considered

Proposal 8 (xiaomi): 0 dBm is defined for the maximum input power for device 1

Proposal 9 (CMCC): -4dBm max input power with 30dB dynamic range assumption.

**Recommended WF:**

Max input level is 30dB higher than peak EIS, detailed value is based on conclusion of min sensitivity.

# OTA test method

## Topic 4-1: General

**Issue 4-1-1: testing frequencies**

|  |
| --- |
| **Agreement in RAN4#115:*** RAN4 agreed to test all low, middle and high frequency ranges, and leave RAN5 to determine testing frequency range.
 |

Proposal 1 (HW): select a single bandwidth for OTA tests

**Recommended WF:**

Wait for the conclusion from core requirements discussion.

## Topic 4-2: Test setup

**Issue 4-2-1: testing antenna and CW antenna relationship**

|  |
| --- |
| **Agreement in RAN4#115:*** Power difference between received backscatter signal and the CW signal leakage is at least [15dB]
	+ FFS on reference point of power difference
 |

Proposal 1 (Sony): RAN4 focus on the test case where the CW antenna and reader antenna is collocated in Rel-19.

Proposal 2 (Qualcomm): For backscatter power/gain testing, the separation between measurement antenna and CW antenna is 0 degree, i.e., using the same probe as measurement antenna and CW antenna. The peak direction and CW polarization could be declared by device.

Proposal 3: (Ericsson:

* implement 2D scan-based performance metrics for A-IoT device 1 with a CW incident angle of 30°.
* 2D scanning should be performed in a plane 45° rotated from E-plane.
* these 2D scan-based performance metrics are only for A-IoT device 1, which lack internal RF transmitters, and do not set a precedent for future “active” A-IoT devices.
* a 2D scan by fixing both the DUT and CWT node and moving the testing antenna along a boom or using multiple probes on a boom, as shown in Figure 2.



Figure 2. Performing 2D scanning for A-IoT device 1 testing

**Recommended WF：**

CW and measurement antenna are co-located, i.e.using the same probe,

**Issue 4-2-2: Power difference between received backscatter signal and the CW signal leakage**

|  |
| --- |
| **Agreement in RAN4#115:*** Power difference between received backscatter signal and the CW signal leakage is at least [15dB]
* FFS on reference point of power difference
 |

Proposal 1 (Qualcomm): There is no need to specify power difference between received backscatter signal and the CW signal leakage. The min. isolation is defined to avoid the blocking issue at the receiver if separate CW antenna and measurement antenna is used.

Proposal 2 (Vivo): No need to define the power difference between backscatter signal and CW leakage

Proposal 3 (OPPO): The reference point of power difference can be calibrated at the measurement antenna.

Proposal 4 (CMCC): power difference is needed because the leakage of CW will mix with the backscatter signal in frequency domain.

**Recommended WF：**

No need to specify power difference between received backscatter signal and the CW signal leakage

**Issue 4-2-3: polarization of CW antenna**

|  |
| --- |
| **Agreement in RAN4#115:*** The CW signal shall be sent in two polarized sequentially, FFS on how to combine two polarization test results.
 |

Proposal 1 (Sony): The CW signal shall be sent in two polarized sequentially, and backscattered loss shall be defined either as the summed value between the two polarizations or the average value between the two polarization (assuming 3 dB polarization loss).

Proposal 2 (Qualcomm):

* To verify the emission, two CW polarizations should be sent sequentially.
* To simplify the testing process, the device can declare the polarization of the CW signal for REFSENS, backscatter power, maximum input level testing.

Proposal 3 (vivo):

* The D2R backscatter power is combine from all polarization combinations:

$$EIRP\left(θ,ϕ\right)=EIRP\_{θ}\left(θ,ϕ\right)|\_{cw\_{θ}\left(θ,ϕ\right)}+EIRP\_{ϕ}\left(θ,ϕ\right)|\_{cw\_{θ}\left(θ,ϕ\right)}+EIRP\_{θ}\left(θ,ϕ\right)|\_{cw\_{ϕ}\left(θ,ϕ\right)}+EIRP\_{ϕ}\left(θ,ϕ\right)|\_{cw\_{ϕ}\left(θ,ϕ\right)}$$

* The EIS is combined from $θ$ and $ϕ$ polarization by following equation:

$$EIS\left(θ,ϕ\right)=\frac{1}{(\frac{1}{EIS\_{θ}\left(θ,ϕ\right)}+\frac{1}{EIS\_{ϕ}\left(θ,ϕ\right)})}$$

* For Rx requirements verification, the CW configuration is same as backscatter loss with the polarization combination that can get maximum EIRP.

Proposal 4 (HW):

* The EIS measurement is performed for both θ-polarization and ϕ-polarization. And the average EIS is calculated as:

EIS = [1/EIS(PolMeas= +1/EIS(PolMeas=]-1

* For backscatter power measurement, the CW signal is transmitted in two orthogonal polarisation directions in separate steps. And for each CW stimulation, the backscattered power is measured in two orthogonal directions. The following equations are used for derive the backscatter power $p\_{back}$:

$$p\_{back,1}=p\_{back,1}\left(PolMeas=θ\right)+p\_{back,1}\left(PolMeas=φ\right)$$

$$p\_{back,2}=p\_{back,2}\left(PolMeas=θ\right)+p\_{back,2}\left(PolMeas=φ\right)$$

$p\_{back}= p\_{back,1}+p\_{back,2}$.

Proposal 5 (OPPO):

* To combine the two polarization of CW signal, test each polarization once with measurement antenna at horizontal and vertical polarization and add them together.
* In spec, to mention that the reflected power is correctly received by the measurement antenna to avoid the total vertical case.

**Recommended WF：**

* For Rx requirement, reuse the same EIS calculation equation as UE FR1 EIS:

$$EIS\left(θ,ϕ\right)=\frac{1}{(\frac{1}{EIS\_{θ}\left(θ,ϕ\right)}+\frac{1}{EIS\_{ϕ}\left(θ,ϕ\right)})}$$

* For Tx requirements, The D2R backscatter power is combine from all polarization combinations:

$$EIRP\left(θ,ϕ\right)=EIRP\_{θ}\left(θ,ϕ\right)|\_{cw\_{θ}\left(θ,ϕ\right)}+EIRP\_{ϕ}\left(θ,ϕ\right)|\_{cw\_{θ}\left(θ,ϕ\right)}+EIRP\_{θ}\left(θ,ϕ\right)|\_{cw\_{ϕ}\left(θ,ϕ\right)}+EIRP\_{ϕ}\left(θ,ϕ\right)|\_{cw\_{ϕ}\left(θ,ϕ\right)}$$

* In spec, to mention that the reflected power is correctly received by the measurement antenna to avoid the total vertical case.

**Issue 4-2-3: testing direction and 3D scan for each requriements**

|  |
| --- |
| **Agreement:** * For TRP, TRS, EIRP and EIS requirements (depending on core requirements) measurement grid:
* For TRP and EIRP, use 30 degree as starting point
* For TRS and EIS, use 45 degree as starting point.
 |

Proposal 1 (HW):

* measure backscattering power in a single direction declared by manufacturers
* measure device sensitivity over a solid angle, e.g. hemisphere or partial sphere.

Proposal 2 (Qualcomm):

* For backscatter power/gain testing, the peak direction could be declared by device.
* For AIoT device emission testing, the test direction is the same as the test direction of backscatter power/gain testing, i.e., peak direction declared by device. The input power level of CW signal should be decided together with core requirements.
* The testing direction for EIS at peak direction should be declared by device.
* The testing direction for maximum input level should be declared by device.

Proposal 3 (vivo): For min EIS over partial sphere, only test the points with 90° separation at edge of partial sphere.

Proposal 4 (OPPO): For REFSENS requirement, define 4 extra test points at theta = 60° plane to verify the antenna pattern and coverage.

Proposal 5 (Ericsson):

* implement 2D scan-based performance metrics for A-IoT device 1 with a CW incident angle of 30°.
* 2D scanning by fixing both the DUT and CWT node and moving the testing antenna along a boom or using multiple probes on a boom should be performed in a plane 45° rotated from E-plane.
* these 2D scan-based performance metrics are only for A-IoT device 1, which lack internal RF transmitters, and do not set a precedent for future “active” A-IoT devices.



Figure 2. Performing 2D scanning for A-IoT device 1 testing

**Recommended WF：**

* the testing directions for following requirements should be declared by device:
	+ Backscatter power at peak direction
	+ EIS at peak direction
	+ Emission testing at peak direction
	+ Maximum input level at peak direction
* For EIS spherical coverage testing, only test the points with 90° separation at edge of partial sphere where the partial sphere is defined in core requirements part.



* **Figure I Illustration of additional test point for sensitivity**

## Topic 4-3: Test procedure

**Issue 4-3-2: Test procedure for receiver RF requirements**

|  |
| --- |
| **Agreement:** * Step 1: Conduct the calibration procedure to determine testing antenna gain, CW antenna gain, mismatch between testing/CW antenna to DUT, insertion loss and cable loss, etc.
* Step 2: Place DUT based on UE positioning guidelines.
* Step 3: Device is assumed charging during the measurement according to device declaration on the required energy conditions.
* Step 4: Set the target test frequency and transmit power for signal generator and CW signal. The transmit power of signal generator shall be set as that the received power at DUT’s antenna is equal to minimum reference sensitivity requirement of device. FSS on the CW signal level.
* Step 5: Determine whether DUT can send the correct response in D2R channel within timing window, e.g., TR2D\_min
* Step 6: Move to next measurement point and repeat Step 3-5 until complete all the testing point in the measurement grid.
* Step 7: FFS on performance metric. FFS on how to specify the performance metric.
 |

Proposal 1 (HW): The measurement procedure includes the following steps:

1. Conduct the calibration procedure to determine testing antenna gain, CW antenna gain, mismatch between testing/CW antenna to DUT, insertion loss and cable loss, etc.
2. Place DUT based on UE positioning guidelines.
3. Device is assumed charged during the measurement according to device declaration on the required energy conditions.
4. Set the target test frequency and transmit power for signal generator and CW signal. The transmit power of signal generator shall be set such that the received power at DUT’s antenna is a few dB above minimum reference sensitivity requirement of device.
5. Reader transmits in θ-polarization, but receives in θ-polarization and ϕ-polarization either simultaneously or sequentially.
6. CW transmits in θ-polarization to ensure CW incident power at the device antenna is [x]dB higher than the receiver sensitivity requirement.
7. Initial Reader transmit power shall be high enough for Reader to receive and decode responses from device successfully.
8. Then Reader transmit power level is reduced to achieve 90% response decode success rate by determining whether DUT can send correct response in D2R channel within correct timing relationship.
9. Repeat step 5) to 8) for all grid points over hemisphere and record the Reader received power levels.
10. Change Reader configuration to: Reader transmits in ϕ-polarization, but receives in both θ‑polarization and ϕ-polarization.
11. Change CW configuration to: CW transmits in ϕ-polarization to ensure device reception
12. Repeat step 5) and 8) for all grid points over hemisphere and record the Reader received power levels
13. For every measured grid points, calculate total transmit power from Reader in both polarizations in dB:
	1. Pθ (θi, ϕj) = PTx(θ-polarization) + Gainantenna – Pathloss
	2. Pϕ (θi, ϕj) = PTx(ϕ-polarization) + Gainantenna – Pathloss
14. Calculate sensitivity at grid point (i, j) using linear values:

Refsens(θi, ϕj) = $[\frac{1}{Plinear\_{θ}(θ\_{i}, ϕ\_{j})}+\frac{1}{Plinear\_{ϕ}(θ\_{i}, ϕ\_{j})}]^{-1}$

.

Proposal 2 (Qualcomm):

* Input power level of CW signal and the power level of R2D should be decided together with core requirements. The level of R2D could be set as sensitivity+[X]dB. FFS on X.
* The CW input level should be at least equal to the maximum input level of R2D for REFSENS testing.
* The CW input level should be at least equal to the maximum input level of R2D for maximum input level testing.

Proposal 3 (vivo): For Rx requirements verification, the CW configuration is same as backscatter loss with the polarization combination that can get maximum EIRP.

Proposal 4 (OPPO):

* To combine the two polarization of CW signal, test each polarization once with measurement antenna at horizontal and vertical polarization and add them together.
* In spec, to mention that the reflected power is correctly received by the measurement antenna to avoid the total vertical case.

**Recommended WF:**

* Use proposal 1 from HW as baseline for polarization testing procedure and wait for the conclusion of EIS calculation and CW input level
* CW input level:
	+ Ensure CW incident power at the device antenna is [3]dB higher than the receiver sensitivity requirement

**Issue 4-3-3: Test procedure for Tx RF requirements**

|  |
| --- |
| **Agreement:** * Step 1: Conduct the calibration procedure to determine testing antenna gain, CW antenna gain, mismatch between testing/CW antenna to DUT, insertion loss and cable loss, etc.
* Step 2: Place DUT based on UE positioning guidelines.
* Step 3: Device is assumed charging during the measurement according to device declaration on the required energy conditions.
* Step 4: Set the target test frequency and transmit power for signal generator and CW signal. The received power at the antenna of DUT is Pin. Pin is set as the power level of minimum reference sensitivity of device equal to or larger than “sensitivity+[X]dB”
* Step 5: Measure and record the backscattering signal level from DUT and calculate the backscattering power level transmitting from DUT antenna, i.e., Pout, based on the calibration data from step 1
* Step 6: Move to next measurement point and repeat Step 3-5 until complete all the testing point in the measurement grid.
* Step 7: Calculate the ratio of CW power level to D2R signal power (i.e., before and after backscattering) according to the equation: backscattering loss (dB) = Pout (TRP) – Pin (TRP)
* Step 8: FFS on performance metric. FFS on how to specify the performance metric.
 |

Proposal 1 (HW): The measurement procedure includes the following steps, which add the polarization testing procedure.

1. Conduct the calibration procedure to determine testing antenna gain, CW antenna gain, mismatch between test/CW antenna to DUT, insertion loss and cable loss, etc.
2. Position Reader and device such that the direction of maximum backscattering faces the Reader according to the declaration from device manufacturers.
3. Device is assumed charged during the measurement according to device declaration on the required energy conditions.
4. Set the target test frequency and transmit power for signal generator and CW signal. The transmit power of signal generator shall be set such that the received power at DUT’s antenna is larger than minimum reference sensitivity requirement of device. CW transmits in θ-polarization to ensure CW incident power at the device antenna is [x]dB higher than the receiver sensitivity requirement.
5. Reader receives in θ-polarization and ϕ-polarization either simultaneously or sequentially and record received power levels. Repeat step 2) and 3) with CW transmits in ϕ-polarization.
6. Calculate backscattered power from the device: Pout = $\sum\_{CW=θ,ϕ }^{}\{(EIRP\_{θ}-Pathloss-Gain\_{antenna})+(EIRP\_{ϕ}-Pathloss- Gain\_{antenna})\}$

Where

 Pathloss : free space propagation loss between test antenna and device

 Pout : backscattered power

 Pin : CW incident power at device

 PCW,θ and PCW,ϕ : CW transmit power in θ-polarization and the ϕ-polarization, respectively

 $EIRP\_{θ} and EIRP\_{ϕ}$ ：Reader received power in θ-polarization and the ϕ-polarization, respectively

Gainantenna : test antenna gain

Proposal 2 (Qualcomm): Input power level of CW signal and the power level of R2D should be decided together with core requirements. The level of R2D could be set as sensitivity+[X]dB. FFS on X.

**Recommended WF:**

* Use proposal 1 from HW as baseline for polarization testing procedure and wait for the conclusion of CW input level
* The input CW level for Tx requirements will be decided together with core requirements.

## Topic 4-4: Energy source and energy harvesting

**Issue 4-4-1: energy source and energy harvesting**

|  |
| --- |
| **Agreement:** * Device declaration on the required energy conditions.
* External energy source directly connected to the device with cable and/or battery is excluded.
 |

Proposal 1 (Sony): The UE charging time duration and periodicity may need to be declared in the OTA test

Proposal 2 (Qualcomm): From AIoT testing PoV, at least the time to complete charging, and the duration the device can remain ON after charging should be declared. FFS on other needed device declaration information.

**Recommended WF:**

Following charging related configuration need to be declared.

* The time to complete charging
* The duration the device can remain ON after charging
* Charging periodicity

## Topic 4-5: MU

**Issue 4-5-1:MU assessment**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  **Agreement in RAN4#115:*** Use following MU as starting point

**Table 1 MU for Tx requirements**

|  |  |  |
| --- | --- | --- |
| **UID** | **Description of uncertainty contribution** | **Reuse or not** |
| **Stage 2: DUT measurement (Figure 7.2-1, Figure 7.2-2)** |
| 1 | Mismatch of receiver chain  | reused |
| 2 | Insertion loss of receiver chain | reused |
| 3 | Influence of the measurement antenna cable | reused |
| 4 | Measurement Receiver: uncertainty of the absolute level | [-0.65] |
| 5 | Measurement distance | reused |
| 6 | Quality of quiet zone | reused |
| 7 | DUT Tx-power drift | FFS |
| ~~8~~ | ~~Uncertainty related to the use of phantoms~~ | No needs |
| 9 | Coarse sampling grid | - For TRP and EIRP, use 30 degree as starting point- For TRS and EIS, use 45 degree as starting point |
| 10 | Random uncertainty  | reused |
| 11 | Frequency Response | reused |
| **Stage 1: Calibration measurement, network analyzer method (Figure 7.3-1)** |
| 12 | Uncertainty of network analyzer | reused |
| 13 | Mismatch of receiver chain | reused |
| 14 | Insertion loss of receiver chain | reused |
| 15 | Mismatch in the connection of calibration antenna | reused |
| 16 | Influence of the calibration antenna feed cable | reused |
| 17 | Influence of the measurement antenna cable | reused |
| 18 | Uncertainty of the absolute gain/ radiation efficiency of the calibration antenna | reused |
| 19 | Measurement distance | reused |
| 20 | Quality of the Quiet Zone | reused |
| **Systematic Errors** |
| 21 | Systematic Error related to TRP grids | reused |

**Table 2 MU for Rx requirements**

|  |  |  |
| --- | --- | --- |
| UID | Description of uncertainty contribution for sensitivity | Details in clause |
| Stage 2: DUT measurement (Figure 7.2-1, Figure 7.2-2) |
| 1 | Mismatch of transmitter chain  | Reused  |
| 2 | Insertion loss of transmitter chain | Reused  |
| 3 | Influence of the measurement antenna cable | Reused  |
| 4 | R2D for sensitivity measurement: uncertainty of the absolute output level |  0.27 |
| 5 | Sensitivity measurement: output level step resolution | Reused  |
| 6 | Measurement distance | Reused  |
| 7 | Quality of quiet zone  | Reuse the same QZ size and minimum range length as in 38.870. i.e. 30cm QZ size and 90cm minimum range length. |
| 8 | DUT sensitivity drift |  0.12 |
| ~~9~~ | ~~Uncertainty related to the use of phantoms~~ | No needs |
| 10 | Coarse sampling grid | -              For TRP and EIRP, use 30 degree as starting point-              For TRS and EIS, use 45 degree as starting point |
| 11 | Random uncertainty  | Reused  |
| 12 | Frequency Response | Reused  |
| **Stage 1: Calibration measurement, network analyzer method (Figure 7.3-1)** |
| 13 | Uncertainty of network analyzer  | Reused |
| 14 | Mismatch of transmitter chain  | Reused |
| 15 | Insertion loss of transmitter chain | Reused |
| 16 | Mismatch in the connection of calibration antenna | Reused |
| 17 | Influence of the calibration antenna feed cable | Reused |
| 18 | Influence of the measurement antenna cable | Reused |
| 19 | Uncertainty of the absolute gain/radiation efficiency of the calibration antenna | Reused |
| 20 | Measurement distance | Reused |
| 21 | Quality of quiet zone | Reuse the same QZ size and minimum range length as in 38.870. i.e. 30cm QZ size and 90cm minimum range length. |
| **Systematic Errors** |
| 22 | Systematic Error related to TRS grids | Reused |

 |

# TPs

**All following TPs need to be revised according to the final conclusion.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Number** | **Section in TS38.191** | **Volunteer companies** | **Proposed TP in this meeting** |
| No.1 | **3 Definitions, symbols and abbreviations** | CMCC | R4-2509719 (CMCC) |
| *3.1 Definitions* |
| *3.2 Symbols* |
| *3.3 Abbreviations* |
| No.2 | **4 General** | CATT | R4-2509364(CATT) |
| *4.1 Relationship between minimum requirements and test requirements* |
| *4.2 Applicability of minimum requirements* |
| No.3 | **5 Operating bands and channel arrangement** | Xiaomi | R4-2509809 (xiaomi) |
| *5.1 General* |
| *5.2 Operating bands* |
| No.4 | *5.3 Channel bandwidth* | CMCC | R4-2509720 (CMCC)R4-2509882 (HW)R4-2511435 (Ericsson), D2R channel bandwidth |
| No.5 | *5.4 Channel Arrangement* | CMCC |
| No.6 | **6 Transmitter characteristics** | Ericsson | R4-2511435 (Ericsson), max output powerR4-2511434 (Ericsson, Sony), backscatter power loss |
| *6.1 General* |
| *6.2 Backscatter power* |
|  | *6.3 Backscatter signal quality*  | No need |  |
| No.7 | *6.4 Output RF spectrum emissions* | vivo | R4-2510251 (vivo) |
| No.8 | **7 Receiver characteristics** | Huawei | R4-2511421 (Huawei, HiSilicon) |
| *7.1 General* |
| *7.2 Reference sensitivity power level* |
| No.9 | *7.3 Maximum input level* | Spreadtrum | R4-2510204 (Spreadtrum,UNISOC) reservedR4-2510210 (Spreadtrum,UNISOC) |
| No.10 | **8 OTA test characteristics** | OPPO | R4-2510846 |
| *8.1 General* |
| *8.1.1 Testing bands* |
| No.11 | *8.2 Performance metrics* | vivo | R4-2510253 (vivo)R4-2510254 (vivo) CR to TR 38.870 on AIoT test method |
| No.12 | *8.3 Device positioning guidelines* | CMCC | R4-2509721 (CMCC) |
| No.13 | *8.4 Anechoic Chamber method* | Huawei, Qualcomm | R4-2509106 (HW) |
| No.14 | Annex A (normative): Device coordinate system | Huawei | R4-2509107 (HW) |
| Annex B (normative): Estimation of Measurement uncertainty |
| No.15 | Annex C (normative): FRC | ZTE | R4-2511129 (ZTE) |