**Title:****[Post-117-AIoT-01] Email discussion on remaining Ambient IoT evaluation assumptions**

# Background

[Post-117-AIoT-01] – Xiaodong (CMCC)

Email discussion on remaining Ambient IoT evaluation assumptions from May 29 until June 5 (the weekend is a quiet period)

• Approval of note 1 of the link budget table (highlighted in yellow) in section 9.4.1.1 of R1-2405696.

• Approval of the link level simulation table (highlighted in yellow) in section 9.4.1.1 of R1-2405696.

# Post-117 email discussion proposals

The proposals under discussion are summarized in a document (V001) in section 2, which is now available in draft folder (Please find the link below).

[https://www.3gpp.org/ftp/tsg\_ran/WG1\_RL1/TSGR1\_117/Inbox/[Post-117]/[AIoT-01](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_117/Inbox/%5bPost-117%5d/%5bAIoT-01)]

I suggest dividing email discussion into 3 phases.

* Phase 1: Company to input comments to the 2 proposals (May 29 UTC 00:01 ~ May 30 UTC 00:00)
* Phase 2: Update the proposals and provide another round of comments (May 30 UTC 00:01~ May 31 UTC 23:59)
* Phase 3: Update the proposals again and try to stabilize the proposals (June 3 ~ June 5)

## link budget table

### Round 1

**[H][Proposal1-v1]**

Agreement

The link budget table is updated as follows (the yellow parts are not agreed and will be discussed by email),

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** |
| **(0) System configuration** | | | |
| [0A] | Scenarios | D1T1-A1/A2/B/C  D2T2-A1/A2/B/C | D1T1-A1/A2/B/C  D2T2-A1/A2/B/C |
| [0A1] | CW case | N/A | 1-1/1-2/1-4/2-2/2-3/2-4 |
| [0B] | Device 1/2a/2b | Device 1/2a/2b | Device 1/2a/2b |
| [0C] | Center frequency (MHz) | 900MHz (M), 2GHz (O) | 900MHz (M), 2GHz (O) |
| [0D] | Topology/Pathloss model | For D2T2:   * [0D]-Alt1: InF-DL NLOS * [0D]-Alt2: InH-Office LOS   For D1T1:   * InF-DH NLOS | For D2T2:   * [0D]-Alt1: InF-DL NLOS * [0D]-Alt2: InH-Office LOS   For D1T1:   * InF-DH NLOS |
| **(1) Transmitter** | | | |
| [1D] | Number of Tx antenna elements / TxRU/ Tx chains modelled in LLS | For BS:  - 2(M) or 4(O) antenna elements for 0.9 GHz  For Intermediate UE:  - 1(M) or 2(O) | 1 |
| [1E] | Total Tx Power (dBm) | * For BS in DL spectrum for indoor   + [1E]-R2D-Alt1: 33dBm(M),   + [1E]-R2D-Alt2: 38dBm(O),   + [1E]-R2D-Alt3: 24dBm(M)   + Companies to report if PSD constraints are imposed (company to report the condition for applying PSD constraints in Row [5A]: Other notes) * For UL spectrum for indoor,   + [1E]-R2D-Alt4:23dBm (M)   + [1E]-R2D-Alt5:26dBm(O) | * For device 1/2a:   + [1E]-D2R-Alt1: (For scenarios ‘B’)     - The Device Tx Power is calculated by CW received power which can be derived by at least CW2D distance (m) value and other related factors.   + [1E]-D2R-Alt2: (For scenarios ‘A1’ and ‘A2’)     - The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. * For device 2b: (For scenarios ‘C’)   + [1E]-D2R-Alt3: -20 dBm(M)   + [1E]-D2R-Alt4: -10 dBm(O) |
| [1E1] | CW Tx power (dBm) | N/A | For scenario ‘A1’, ‘A2’ and ‘B’   * Report a value from the candidate values [1E]-R2D-Alt1/[1E]-R2D-Alt2/[1E]-R2D-Alt3 from [1E]-R2D if CW in DL spectrum * Report a value from the candidate values [1E]-R2D-Alt4/[1E]-R2D-Alt5 from [1E]-R2D if CW in UL spectrum.   Note: only applicable for device 1/2a |
| [1E2] | CW Tx antenna gain (dBi) | N/A | * Company to report, the value equals to   + UE Tx ant gain, or   + BS Tx ant gain   Note: only applicable for device 1/2a |
| [1E3] | CW2D distance (m) | N/A | For scenarios ‘B’   * + D1T1-B:     - 5m,     - 10m,     - 20m     - CW2D distance is derived assuming CW node is located with the same position as ‘R1’ in ‘A1’ scenario   + D2T2-B:     - 5m,     - 10m,   + FFS other values   For scenarios ‘A1’ and ‘A2’   * + Calculated (see note 1), (i.e., CW2D distance is calculated by assuming CW2D pathloss = D2R pathloss)   Note: only applicable for device 1/2a  Note: companies to report which value(s) are evaluated. |
| [1E4] | CW2D pathloss (dB) | N/A | Calculated (see note1)  Note: only applicable for device 1/2a |
| [1E5] | CW received power (dBm) | N/A | Calculated (see note1)  Note: only applicable for device 1/2a |
| [1F] | Transmission Bandwidth used for the evaluated channel (Hz) | 180kHz(M),  360kHz(O),  1.08MHz(O) | Refer to LLS table [1a] |
| [1G] | Tx antenna gain (dBi) | * For BS for indoor, 6 dBi(M), 2dBi(M) * For intermediate UE, 0 dBi | * For A-IoT device, 0dBi |
| [1H] | Ambient IoT backscatter loss (dB) due to Modulation factor | N/A | * OOK: 6 dB * PSK: 0 dB * FSK: Y dB   It is applicable for device 1 and 2a  Companies to report and justify their assumptions for Y.  Companies to report in row 3D if they assume any additional related loss. |
| [1J] | Ambient IoT on-object antenna penalty | Not applicable | 0.9dB or 4.7dB |
| [1K] | Ambient IoT backscatter amplifier gain (dB) | N/A | * 10 dB (M) * 15 dB (O)   Note: Only for device 2a |
| [1N] | Cable, connector, combiner, body losses, etc. (dB) | * For BS, X dB, X <=3 to be reported by companies with justification provided in row 5A * For intermediate UE, 1 dB | N/A |
| [1M] | EIRP (dBm) | Calculated (see Note 1)  FFS: any limitation of the EIRP subject to future discussion | Calculated (see Note 1) |
| **(2) Receiver** | | | |
| [2A] | Number of receive antenna elements / TxRU / chains modelled in LLS | Same as [1D]-D2R | Same as [1D]-R2D |
| [2B] | Bandwidth used for the evaluated channel (Hz) | Refer to LLS table [1b] ED bandwidth | Refer to LLS table [2a] [receiver bandwidth?] |
| [2C] | Receiver antenna gain (dBi) | same as [1G]-D2R | Same as [1G]-R2D |
| [2X] | Cable, connector, combiner, body losses, etc. (dB) | N/A | Same as [1N]-R2D |
| [2D] | Receiver Noise Figure (dB) | For RF-ED receiver   * 20dB, Device 2   + FFS other values   For IF/ZIF receiver   * 15dB, Device 2 | For BS as reader   * 5dB   For intermediate UE as reader   * 7dB |
| [2E] | Thermal Noise power spectrum density (dBm/Hz) | -174 | -174 |
| [2F] | Noise Power (dBm) | Calculated (see Note 1) | Calculated (see Note 1) |
| [2G] | Required SNR/CNR | Reported by companies for Budget-Alt2 | Reported by companies for Budget-Alt2 |
| [2H] | Ambient IoT on-object antenna penalty | 0.9dB or 4.7dB | Not applicable |
| [2J] | Budget-Alt1/ Budget-Alt2 | Budget-Alt1/ Budget-Alt2 (see note1) | Budget-Alt2 |
| [2K] | CW cancellation (dB) | N/A | Companies to report for scenario A2/A1/B for BS and intermediate UE.  Note:   * Only applicable for device 1/2a * The value provided is for the unmodulated single-tone CW. The impact of a multi-tone CW, e.g., assuming an [X] dB difference, is FFS |
| [2K1] | Remaining CW interference (dB) | N/A | Calculated (see Note 1)  Note: only applicable for device 1/2a |
| [2K2] | Receiver sensitivity loss(dB) | N/A | Calculated (see Note 1)  Note: only applicable for device 1/2a |
| [2L] | Receiver Sensitivity (dBm) | For Budget-Alt1,   * For device 1 (RF-ED), for example:   + {-30dBm, -36dBm, -40dBm, etc} * For device 2 (RF-ED), for example:   + {-40dBm, -45dBm, etc}   For Budget-Alt2,   * Calculated (see note1) | Calculated (see Note 1)  Note: the receiver sensitivity includes the receiver sensitivity loss [2K2], i.e. after CW cancellation at least if ‘A2’ scenario is used |
| **(3) System margins** | | | |
| [3A] | Shadow fading margin (dB) | For D1T1: 4 dB  For D2T2: 3dB for InH-LOS  7.2dB for InF-DL-NLOS | For D1T1: 4 dB  For D2T2: 3dB for InH-LOS  7.2dB for InF-DL-NLOS |
| [3B] | polarization mismatching loss (dB) | 3 dB | 3 dB |
| [3C] | BS selection/macro-diversity gain (dB) | 0 dB  FFS: other values are not precluded | 0 dB  FFS: other values are not precluded |
| [3D] | Other gains (dB) (if any please specify) | Reported by companies with justification | Reported by companies with justification |
| **(4) MPL / distance** | | | |
| [4A] | MPL (dB) | Calculated (see Note 1) | Calculated (see Note 1) |
| [4B] | Distance (m) | Calculated (see Note 1) | Calculated (see Note 1) |
| **（5）Other** | | | |
| [5A] | Other notes | Companies to report | Companies to report |

*<Editor Notes: Note 1 will be updated once the table has stabilized >*

Note1 (for email discussion): calculated values in the Table XXXX are derived according to the followings,

[1M]:

* For R2D,
  + [1M] = [1E] + [1G] - [1N] - FFS: [1J]
* For D2R
  + Device 1:
    - [1M] = [1E] + [1G] - [1H] - [1J]
  + Device 2a:
    - [1M] = [1E] + [1G] + [1K] - [1H] - [1J]
  + Device 2b:
    - [1M] = [1E] + [1G] - [1J]

[2F]:

* [2F] = [2D] + [2E] +*lin2dB*([2B])

[2G]

* For the R2D LLS for ED, CINR/CNR is reported, where CINR/CNR is defined as the ratio of signal power spectral density in the transmission bandwidth to the noise and interference (if any) power spectral density in the device ED channel bandwidth.

[2J]

* For R2D link in the coverage evaluation, for device 1
  + Budget-Alt1 is used (note: receiver architecture is RF ED)
* For R2D link in the coverage evaluation for device 2,
  + *Budget-Alt1* is used if receiver architecture is RF ED
  + *Budget-Alt2* is used if receiver architecture is IF/ZIF ED
* Note1a: this does not preclude to have LLS for device 1 and 2 R2D link with RF-ED if needed.
* Note1b: For device 2 R2D link with RF-ED, *Budget-Alt1* is mandatory, *Budget-Alt2* is optional.
* Note1c: this does not imply all M values are achievable with the sensitivity given by *Budget-Alt1* for RF ED
* Note1d: For device 2 with an RF ED-based receiver on the R2D link, if the receiver sensitivity derived from *Budget-Alt2*, assuming a noise figure of [X dB], exceeds the receiver sensitivity based on *Budget-Alt1*, then *Budget-Alt2* is applied.

[2K1]:

* FFS:
  + Alt1: [2K1] = [1E1] + [1E2] - [2K] or
  + Alt2: [2K1] = [1E1] + [1E2] + [2C] - [2K]

[2K2]:

[2L]:

* For R2D and *Budget-Alt2*,
  + [2L] = [2G] - *lin2dB*([2B] / [1F]) + [2F]
  + Note 1e: the term ‘*lin2dB*([2B] / [1F])’ is applied due to scaling from CNR/CINR to SNR/SINR.
* For D2R,
  + [2L] = [2G] + [2F] + [2K2], device 1/2a
  + [2L] = [2G] + [2F], device 2b

[4A]

* [4A]=[1M]+[2C]-[2L]-[3A]-[3B]+[3C]+[3D]
* Note 1f: For scenarios ‘A1’ and ‘A2’, The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. i.e.,
  + TBC: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]-[1H]) for device 1,
  + TBC: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]+[1K]) for device 2

|  |  |  |
| --- | --- | --- |
| **Company** | **Which item?** | **Comments** |
| Company A | [1M] | Example….., |
| Huawei, HiSilicon | [1M] | The [1J] is not relevant to R2D anymore, thus propose the following update:  [1M]:   * For R2D,   + [1M] = [1E] + [1G] - [1N] ~~- FFS: [1J]~~ * For D2R   + Device 1:     - [1M] = [1E] + [1G] - [1H] - [1J]   + Device 2a:     - [1M] = [1E] + [1G] + [1K] - [1H] - [1J]   + Device 2b:   [1M] = [1E] + [1G] - [1J] |
| Huawei, HiSilicon | [2G] | [2G] is now agreed as “reported by companies”, not calculated, there is nothing else to discuss, hence it can be removed from this email discussion. |
| Huawei, HiSilicon | [2J] | Similar comments as 2G, [2J] is not calculated by others and just methodology alternatives. Since when to use Alt1/Alt2 have already been agreed and in [2L] there will be details of each Alt1, this item can be removed from this email discussion. |
| Huawei, HiSilicon | [2K1] | We think Alt2 should be the way to proceed, since the CW interference will be used to calculate sensitivity loss. Thus, propose the following update:  [2K1]:   * ~~FFS:~~   + ~~Alt1: [2K1] = [1E1] + [1E2] - [2K] or~~   Alt2: [2K1] = [1E1] + [1E2] + [2C] - [2K] |
| Huawei, HiSilicon | [4A] | The [4A] calculation is fine but the note seems need to be update  1. To avoid duplicated/contradict to previous agreement, suggest to have some editorial change.  2. Add missing parameters.  The overall updates are as follows:  [4A]   * [4A]=[1M]+[2C]-[2L]-[3A]-[3B]+[3C]+[3D] * Note 1f: For scenarios ~~‘A1’ and ‘A2’,~~ where ~~T~~the Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. i.e.,   + ~~TBC~~ For D2R: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]+2\*[3C]+2\*[3D]+2\*[1G]-[1J]-[2L]+[2C]-[1H]) for device 1,   ~~TBC~~ For D2R: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B] +2\*[3C]+2\*[3D]+2\*[1G]-[1J]-[2L]+[2C]-[1H]+[1K]) for device 2a |
| DOCOMO | [1M] | Same comment as HW. |
| OPPO | [1M], [2K1],  [4A] | [1M]: For R2D, “FFS:[1J]” can be removed as [1J] is not applicable for R2D.  [2K1]: Alt 2 should be used.  [4A]: The 2 TBC can be confirmed. But we suggest to add “-[1H]” for the following similar as that for [1M]. “device 2” should be changed to “device 2a”.   * + [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]+[1K]-[1H]) for device 2a   There seems a typo in [1F]-D2R, it should be “Refer to LLS table [2a1]~~[1a]~~”, maybe we can take this chance to fix it. |
| Spreadtrum | [1M], [2K1] | [1M]: For R2D, “FFS: [1J]” should be removed.  [2K1]: We think Alt2 should be used. |
| vivo | [1M] EIRP (dBm) | For [1M]   * 1. For R2D, [1J] Ambient IoT on-object antenna penalty should be removed, since it has been agreed not applicable to R2D in transmitter side.   2. For D2R, [1N] ‘Cable, connector, combiner, body losses’ should be considered in CW transmission power and which impacts the EIRP of the D2R EIRP for device 1/2a. The calculation should be revised to  |  | | --- | | [1M]:   * For R2D,   + [1M] = [1E] + [1G] - [1N] ~~- FFS: [1J]~~ * For D2R   + Device 1:     - [1M] = [1E] + [1G] -[1N] - [1H] - [1J]   + Device 2a:     - [1M] = [1E] + [1G] -[1N] + [1K] - [1H] - [1J]   + Device 2b:     - [1M] = [1E] + [1G] - [1J] | |
| vivo | [2K1] Remaining CW interference | For the item [2K1], we think that the receiver antenna gain[2C] and the Cable, connector, body losses[1N] and [2X] also need to be considered.  So, we suggest to update the item[2K1] as follows:  [2K1] = [1E1]( CW Tx power (dBm)) + [1E2] (CW Tx antenna gain (dBi))+ [2C] Receiver antenna gain (dBi) - [1N] Cable… Loss - [2X] Cable… Loss - [2K] CW cancellation (dB)  Antenna gain and cable… loss should be considered twice at least for monostatic case with separated Tx antenna for CW transmission and D2R receiver, and cases where CW tx node is separated from D2R receiving node. |
| vivo | [4A] MPL | The Cable, connector, body losses[1N] and [2X] also need to be considered.  Besides, the item[1H] is also applicable for device2a.  And the calculation is updated as follows:  [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]-[1H]-[1N]-[2X]) for device 1,  [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]+[1K]-[1H]-[1N]-[2X]) for device 2  As for the scenario B, the Cable, connector, body losses[1N] and [2X] also need to be considered, duo to the item[1N] is included in the item[1M] . So the item [4A] MPL needs changed as following formula:   * [4A]=[1M]+[2C]-[2X]-[2L]-[3A]-[3B]+[3C]+[3D] |
| vivo | [2L] for R2D | In our understanding, following conversion for R2D and *Budget-Alt2* is not needed, since noise power within [2B] ED BW have been considered in [2F] calculation.  [2L] = [2G] ~~-~~ *~~lin2dB~~*~~([2B] / [1F])~~ + [2F] |
| ZTE, Sanechips | 1M | For R2D,   * + [1M] = [1E] + [1G] - [1N] - ~~FFS: [1J]~~ [2H]   Comments: For R2D, on object penalty is 2H, instead of 1J. |
| ZTE, Sanechips | 2K1 | Alt2: [2K1] = [1E1] + [1E2] + [2C] - [2K] |
| CATT | [1M] | Share the similar view with others that [1J] can be removed. We also share the view of ZTE that [2H] needs to be considered for R2D   * For R2D,   + [1M] = [1E] + [1G] - [1N] - [2H] |
| CATT | [2G] | It includes “- For the R2D LLS for ED, CINR/CNR is reported, …”. For completeness, suggest adding “ - For the D2R LLS, the SINR/SNR is reported…” based on the following WA.  Working assumption:   * For the D2R LLS, the SINR/SNR is reported and it is defined as the ratio of signal power to noise and interference (if any) power in the receiver bandwidth. * FFS: receiver bandwidth * On/off keying backscatter loss is not taken into account in the LLS and is included in link budget table [1H]. |
| CATT | [2K1] | The cable, connector, body losses[1N] and [2X] may also be considered as vivo suggested:   * Alt2: [2K1] = [1E1] + [1E2] + [2C] - [2K] – [1N] – [2X] |
| CATT | [4A] | We share the similar view as vivo that body losses[1N] and [2X] may also need to be considered. |
| Ericsson | [1E]  [2J]  [2K1]  [4A] | **[1E]**  For Device 1/2a, for [1E]-D2R-Alt1 (for scenarios ‘B’), perhaps we should add an equation and clarify which losses/gains need to be considered, e.g., as follows?  [1E] = [1E1]+[1E2]-[1E4] -2\*[3A]-2\*[3B]-[2H]+[2C] (?)  **[2J]**  We think Budget-Alt2 can be optional for Device 1 (as for Device 2)   * For R2D link in the coverage evaluation, for device 1   + Budget-Alt1 is used (note: receiver architecture is RF ED)   + Budget-Alt2 is optional.   **[2K1]**  A question for clarification, why is it that only receiver antenna gain has been considered in Alt2? Shouldn’t we also consider losses?  **[4A]**  Perhaps we should make the following correction?  [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]-[1H]-[2H]) for device 1,  [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]+[1K]-[1H]-[2H]) for device 2 |
| Apple | [1M], [2K1] | [1M]: For R2D, remove FFS: [1J]  [2G]: Similar view as Huawei  [2K1]: Support Alt 2 |
| Futurewei | [1M] R2D  [2J]  [2K1]  [4A] | [1M]  For R2D,   * + [1M] = [1E] + [1G] - [1N] ~~- FFS: [1J]~~   Remove [1J] since [1J] should only appear in AIoT transmit  [2J]  If [X dB] is not defined, then Note1d is meaningless  [2K1]  Prefer Alt2   * + Alt2: [2K1] = [1E1] + [1E2] + [2C] - [2K]   Antenna gain should apply to signal the antenna receives  [4A]   * [4A]=[1M]+[2C]-[2L]-[3A]-[3B]+[3C]+[3D] * Note 1f: For scenarios ‘A1’ and ‘A2’, The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. i.e.,   + TBC: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]+2\*[3C]+2\*[3D]-[1J]-[2L]+[2C]-[1H]) for device 1,   + TBC: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]+ 2\*[3C]+2\*[3D -[1J]-[2L]+[2C]+[1K]+[1H]) for device 2 |
| Lenovo | [1M] | For R2D,  [1M] = [1E] + [1G] - [1N] - [1J]  We strongly prefer to keep the on-object penalty in the R2D link. There are references available showing the effect of the on-object penalty on R2D link also affecting the received power at the tag.  Reference:   1. Joshua D. Griffin, et. al, Complete Link Budgets for Backscatter-Radio and RFID Systems 2. DILUKA A. LOKU GALAPPATHTHIGE, et. al, Link Budget Analysis for Backscatter-Based Passive IoT |
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### Round 2

Based on the comments from round 1, a summary is provided as follows,

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| --- | --- | --- | --- |
| **Company** | **Item** | **Companies’ comments** | **FL comments** |
| FL | [1E3][1E4][1E5] |  | It is said that [1E3][1E4][1E5] is calculated. But the formular is missing.  For [1E4] scenarios ‘A1/A2’, the following relation holds when assume CW2D pathloss = R2D pathloss,  [1E1] + [1E2] - [1N](CW2D) – [1E4] + [2C] (CW2D) – [2H](CW2D) - [3A] - [3B] + [3C](CW2D) + [3D](CW2D) + [1K] – [1H] + [1G] – [1J] – [1E4] - [3A] - [3B] + [2C] – [2X] + [3C] + [3D] = [2L]  Hence,  [1E4] =0.5\* ( [1E1] + [1E2] - [1N]( CW2D) + [2C] (CW2D) – [2H]( CW2D) – 2\*[3A] – 2\*[3B] + [3C](CW2D) + [3D](CW2D) + [1K] – [1H] + [1G] – [1J] + [2C] – [2X] – [2L] + [3C] + [3D] )  Note that [1N](CW2D), [2C] (CW2D), [2H](CW2D), [3C](CW2D), [3D](CW2D) using the same assumption as for R2D  The proposals are as follows,  Proposals  Note 1:  …  [1E3]   * For scenarios ‘A1’ and ‘A2’, [1E3] is derived by assuming pathloss [1E4] using pathloss formula as agreed.   [1E4]   * For scenarios ‘B’   + [1E4] is derived according to path loss formula by assume distance is [1E3] * For scenarios ‘A1/A2’   + [1E4] = 0.5\* ( [1E1] + [1E2] - [1N](R2D) + [2C] (R2D) – [2H](R2D) – 2\*[3A] – 2\*[3B] + [3C](R2D) + [3D](R2D) + [1K] – [1H] + [1G] – [1J] + [2C] – [2X] – [2L] + [3C] + [3D] )   [1E5]   * [1E5]=[1E1] + [1E2] - [1N](R2D) - [1E4] + [2C] (R2D) – [2H](R2D) – [3A] – [3B] + [3C](R2D) + [3D]( R2D) |
| Ericsson | [1E] | **[1E]**  For Device 1/2a, for [1E]-D2R-Alt1 (for scenarios ‘B’), perhaps we should add an equation and clarify which losses/gains need to be considered, e.g., as follows?  [1E] = [1E1]+[1E2]-[1E4] -2\*[3A]-2\*[3B]-[2H]+[2C] (?) | Based on E///’s suggestion, added [1E] in note 1 for both For scenarios ‘B’ and For scenarios ‘A1/A2’ and add a sentence in [1E]-D2R see note 1.  FL’s suggestion, no need to consider [3A][3B] twice for [1E]. Since [1E] is the D2R Tx power.  [1E] = [1E1] + [1E2] - [1N](CW2D) + [2C] (CW2D) – [2H](CW2D) –[3A] – [3B] + [3C](CW2D) + [3D](CW2D) + [1K] – [1H]  Note that [1K] and [1H] is considered in [1E], then no need to account that in [1M] D2R again. [1J] and [1G] are accounted in [1M].  And [1N](CW2D), [2C] (CW2D), [2H](CW2D), [3C](CW2D), [3D](CW2D) using the same assumption as for R2D  The proposals are as follows,  [1E]   * [1E] = [1E1] + [1E2] - [1N]( R2D) + [2C] (R2D) – [2H]( R2D) –[3A] – [3B] + [3C]( R2D) + [3D]( R2D) + [1K] – [1H] * [1K] is only for device 2a |
| OPPO | [1F] | There seems a typo in [1F]-D2R, it should be “Refer to LLS table [2a1]~~[1a]~~”, maybe we can take this chance to fix it. | Will update accordingly in next version. |
| Huawei, HiSilicon | [1M] | The [1J] is not relevant to R2D anymore, thus propose the following update:  [1M]:   * For R2D,   + [1M] = [1E] + [1G] - [1N] ~~- FFS: [1J]~~ * For D2R   + Device 1:     - [1M] = [1E] + [1G] - [1H] - [1J]   + Device 2a:     - [1M] = [1E] + [1G] + [1K] - [1H] - [1J]   + Device 2b:   [1M] = [1E] + [1G] - [1J] | Remove [1J] in [1M]-R2D. [1M]-R2D is the transmitter side, so no need to add -[2H] for [1M] here. –[2H] will be accounted in calculation of [4A]. Please see FL’s update of [4A] formula.  Regarding vivo’s comment, calculation of [1E] has already considered the [1N] if any. Please see FL’s update of [1E] formula. As suggested by Ericsson to add [1E] to clarify this.  The proposals are as follows,  [1M]:   * For R2D,   + [1M] = [1E] + [1G] - [1N] ~~- FFS: [1J]~~ * For D2R   + Device 1:     - [1M] = [1E] + [1G] ~~- [1H]~~ - [1J]   + Device 2a:     - [1M] = [1E] + [1G] ~~+ [1K] - [1H]~~ - [1J]   + Device 2b:     - [1M] = [1E] + [1G] - [1J] |
| DOCOMO | [1M] | Same comment as HW. |
| OPPO | [1M], | [1M]: For R2D, “FFS:[1J]” can be removed as [1J] is not applicable for R2D. |
| Spreadtrum | [1M] | [1M]: For R2D, “FFS: [1J]” should be removed. |
| vivo | [1M] EIRP (dBm) | For [1M]   * 1. For R2D, [1J] Ambient IoT on-object antenna penalty should be removed, since it has been agreed not applicable to R2D in transmitter side.   2. For D2R, [1N] ‘Cable, connector, combiner, body losses’ should be considered in CW transmission power and which impacts the EIRP of the D2R EIRP for device 1/2a. The calculation should be revised to  |  | | --- | | [1M]:   * For R2D,   + [1M] = [1E] + [1G] - [1N] ~~- FFS: [1J]~~ * For D2R   + Device 1:     - [1M] = [1E] + [1G] -[1N] - [1H] - [1J]   + Device 2a:     - [1M] = [1E] + [1G] -[1N] + [1K] - [1H] - [1J]   + Device 2b:     - [1M] = [1E] + [1G] - [1J] | |
| ZTE, Sanechips | 1M | For R2D,   * + [1M] = [1E] + [1G] - [1N] - ~~FFS: [1J]~~ [2H]   Comments: For R2D, on object penalty is 2H, instead of 1J. |
| CATT | [1M] | Share the similar view with others that [1J] can be removed. We also share the view of ZTE that [2H] needs to be considered for R2D   * For R2D,   + [1M] = [1E] + [1G] - [1N] - [2H] |
| Apple | [1M], | [1M]: For R2D, remove FFS: [1J] |
| Futurewei | [1M] R2D | [1M]  For R2D,   * + [1M] = [1E] + [1G] - [1N] ~~- FFS: [1J]~~   Remove [1J] since [1J] should only appear in AIoT transmit |
| Lenovo | [1M] | For R2D,  [1M] = [1E] + [1G] - [1N] - [1J]  We strongly prefer to keep the on-object penalty in the R2D link. There are references available showing the effect of the on-object penalty on R2D link also affecting the received power at the tag.  Reference:   1. Joshua D. Griffin, et. al, Complete Link Budgets for Backscatter-Radio and RFID Systems 2. DILUKA A. LOKU GALAPPATHTHIGE, et. al, Link Budget Analysis for Backscatter-Based Passive IoT |
| Huawei, HiSilicon | [2G] | [2G] is now agreed as “reported by companies”, not calculated, there is nothing else to discuss, hence it can be removed from this email discussion. | Regarding [2G], adding the following sentences (as agreed) in note 1. We may not discuss the agreement in email discussion.  [2G]   * For the R2D LLS for ED, CINR/CNR is reported, where CINR/CNR is defined as the ratio of signal power spectral density in the transmission bandwidth to the noise and interference (if any) power spectral density in the device ED channel bandwidth. * For R2D ZIF receiver, report the same metrics (i.e., CNR/CINR, signal transmission bandwidth, ED bandwidth) as agreed for RF-ED/IF receiver. * For the D2R LLS, the SINR/SNR is reported and it is defined as the ratio of signal power to noise and interference (if any) power in the receiver bandwidth. * On/off keying backscatter loss is not taken into account in the LLS and is included in link budget table [1H]. |
| Huawei, HiSilicon | [2G] | [2G] is now agreed as “reported by companies”, not calculated, there is nothing else to discuss, hence it can be removed from this email discussion. |
| CATT | [2G] | It includes “- For the R2D LLS for ED, CINR/CNR is reported, …”. For completeness, suggest adding “ - For the D2R LLS, the SINR/SNR is reported…” based on the following WA.  Working assumption:   * For the D2R LLS, the SINR/SNR is reported and it is defined as the ratio of signal power to noise and interference (if any) power in the receiver bandwidth. * FFS: receiver bandwidth * On/off keying backscatter loss is not taken into account in the LLS and is included in link budget table [1H]. |
| Huawei, HiSilicon | [2J] | Similar comments as 2G, [2J] is not calculated by others and just methodology alternatives. Since when to use Alt1/Alt2 have already been agreed and in [2L] there will be details of each Alt1, this item can be removed from this email discussion. | Regarding [2J], which alternative to use has some dependence to other items. So FL suggest to keep these dependence in the note 1. And we may not need to discuss the agreement in the email discussion.  [2J]   * For R2D link in the coverage evaluation, for device 1   + Budget-Alt1 is used (note: receiver architecture is RF ED) * For R2D link in the coverage evaluation for device 2,   + *Budget-Alt1* is used if receiver architecture is RF ED   + *Budget-Alt2* is used if receiver architecture is IF/ZIF ED * Note1a: this does not preclude to have LLS for device 1 and 2 R2D link with RF-ED if needed. * Note1b: For device 2 R2D link with RF-ED, *Budget-Alt1* is mandatory, *Budget-Alt2* is optional. * Note1c: this does not imply all M values are achievable with the sensitivity given by *Budget-Alt1* for RF ED * Note1d: For device 2 with an RF ED-based receiver on the R2D link, if the receiver sensitivity derived from *Budget-Alt2*, assuming a noise figure of [X dB], exceeds the receiver sensitivity based on *Budget-Alt1*, then *Budget-Alt2* is applied. |
| Ericsson | [2J] | **[2J]**  We think Budget-Alt2 can be optional for Device 1 (as for Device 2)   * For R2D link in the coverage evaluation, for device 1   + Budget-Alt1 is used (note: receiver architecture is RF ED)   + Budget-Alt2 is optional. |
| Futurewei | [2J] | [2J]  If [X dB] is not defined, then Note1d is meaningless |
| Huawei, HiSilicon | [2K1] | We think Alt2 should be the way to proceed, since the CW interference will be used to calculate sensitivity loss. Thus, propose the following update:  [2K1]:   * ~~FFS:~~   + ~~Alt1: [2K1] = [1E1] + [1E2] - [2K] or~~   Alt2: [2K1] = [1E1] + [1E2] + [2C] - [2K] | Majority companies prefer Alt2.  Regarding Ericsson and CATT’s comment, FL make further revision to Alt 2.  [2K1]:   * [2K1] = [1E1] + [1E2] -[1N](CW2D) + [2C] - [2X] - [2K]   Note that [1N](CW2D) using the same assumption as for R2D  The proposals are as follows,  [2K1]:   * [2K1] = [1E1] + [1E2] -[1N](R2D) + [2C] - [2X] - [2K] |
| OPPO | [2K1], | [2K1]: Alt 2 should be used. |
| Spreadtrum | [2K1] | [2K1]: We think Alt2 should be used. |
| vivo | [2K1] Remaining CW interference | For the item [2K1], we think that the receiver antenna gain[2C] and the Cable, connector, body losses[1N] and [2X] also need to be considered.  So, we suggest to update the item[2K1] as follows:  [2K1] = [1E1]( CW Tx power (dBm)) + [1E2] (CW Tx antenna gain (dBi))+ [2C] Receiver antenna gain (dBi) - [1N] Cable… Loss - [2X] Cable… Loss - [2K] CW cancellation (dB)  Antenna gain and cable… loss should be considered twice at least for monostatic case with separated Tx antenna for CW transmission and D2R receiver, and cases where CW tx node is separated from D2R receiving node. |
| ZTE, Sanechips | 2K1 | Alt2: [2K1] = [1E1] + [1E2] + [2C] - [2K] |
| CATT | [2K1] | The cable, connector, body losses[1N] and [2X] may also be considered as vivo suggested:   * Alt2: [2K1] = [1E1] + [1E2] + [2C] - [2K] – [1N] – [2X] |
| Ericsson | [2K1] | **[2K1]**  A question for clarification, why is it that only receiver antenna gain has been considered in Alt2? Shouldn’t we also consider losses? |
| Apple | [2K1] | [2K1]: Support Alt 2 |
| Futurewei | [2K1] | [2K1]  Prefer Alt2   * + Alt2: [2K1] = [1E1] + [1E2] + [2C] - [2K]   Antenna gain should apply to signal the antenna receives |
| vivo | [2L] for R2D | In our understanding, following conversion for R2D and *Budget-Alt2* is not needed, since noise power within [2B] ED BW have been considered in [2F] calculation.  [2L] = [2G] ~~-~~ *~~lin2dB~~*~~([2B] / [1F])~~ + [2F] | Since R2D use CNR [2G] which are defined as the ratio of signal power spectral density in the transmission bandwidth to the noise and interference (if any) power spectral density in the device ED channel bandwidth. However, [2F] is across the whole RF-ED BW, so scaling is needed. |
| Huawei, HiSilicon | [4A] | The [4A] calculation is fine but the note seems need to be update  1. To avoid duplicated/contradict to previous agreement, suggest to have some editorial change.  2. Add missing parameters.  The overall updates are as follows:  [4A]   * [4A]=[1M]+[2C]-[2L]-[3A]-[3B]+[3C]+[3D] * Note 1f: For scenarios ~~‘A1’ and ‘A2’,~~ where ~~T~~the Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. i.e.,   + ~~TBC~~ For D2R: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]+2\*[3C]+2\*[3D]+2\*[1G]-[1J]-[2L]+[2C]-[1H]) for device 1,   ~~TBC~~ For D2R: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B] +2\*[3C]+2\*[3D]+2\*[1G]-[1J]-[2L]+[2C]-[1H]+[1K]) for device 2a | [1E] has been updated and add a formular to derive its value for the following cases,   * For device 1/2a:   + [1E]-D2R-Alt1: (For scenarios ‘B’)     - The Device Tx Power is calculated by CW received power which can be derived by at least CW2D distance (m) value and other related factors.   + [1E]-D2R-Alt2: (For scenarios ‘A1’ and ‘A2’)     - The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss.   [1M] is derived from [1M]. And by using [1M], only the receiver-side gains/penalties are accounted for deriving [4A]. The following formular can be used.  The proposals are as follows,  proposals  [4A]   * [4A]=[1M]+[2C]-[2X]-[2H]-[2L]-[3A]-[3B]+[3C]+[3D] * ~~Note 1f: For scenarios ‘A1’ and ‘A2’, The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. i.e.,~~    + ~~TBC: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]-[1H]) for device 1,~~   + ~~TBC: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]+[1K]) for device 2~~ |
| OPPO | [4A] | [4A]: The 2 TBC can be confirmed. But we suggest to add “-[1H]” for the following similar as that for [1M]. “device 2” should be changed to “device 2a”.   * + [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]+[1K]-[1H]) for device 2a |
| vivo | [4A] MPL | The Cable, connector, body losses[1N] and [2X] also need to be considered.  Besides, the item[1H] is also applicable for device2a.  And the calculation is updated as follows:  [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]-[1H]-[1N]-[2X]) for device 1,  [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]+[1K]-[1H]-[1N]-[2X]) for device 2  As for the scenario B, the Cable, connector, body losses[1N] and [2X] also need to be considered, duo to the item[1N] is included in the item[1M] . So the item [4A] MPL needs changed as following formula:   * [4A]=[1M]+[2C]-[2X]-[2L]-[3A]-[3B]+[3C]+[3D] |
| CATT | [4A] | We share the similar view as vivo that body losses[1N] and [2X] may also need to be considered. |
| Ericsson | [4A] | **[4A]**  Perhaps we should make the following correction?  [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]-[1H]-[2H]) for device 1,  [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]+[1K]-[1H]-[2H]) for device 2 |
| Futurewei | [4A] | [4A]   * [4A]=[1M]+[2C]-[2L]-[3A]-[3B]+[3C]+[3D] * Note 1f: For scenarios ‘A1’ and ‘A2’, The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. i.e.,   + TBC: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]+2\*[3C]+2\*[3D]-[1J]-[2L]+[2C]-[1H]) for device 1,   + TBC: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]+ 2\*[3C]+2\*[3D -[1J]-[2L]+[2C]+[1K]+[1H]) for device 2 |

In summary, the table and note1 is revised as follows,

**[H][Proposal1-v2]**

Update [1E] as follows,

|  |  |  |  |
| --- | --- | --- | --- |
| [1E] | Total Tx Power (dBm) | * For BS in DL spectrum for indoor   + [1E]-R2D-Alt1: 33dBm(M),   + [1E]-R2D-Alt2: 38dBm(O),   + [1E]-R2D-Alt3: 24dBm(M)   + Companies to report if PSD constraints are imposed (company to report the condition for applying PSD constraints in Row [5A]: Other notes) * For UL spectrum for indoor,   + [1E]-R2D-Alt4:23dBm (M)   + [1E]-R2D-Alt5:26dBm(O) | * For device 1/2a: (see note 1)   + [1E]-D2R-Alt1: (For scenarios ‘B’)     - The Device Tx Power is calculated by CW received power which can be derived by at least CW2D distance (m) value and other related factors.   + [1E]-D2R-Alt2: (For scenarios ‘A1’ and ‘A2’)     - The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. * For device 2b: (For scenarios ‘C’)   + [1E]-D2R-Alt3: -20 dBm(M)   + [1E]-D2R-Alt4: -10 dBm(O) |

Update note 1 in link budget table as follows,

Note1 (for email discussion): calculated values in the Table XXXX are derived according to the followings,

[1E3]

* For scenarios ‘A1’ and ‘A2’, [1E3] is derived by assuming pathloss is [1E4] and use the pathloss formula as agreed.

[1E4]

* For scenarios ‘B’
  + [1E4] is derived according to pathloss formula by assume distance is [1E3]
* For scenarios ‘A1/A2’
  + [1E4] = 0.5\* ( [1E1] + [1E2] - [1N](R2D) + [2C] (R2D) – [2H](R2D) – 2\*[3A] – 2\*[3B] + [3C](R2D) + [3D](R2D) + [1K] – [1H] + [1G] – [1J] + [2C] – [2X] – [2L] + [3C] + [3D] )

[1E5]

* [1E5] = [1E1] + [1E2] - [1N](R2D) - [1E4] + [2C] (R2D) – [2H](R2D) – [3A] – [3B] + [3C](R2D) + [3D](R2D)

[1E]

* [1E] = [1E1] + [1E2] - [1N](R2D) + [2C] (R2D) – [2H](R2D) –[3A] – [3B] + [3C](R2D) + [3D](R2D) + [1K] – [1H]
* [1K] is only for device 2a

[1M]:

* For R2D,
  + [1M] = [1E] + [1G] - [1N] ~~- FFS: [1J]~~
* For D2R
  + Device 1:
    - [1M] = [1E] + [1G] - ~~[1H]~~ - [1J]
  + Device 2a:
    - [1M] = [1E] + [1G] ~~+ [1K] - [1H]~~ - [1J]
  + Device 2b:
    - [1M] = [1E] + [1G] - [1J]

[2F]:

* [2F] = [2D] + [2E] +*lin2dB*([2B])

[2G]

* For the R2D LLS for ED, CINR/CNR is reported, where CINR/CNR is defined as the ratio of signal power spectral density in the transmission bandwidth to the noise and interference (if any) power spectral density in the device ED channel bandwidth.
* For R2D ZIF receiver, report the same metrics (i.e., CNR/CINR, signal transmission bandwidth, ED bandwidth) as agreed for RF-ED/IF receiver.
* For the D2R LLS, the SINR/SNR is reported and it is defined as the ratio of signal power to noise and interference (if any) power in the receiver bandwidth.
* On/off keying backscatter loss is not taken into account in the LLS and is included in link budget table [1H].

[2J]

* For R2D link in the coverage evaluation, for device 1
  + Budget-Alt1 is used (note: receiver architecture is RF ED)
* For R2D link in the coverage evaluation for device 2,
  + *Budget-Alt1* is used if receiver architecture is RF ED
  + *Budget-Alt2* is used if receiver architecture is IF/ZIF ED
* Note1a: this does not preclude to have LLS for device 1 and 2 R2D link with RF-ED if needed.
* Note1b: For device 2 R2D link with RF-ED, *Budget-Alt1* is mandatory, *Budget-Alt2* is optional.
* Note1c: this does not imply all M values are achievable with the sensitivity given by *Budget-Alt1* for RF ED
* Note1d: For device 2 with an RF ED-based receiver on the R2D link, if the receiver sensitivity derived from *Budget-Alt2*, assuming a noise figure of [X dB], exceeds the receiver sensitivity based on *Budget-Alt1*, then *Budget-Alt2* is applied.

[2K1]:

* ~~FFS:~~
  + ~~Alt1: [2K1] = [1E1] + [1E2] - [2K] or~~
  + ~~Alt2: [2K1] = [1E1] + [1E2] + [2C] - [2K]~~
* [2K1] = [1E1] + [1E2] -[1N](R2D) + [2C] - [2X] - [2K]

[2K2]:

[2L]:

* For R2D and *Budget-Alt2*,
  + [2L] = [2G] - *lin2dB*([2B] / [1F]) + [2F]
  + Note 1e: the term ‘*lin2dB*([2B] / [1F])’ is applied due to scaling from CNR/CINR to SNR/SINR.
* For D2R,
  + [2L] = [2G] + [2F] + [2K2], device 1/2a
  + [2L] = [2G] + [2F], device 2b

[4A]

* [4A]=[1M]+[2C] -[2X]-[2H]-[2L]-[3A]-[3B]+[3C]+[3D]
* ~~Note 1f: For scenarios ‘A1’ and ‘A2’, The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. i.e.,~~ 
  + ~~TBC: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]-[1H]) for device 1,~~
  + ~~TBC: [4A] = 0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]+[1K]) for device 2~~

|  |  |  |
| --- | --- | --- |
| **Company** | **Which item?** | **Comments** |
|  |  |  |
|  |  |  |

## link level simulation table

### Round 1

It is suggested to discuss the following link level simulation table. The text is marked red/green compared to the agreements in RAN1#116bis are for information.

Note: The green part is agreement in RAN1#117. The red part is revised text after RAN1#116bis.

And moderator suggest let’s focused on the text with red color.

**[H][Proposal2-v1]**

The link level simulation table is updated as follows,

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Parameters** | | **Assumptions** | **Company result1** | **Company result 2** |
|  | **R2D/D2R common parameters** | | |  |  |
| **[0a]** | Carrier frequency | | Refer to link budget template |  |  |
| **[0b]** | SCS | | 15 kHz as baseline |  |  |
| **[0c]** | Block structure | | Blocks as agreed in 9.4.2.3, or other blocks reported by companies |  |  |
| **[0d]** | Channel model | | <Editor’s Note: will be updated according to the agreements made for channel model> |  |  |
| **[0e]** | Delay spread | | ~~[30, 150] ns~~   * An RMS delay spread of 30 ns and [150] ns is considered for TDL-A channel model. * An RMS delay spread of 30 ns is considered for TDL-D channel model. |  |  |
| **[0f]** | Device velocity | | 3 km/h |  |  |
| **[0g]** | Number of Tx/Rx chains for Ambient IoT device | | 1 |  |  |
| **[0h1]** | BS | Number of antenna elements | 2 or 4 |  |  |
| **[0h2]** | Number of TXRUs | 2 or 4 |  |  |
| **[0j1]** | Intermediate UE | Number of antenna elements | 1 or 2 |  |  |
| **[0j2]** | Number of TXRUs | 1 or 2 |  |  |
| **[0m]** | Reference data rate | | ~~[0.1, 1, 5] kbps~~  [0.1] kbps (M), [1] kbps (M), [7] kbps (O), [large value] (O) |  |  |
| **[0n]** | Message size | | {20 bits, 96 bits, 400 bits} are considered for message size.   * Note: companies to report the M value and chip length used for each message size |  |  |
| **[0p]** | BLER target | | 1%, 10% |  |  |
| **[0q]** | Sampling frequency | | ~~<Editor’s Note: will be updated according to the agreements made for Sampling frequency >~~  Sampling frequency is 1.92 Msps.  Initial SFO (Sampling Frequency Offset) (Fe):   * [0.1 ~ 1] \* 10^5 ppm ~~for device 1, reported by company~~ * ~~[0.1 ~ 1] \* 10^4 ppm for device 2, reported by company~~   The timing drift ΔT over a time T is modelled as ΔT = ±Fe \* T.  FFS: Accuracy after clock calibration for device 2.  FFS: CFO for device 2b.  Note: the values are for coverage evaluation purpose. A harmonized design approach for all devices should be considered when utilizing these values in the design. |  |  |
| **[0r]** | Device 1/2a/2b | | Options are as follows,   * Device 1, RF-ED * Device 2a, RF-ED * Device 2b, RF-ED/IF-ED/ZIF   <Editor’s Note: will be updated according to agreements from 9.4.1.2> |  |  |
|  | **R2D specific parameters** | | |  |  |
| **[1a]** | Transmission bandwidth | | 180 kHz as baseline |  |  |
| **[1b]** | ~~FFS:~~ ED bandwidth | | The ED bandwidth is the bandwidth for calculating the noise/interference (if any) power:  For evaluations, the value(s) of ED bandwidth is 20 MHz for RF-ED, [180] kHz for IF/ZIF receiver.  Note: this does not imply that a A-IoT device supports sampling clock rate as large as RF ED bandwidth. |  |  |
| **[1c]** | ~~FFS:~~ BB LPF | | [X]-order Butterworth/RC filter with cutoff frequency at ~~[Y] kHz,~~ half of R2D transmission bandwidth.  Companies to report X = {3, 5}. |  |  |
| **[1d]** | Waveform | | OOK waveform generated by OFDM modulator |  |  |
| **[1e]** | Modulation | | OOK  Companies to report, e.g., OOK-1, OOK-4 with M chips per OFDM symbol |  |  |
| **[1f]** | Line code | | Companies to report, e.g., Manchester, PIE |  |  |
| **[1g]** | FEC | | No FEC as baseline |  |  |
| **[1h]** | ADC bit width | | 1-bit for device 1  4-bit for device 2 |  |  |
| **[1j]** | Detection/decoding method for Line code | | Companies to report |  |  |
|  | **D2R specific parameters** | | |  |  |
| **[2a1]** | Transmission bandwidth ~~(w.r.t. D2R data rate)~~ | | ~~[FFS: 15kHz, 180kHz]~~   * **[2a1]-Alt1:**    + DSB   + X kHz ~~(M) and Y kHz (O)~~ is considered for D2R transmission bandwidth.   + The value is for two sidebands, i.e., the total transmission bandwidth for DSB is X kHz ~~(M) and Y kHz (O)~~. * **[2a1]-Alt2:**    + SSB   + X kHz ~~(M) and Y kHz (O)~~ is considered for D2R transmission bandwidth.   + The value is for one sideband, i.e., the total transmission bandwidth for DSB is X kHz ~~(M) and Y kHz (O)~~. * The value of X ~~and Y~~ is as follows, to be down-select from alternative 1 and 2   + Alternative 1:     - X = {15 (M), 180 (O)}     - ~~Y =180~~   + Alternative 2:     - X ~~and Y~~ reported by companies,       * the value may be related to, e.g.,         + Reference data rate         + Coding scheme         + Repetition         + With or without SFS         + SSB or DSB |  |  |
| **[2a2]** | [OOK/BPSK/BFSK chip rate] | | Companies to report |  |  |
| **[2a3]** | Receiver bandwidth | | D2R receiver bandwidth is the bandwidth used at the reader side to filter out the D2R signals for calculating noise and interference (if any) power.   * Assume the receiver matches the transmitter's modulation, i.e., to receiver uses SSB when transmitter uses SSB, receiver uses DSB when transmitter uses DSB.   Companies to report the value. |  |  |
| **[2b]** | Waveform (CW) | | Companies to report waveform, e.g., unmodulated single tone, multi-tone(multiple unmodulated single tone) |  |  |
| **[2d]** | Modulation | | Companies to report modulation, e.g., OOK, BPSK, BFSK |  |  |
| **[2e]** | Line code | | Companies to report, e.g., Manchester encoding, FM0 encoding, Miller encoding, no line coding |  |  |
| **[2g]** | FEC | | Companies to report, e.g., CC, No FEC |  |  |
| **[2h]** | ADC bit width | | Companies to report, e.g., 11-bit |  |  |
| **[2j]** | D2R receiver | | ~~FFS: Reader receiver, e.g., coherent receiver / non-coherent receiver~~  Companies to report, e.g., coherent receiver / non-coherent receiver |  |  |
|  | **Other assumptions** | | |  |  |
| **[3a]** | Other assumptions | | To be reported by company |  |  |
| **[3b]** | Note: Companies to report required SINR/SNR/CINR/CNR according to BLER target. | | |  |  |

|  |  |  |
| --- | --- | --- |
| **Company** | **Which item?** | **Comments** |
| Company A | [0m] | Example….., |
| Huawei, HiSilicon | [0m] | We are fine with the proposal in general and would like to clarify our understanding that the intention of this LLS table is for coverage evaluation (in relation to Budget-Alt2). In that sense, we think focus on small values (0.1 kbps, 1 kbps) is enough for coverage evaluation. Further we understand data rate in link level simulation may not be achieved exactly same as reference data rate defined here in the table due design aspects of line coding chip length, FEC, repetition etc. Thus the simulation may be just approximately close to the data rate. |
| Huawei, HiSilicon | [0q] | We are supportive of the proposal. |
| Huawei, HiSilicon | [1c] | We are supportive of the proposal. |
| Huawei, HiSilicon | [2a1] | We are supportive of [2a1]-Alt1 since for D2R we understand DSB should be the choice which can be supported by all devices. We are also supportive of Alternative 1, since Alternative 2 is not a full list and will be derived from other design agenda items. |
| Huawei, HiSilicon | [2a2] | We are fine to add [2a2] |
| Huawei, HiSilicon | [2a3] | We are fine with the proposal and as we stated above, we think DSB should be the choice for D2R. |
| DOCOMO | [0q] | Comment #1:  For the timing drift, “Fe” can be the SFO corresponds to after clock calibration and it should be clarified, per our understanding. Therefore, we prefer to add the following note.  The timing drift ΔT over a time T is modelled as ΔT = ±Fe \* T.  Note: SFO corresponds to after clock calibration can be applied to Fe.  Comment #2:  For the first FFS, we prefer to add “at least” for device 2 as follows.  FFS: Accuracy after clock calibration at least for device 2.  Comment #3:  As commented by companies at the online session, the note can be simplified as follows.  Note: the values are for coverage evaluation purpose. ~~A harmonized design approach for all devices should be considered when utilizing these values in the design.~~ |
| DOCOMO | [2a1] | Comment#1:  In our understanding, alternatives in the 3rd main bullet does not correspond to [2a1]-Alt1 and [2a1]-Alt2, i.e., regardless of [2a1]-Alt1 or [2a1]-Alt2, alternatives in the 3rd bullet can be selected.  Comment#2:  The applicable device type of each [2a1]-Alt1 and [2a1]-Alt2 can be further clarified.  Comment#3:  For Alt.2 in the 3rd main bullet, it is unclear for us how repetition would affect to the transmission bandwidth. |
| OPPO | [0q], [2a1], [2a2] | [0q]: we suggest agreeing one value for “CFO for device 2b” as this value is needed for evaluation of D2R of device 2b. In the last meeting 2 options were provided in FL summary, maybe we can use the intersection of the 2 options, i.e. (200ppm, 0.1ppm/s) , as baseline, and other values is up to companies to report. We also support to simplify the Note as proposed by DCM.  [2a1]-Alt 1 should be mandatory, and [2a1]-Alt 2 optional.  We support to report chip rate (i.e. [2a2]). Given that, alternative 2 in [2a1] should be used, as the chip rate and transmission bandwidth are relevant to each other and should be derived from same sets of factors, i.e., reference data rate, DSB/SSB, repetition, … |
| Spreadtrum | [2a1] | We prefer Alt1 in [2a1].  We are OK with [0q], [2a2] and [2a3]. |
| vivo | [0m] Reference data rate | We would like the clarify of the meaning of reference data rate here.  1, the reference data rate may have the following understanding   * opt-1: Raw data rate, which considers only data rate for the coded/uncoded information bits, without considering overhead for CRC, midamble, postamble, if reported. For example, for R2D M=1, and Manchester code is used, which means 2 OFDM symbol is used for each information bits, and data rate for the information bits is 7kbps for this case. (This is how 7kbps come from in our understanding, which may not applicable for D2R in our understanding). * opt-2: data rate in physical channel, the data rate also considers overhead for CRC, midamble, postamble, FEC, repetition, if reported. For this case, it may be difficult to achieve the accurate data rate value, companies may need to adjust the configuration of CRC/midamble/postamble/FEC/repetition to achieve the data rate close to the agreed data rate value? |
| vivo | [1c] BB LPF | We are OK to assume a certain BW value for BB LPF (e.g., [90] kHz), while we don’t think it is related to half of transmission bandwidth. Instead, BB LPF BW depends on data rates. Even for Tx bandwidth of 1.08MHz(O), 90kHz for BB LPF is enough for a low data rate e.g., 7kbps.  Besides, the BB LPF in circuit of the receiver cannot be flexibly adjusted to different data rate and/or transmission BW, a fixed BB LPF BW can be assumed for different data rates/Tx bandwidth. |
| vivo | [2a1] Transmission bandwidth | Prefer [2a1]-Alt1, consider two sidebands. Receiver of D2R signal should be able to employ both sidebands.  We prefer Alternative 2 for transmission BW X, i.e., up to company report. And the BW may relate to line coding scheme, data rate, etc. We are not sure whether company have aligned Tx BW value even if for the same signal generation. Since this value is not used in link budget calculation, the X value can be up to company report, and the details e.g., data rate, coding scheme, repetition are reported together in the link level simulation template. |
| vivo | [2a3] Receiver bandwidth | A limited received BW value(s) for evaluation purpose are needed to ensure same SINR definition across companies, since we have working assumption that ‘For the D2R LLS, the SINR/SNR is reported and it is defined as the ratio of signal power to noise and interference (if any) power in the receiver bandwidth.’  The Rx BW may include Tx BW + potential guard bands in our understanding. We are not sure whether companies would have the same Rx BW for the same D2R signal. If [2a3] receiver bandwidth is totally up to company report, it implies companies would have different SINR definition even for the same D2R transmission signal, if reported ‘receiver BW’ is not aligned across companies. |
| vivo | **[0q]** Sampling frequency | Regarding this item, there is sampling frequency of 1.92Msps, it seems parameter for R2D receiver? We would like to clarify the assumption for initial SFO is also applicable to D2R transmitter. |
| ZTE, Sanechips | 0m | Okay.  For the small data rate, such as 0.1kbps, 1kbps are the data rate required by RAN SI, which needs to be evaluated. We are also okay to include a larger data rate for evaluation, such as 7kbps. |
| ZTE, Sanechips | 0q | Comments are as below.   |  | | --- | | Sampling frequency is 1.92 Msps. |   [ZTE, Sanechips] okay with the sampling frequency.   |  | | --- | | Initial SFO (Sampling Frequency Offset) (Fe):   * [0.1 ~ 1] \* 10^5 ppm ~~for device 1, reported by company~~ * ~~[0.1 ~ 1] \* 10^4 ppm for device 2, reported by company~~ |   [ZTE, Sanechips]  We think different devices with different architectures and capabilities should be equipped with different SFO accuracy.  For device 1, we are okay with the SFO up to 10^5ppm.  However, for device 2a, the implementation with large frequency shift is being discussed. If the SFO is up to 10^5ppm, for a frequency shift gap of 50MHz, the frequency shift uncertainty is 10MHz (50MHz\*0.1\*2), which may exceed the frequency range of FDD UL spectrum. Therefore, to enable the possibility of large frequency shift of device 2a, a higher frequency accuracy than device 1 is needed. Therefore, we think at least 10^4ppm is needed.  For device 2b, the impact of frequency uncertainty is more serious considering the carrier frequency is 900MHz or 2GHz. In this case, we think the model used in LP WUS can be reused for device 2b.  Moreover, we think the SFO value is the max value, not fixed. Hence, the actual SFO can be a random value between 0 and 10^5ppm/10^4ppm/10^2ppm depending on device type.  Therefore, our suggestion is:  **Suggestion:**  Maximum Initial SFO (Sampling Frequency Offset) (Fe):   * [0.1 ~ 1] \* 10^5 ppm for device 1~~, reported by company~~ * [0.1 ~ 1] \* 10^4 ppm for device 2a~~, reported by company~~ * [0.1 ~ 1] \* 10^2 ppm for device 2b  |  | | --- | | The timing drift ΔT over a time T is modelled as ΔT = ±Fe \* T. |   [ZTE, Sanechips] We agree with DoCoMo that the timing drift should be modeled after clock synchronization,instead of using initial sampling offset. Moreover, it seems the model above assume that the clock offset is fixed over the the time duration T. However, if clock drift is considered, the time offset per chip may be varied.  The suggestion is as below:  **Suggestion:**  The timing drift ΔT over a time T is modelled as ΔT = ±Fr~~e~~ \* T. where Fr is clock offset after synchronization. FFS other models.   |  | | --- | | FFS: Accuracy after clock calibration for device 2. |   [ZTE, Sanechips] We think device 1 can also implement clock synchronization. Similar as RF ID tag, the device can count the number of samples during preamble detection. And then using the counted sample numbers to derive the required samples for the follow-up transmission. Therefore, the following is suggested:  **Suggestion:**  FFS: Accuracy after clock calibration for device 1 and 2.   |  | | --- | | Note: the values are for coverage evaluation purpose. A harmonized design approach for all devices should be considered when utilizing these values in the design. |   [ZTE, Sanechips] This is for evaluation discussion, instead of detailed design. The following is suggested.  **Suggestion:**  Note: the values are for coverage evaluation purpose. ~~A harmonized design approach for all devices should be considered when utilizing these values in the design.~~ |
| ZTE, Sanechips | 1c | okay |
| CATT | **[0q]** | For the initial SFO (Sampling Frequency Offset) (Fe),  • [0.1 ~ 1] \* 10^5 ppm  we would like clarification on its meaning. Does it indicate that the maximum SFO can be selected within the range of [0.1 ~ 1] \* 10^5 ppm, or does it mean that the maximum SFO is 10^5 ppm, and a value between [0.1 ~ 1] \* 10^5 ppm can be randomly selected for each LLS?  For the “Note: the values are for coverage evaluation purpose. A harmonized design approach for all devices should be considered when utilizing these values in the design”, considering that not only SFO, but some other values (e.g., the order of Butterworth/RC filter) in the table are also defined for evaluation purposes, but not design parameters, it might be simpler to add a new row, e.g., [3c], and stating that the values in the table are for evaluation purposes. |
| Ericsson | [0q] | Regarding **sampling frequency**, we don’t think there is strong technical reason why the sampling frequency should be 1.92 Msps. Our understanding is that if the maximum data rate is 7 kbps and RF-ED, the sampling rate can be much smaller than that. For example, the sampling frequency could be 56 kHz (2 times the Nyquist rate corresponding to a data rate of 7 kbps).  We think sampling frequency can be up to companies to report.  Regarding **initial SFO**, we support the suggestion from ZTE. Alternatively, we can do coverage evaluation with different sampling frequencies for all device types, e.g., 10^5 ppm (M), 10^3 ppm (O), and 10^2 ppm (O).  Note that oscillators with very large errors will increase synchronization time with the network, resulting in higher energy consumption at the device and increasing complexity for synchronization (time/frequency error correction). |
| Apple | [0m] | We are fine with values being considered, but additionally would prefer to add 2kbps as well. It can be optional |
| Apple | [0q] | Support |
| Apple | [2a1] | Support and prefer Alt1 |
| Apple | [2a3] | Fine |
| Futurewei | [0m] | Ok with the proposed text |
| Futurewei | [0n] | We understand that the message size does not include CRC bits. We propose to add a note to clarify it. |
| Futurewei | [0q] | Sampling frequency is 1.92 Msps.  Initial SFO (Sampling Frequency Offset) (Fe):   * [0.1 ~ 1] \* 10^5 ppm ~~for device 1, reported by company~~ * ~~[0.1 ~ 1] \* 10^4 ppm for device 2, reported by company~~   The timing drift ΔT over a time T is modelled as ΔT = ±Fe \* T.  FFS: Accuracy after clock calibration for device 2.  FFS: CFO for device 2b.  Note: the values are for coverage evaluation purpose. A harmonized design approach for all devices should be considered when utilizing these values in the design.  Propose to use [0.1 ~ 1] \* 10^5 ppm as mandatory for device 1 and 2a. In addition, companies can report an optional value for device 2a for Fe. |
| Futurewei | [1c] | Ok with the proposed text. |
| Futurewei | [2a1] | * **[2a1]-Alt1:**    + DSB   + X kHz ~~(M) and Y kHz (O)~~ is considered for D2R transmission bandwidth.   + The value is for two sidebands, i.e., the total transmission bandwidth for DSB is X kHz ~~(M) and Y kHz (O)~~. * **[2a1]-Alt2:**    + SSB   + X kHz ~~(M) and Y kHz (O)~~ is considered for D2R transmission bandwidth.   + The value is for one sideband, i.e., the total transmission bandwidth for DSB is X kHz ~~(M) and Y kHz (O)~~.   ***Proposal: select DSB over SSB for device 1/2a in back scattering***.  Devices will need additional hardware to support SSB and consume additional energy.   * The value of X ~~and Y~~ is as follows, to be down-select from alternative 1 and 2   + Alternative 1:     - X = {15 (M), 180 (O)}     - ~~Y =180~~   + Alternative 2:     - X ~~and Y~~ reported by companies,       * the value may be related to, e.g.,         + Reference data rate         + Coding scheme         + Repetition         + With or without SFS         + SSB or DSB   We select Alternative 1 so the results can be compared easily among companies. |
| Futurewei | [2a2] | Ok with the proposed text |
| Futurewei | [2a3] | Ok with the proposed text |
| Futurewei | [3b] | ok |
| LGE | [0q], [2a1] | [0q]: In our view, since all types of device 2 may not support clock calibration, we prefer to remove first FFS. Additionally, we prefer to remove second FFS to minimize device specific evaluation. For initial SFO and timing drift, we are okay with the proposal.  [2a1]: In our view, Alt1 should be considered since all types of AmIoT devices may not have capability to isolate one side band. Since the device architecture is not guaranteed, Alt1 should be considered as a baseline for LLS and Alt2 can be optional. Additionally, determining the value of X, we prefer Alternative 1 as a baseline for simplicity. |

### Round 2

Based on the comments from round 1, a summary is provided as follows,

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Item** | **Companies’ comments** | **FL comments** |
| Huawei, HiSilicon | [0m] | We are fine with the proposal in general and would like to clarify our understanding that the intention of this LLS table is for coverage evaluation (in relation to Budget-Alt2). In that sense, we think focus on small values (0.1 kbps, 1 kbps) is enough for coverage evaluation. Further we understand data rate in link level simulation may not be achieved exactly same as reference data rate defined here in the table due design aspects of line coding chip length, FEC, repetition etc. Thus the simulation may be just approximately close to the data rate. | Some companies [vivo][Huawei] think the data rate in link level simulation may not be achieved exactly same as reference data rate defined here in the table due design aspects of line coding chip length, FEC, repetition.  FL added some notes to clarify these.   |  |  |  | | --- | --- | --- | | **[0m]** | Reference data rate | ~~[0.1, 1, 5] kbps~~  [0.1] kbps (M), [1] kbps (M), [2] kbps (O), [7] kbps (O), [large value] (O)   * Note1: companies to report the exact data rate. * Note 2: the exact data rate is close the values listed above. * Note 3: The data rate is calculated by dividing the total message size by the total transmission time. * Note 4: the data rate may be related to coding scheme, repetition and etc. | |
| vivo | [0m] Reference data rate | We would like the clarify of the meaning of reference data rate here.  1, the reference data rate may have the following understanding   * opt-1: Raw data rate, which considers only data rate for the coded/uncoded information bits, without considering overhead for CRC, midamble, postamble, if reported. For example, for R2D M=1, and Manchester code is used, which means 2 OFDM symbol is used for each information bits, and data rate for the information bits is 7kbps for this case. (This is how 7kbps come from in our understanding, which may not applicable for D2R in our understanding).   opt-2: data rate in physical channel, the data rate also considers overhead for CRC, midamble, postamble, FEC, repetition, if reported. For this case, it may be difficult to achieve the accurate data rate value, companies may need to adjust the configuration of CRC/midamble/postamble/FEC/repetition to achieve the data rate close to the agreed data rate value? |
| ZTE, Sanechips | 0m | Okay.  For the small data rate, such as 0.1kbps, 1kbps are the data rate required by RAN SI, which needs to be evaluated. We are also okay to include a larger data rate for evaluation, such as 7kbps. |
| Apple | [0m] | We are fine with values being considered, but additionally would prefer to add 2kbps as well. It can be optional |
| Futurewei | [0m] | Ok with the proposed text |
| Futurewei | [0n] | We understand that the message size does not include CRC bits. We propose to add a note to clarify it. | Add a note2   |  |  |  | | --- | --- | --- | | [0n] | Message size | {20 bits, 96 bits, 400 bits} are considered for message size.   * Note 1: companies to report the M value and chip length used for each message size * Note 2: CRC is not included for the message size | |
| Huawei, HiSilicon | [0q] | We are supportive of the proposal. | To [vivo], the sampling frequency here is for device (e.g., 1.92 Msps). However, there is no specific mention of the reader's sampling frequency. It can be as high as possible, with the assumption left to the companies. Given that the bandwidth is not so large, I believe the reader's sampling frequency is sufficiently high for adequate performance.  To [Ericsson], considering the typical value used and proposed by many companies, FL suggest to keep 1.92Msps and other values are not precluded for evaluation.  To [CATT] remove the note in this item and added another proposal for this.    To [DoCOMO][OPPO]  Clarify these values are not intended for design and only for evaluation.  To [ZTE], I think we need only two SFO values, i.e., initial SFO and after clock calibration SFO. No need to have another maximum initial SFO. Otherwise, we will end up with 3 SFO values.  For SFO, it is unstable for device 2. Some one think it is 10^3-10^4, some proposes 10-10^2. FL added FFS. Let’s further discuss that during this email discussion.  Proposal:   |  |  |  | | --- | --- | --- | | **[0q]** | Sampling frequency | Sampling frequency is 1.92 Msps. Other values are not precluded and reported by companies.  Initial SFO (Sampling Frequency Offset) (Fe):   * [0.1 ~ 1] \* 10^5 ppm for device 1, * FFS device 2:   + [10^4] ppm   + [10^3] ppm   + [10^2] ppm   The timing drift ΔT over a time T is modelled as ΔT = ±Fe \* T.   * FFS: Accuracy after clock calibration for at least device 2. * Note: SFO corresponds to after clock calibration can be applied to Fe.   FFS: CFO for device 2b.   * [200ppm, 0.1ppm/s]   ~~Note: the values are for coverage evaluation purpose. A harmonized design approach for all devices should be considered when utilizing these values in the design.~~ | | **…** |  |  | |  |  |  | | Note:  These values are for evaluation purpose and any differences among device types (if any) are not intended for harmonized design approach. | | | |
| DOCOMO | [0q] | Comment #1:  For the timing drift, “Fe” can be the SFO corresponds to after clock calibration and it should be clarified, per our understanding. Therefore, we prefer to add the following note.  The timing drift ΔT over a time T is modelled as ΔT = ±Fe \* T.  Note: SFO corresponds to after clock calibration can be applied to Fe.  Comment #2:  For the first FFS, we prefer to add “at least” for device 2 as follows.  FFS: Accuracy after clock calibration at least for device 2.  Comment #3:  As commented by companies at the online session, the note can be simplified as follows.  Note: the values are for coverage evaluation purpose. ~~A harmonized design approach for all devices should be considered when utilizing these values in the design.~~ |
| OPPO | [0q] | [0q]: we suggest agreeing one value for “CFO for device 2b” as this value is needed for evaluation of D2R of device 2b. In the last meeting 2 options were provided in FL summary, maybe we can use the intersection of the 2 options, i.e. (200ppm, 0.1ppm/s) , as baseline, and other values is up to companies to report. We also support to simplify the Note as proposed by DCM. |
| vivo | **[0q]** Sampling frequency | Regarding this item, there is sampling frequency of 1.92Msps, it seems parameter for R2D receiver? We would like to clarify the assumption for initial SFO is also applicable to D2R transmitter. |
| ZTE, Sanechips | 0q | Comments are as below.   |  | | --- | | Sampling frequency is 1.92 Msps. |   [ZTE, Sanechips] okay with the sampling frequency.   |  | | --- | | Initial SFO (Sampling Frequency Offset) (Fe):   * [0.1 ~ 1] \* 10^5 ppm ~~for device 1, reported by company~~ * ~~[0.1 ~ 1] \* 10^4 ppm for device 2, reported by company~~ |   [ZTE, Sanechips]  We think different devices with different architectures and capabilities should be equipped with different SFO accuracy.  For device 1, we are okay with the SFO up to 10^5ppm.  However, for device 2a, the implementation with large frequency shift is being discussed. If the SFO is up to 10^5ppm, for a frequency shift gap of 50MHz, the frequency shift uncertainty is 10MHz (50MHz\*0.1\*2), which may exceed the frequency range of FDD UL spectrum. Therefore, to enable the possibility of large frequency shift of device 2a, a higher frequency accuracy than device 1 is needed. Therefore, we think at least 10^4ppm is needed.  For device 2b, the impact of frequency uncertainty is more serious considering the carrier frequency is 900MHz or 2GHz. In this case, we think the model used in LP WUS can be reused for device 2b.  Moreover, we think the SFO value is the max value, not fixed. Hence, the actual SFO can be a random value between 0 and 10^5ppm/10^4ppm/10^2ppm depending on device type.  Therefore, our suggestion is:  **Suggestion:**  Maximum Initial SFO (Sampling Frequency Offset) (Fe):   * [0.1 ~ 1] \* 10^5 ppm for device 1~~, reported by company~~ * [0.1 ~ 1] \* 10^4 ppm for device 2a~~, reported by company~~ * [0.1 ~ 1] \* 10^2 ppm for device 2b  |  | | --- | | The timing drift ΔT over a time T is modelled as ΔT = ±Fe \* T. |   [ZTE, Sanechips] We agree with DoCoMo that the timing drift should be modeled after clock synchronization,instead of using initial sampling offset. Moreover, it seems the model above assume that the clock offset is fixed over the the time duration T. However, if clock drift is considered, the time offset per chip may be varied.  The suggestion is as below:  **Suggestion:**  The timing drift ΔT over a time T is modelled as ΔT = ±Fr~~e~~ \* T. where Fr is clock offset after synchronization. FFS other models.   |  | | --- | | FFS: Accuracy after clock calibration for device 2. |   [ZTE, Sanechips] We think device 1 can also implement clock synchronization. Similar as RF ID tag, the device can count the number of samples during preamble detection. And then using the counted sample numbers to derive the required samples for the follow-up transmission. Therefore, the following is suggested:  **Suggestion:**  FFS: Accuracy after clock calibration for device 1 and 2.   |  | | --- | | Note: the values are for coverage evaluation purpose. A harmonized design approach for all devices should be considered when utilizing these values in the design. |   [ZTE, Sanechips] This is for evaluation discussion, instead of detailed design. The following is suggested.  **Suggestion:**  Note: the values are for coverage evaluation purpose. ~~A harmonized design approach for all devices should be considered when utilizing these values in the design.~~ |
| CATT | **[0q]** | For the initial SFO (Sampling Frequency Offset) (Fe),  • [0.1 ~ 1] \* 10^5 ppm  we would like clarification on its meaning. Does it indicate that the maximum SFO can be selected within the range of [0.1 ~ 1] \* 10^5 ppm, or does it mean that the maximum SFO is 10^5 ppm, and a value between [0.1 ~ 1] \* 10^5 ppm can be randomly selected for each LLS?  For the “Note: the values are for coverage evaluation purpose. A harmonized design approach for all devices should be considered when utilizing these values in the design”, considering that not only SFO, but some other values (e.g., the order of Butterworth/RC filter) in the table are also defined for evaluation purposes, but not design parameters, it might be simpler to add a new row, e.g., [3c], and stating that the values in the table are for evaluation purposes. |
| Ericsson | [0q] | Regarding **sampling frequency**, we don’t think there is strong technical reason why the sampling frequency should be 1.92 Msps. Our understanding is that if the maximum data rate is 7 kbps and RF-ED, the sampling rate can be much smaller than that. For example, the sampling frequency could be 56 kHz (2 times the Nyquist rate corresponding to a data rate of 7 kbps).  We think sampling frequency can be up to companies to report.  Regarding **initial SFO**, we support the suggestion from ZTE. Alternatively, we can do coverage evaluation with different sampling frequencies for all device types, e.g., 10^5 ppm (M), 10^3 ppm (O), and 10^2 ppm (O).  Note that oscillators with very large errors will increase synchronization time with the network, resulting in higher energy consumption at the device and increasing complexity for synchronization (time/frequency error correction). |
| Apple | [0q] | Support |
| Futurewei | [0q] | Sampling frequency is 1.92 Msps.  Initial SFO (Sampling Frequency Offset) (Fe):   * [0.1 ~ 1] \* 10^5 ppm ~~for device 1, reported by company~~ * ~~[0.1 ~ 1] \* 10^4 ppm for device 2, reported by company~~   The timing drift ΔT over a time T is modelled as ΔT = ±Fe \* T.  FFS: Accuracy after clock calibration for device 2.  FFS: CFO for device 2b.  Note: the values are for coverage evaluation purpose. A harmonized design approach for all devices should be considered when utilizing these values in the design.  Propose to use [0.1 ~ 1] \* 10^5 ppm as mandatory for device 1 and 2a. In addition, companies can report an optional value for device 2a for Fe. |
| LGE | [0q] | [0q]: In our view, since all types of device 2 may not support clock calibration, we prefer to remove first FFS. Additionally, we prefer to remove second FFS to minimize device specific evaluation. For initial SFO and timing drift, we are okay with the proposal. |
| Huawei, HiSilicon | [1c] | We are supportive of the proposal. | As suggested by vivo, BW of the BB LPF depends on data rates, then it will be very flexible. As stated by vivo, a fixed BB LPF BW is suggested for different data rates.  Hence, FL still suggest to consider the proposal as it is. |
| vivo | [1c] BB LPF | We are OK to assume a certain BW value for BB LPF (e.g., [90] kHz), while we don’t think it is related to half of transmission bandwidth. Instead, BB LPF BW depends on data rates. Even for Tx bandwidth of 1.08MHz(O), 90kHz for BB LPF is enough for a low data rate e.g., 7kbps.  Besides, the BB LPF in circuit of the receiver cannot be flexibly adjusted to different data rate and/or transmission BW, a fixed BB LPF BW can be assumed for different data rates/Tx bandwidth. |
| ZTE, Sanechips | 1c | okay |
| Futurewei | [1c] | Ok with the proposed text. |
| Huawei, HiSilicon | [2a1] | We are supportive of [2a1]-Alt1 since for D2R we understand DSB should be the choice which can be supported by all devices. We are also supportive of Alternative 1, since Alternative 2 is not a full list and will be derived from other design agenda items. | Most companies prefer DSB (Alt 1).  For Alternative 1 and 2, FL suggest Alternative 1 (as stated by company so the results can be compared easily among companies) and other values can be reported by companies   |  |  |  | | --- | --- | --- | | **[2a1]** | Transmission bandwidth | * **~~[2a1]-Alt1:~~**    + DSB   + X kHz ~~(M) and Y kHz (O)~~ is considered for D2R transmission bandwidth.   + The value is for two sidebands, i.e., the total transmission bandwidth for DSB is X kHz ~~(M) and Y kHz (O)~~. * **~~[2a1]-Alt2:~~**    + ~~SSB~~   + ~~X kHz (M) and Y kHz (O) is considered for D2R transmission bandwidth.~~   + ~~The value is for one sideband, i.e., the total transmission bandwidth for DSB is X kHz (M) and Y kHz (O).~~ * ~~The value of X and Y is as follows, to be down-select from alternative 1 and 2~~   + ~~Alternative 1:~~      - ~~X = {15 (M), 180 (O)}~~     - ~~Y =180~~   + ~~Alternative 2:~~     - ~~X and Y reported by companies,~~       * ~~the value may be related to, e.g.,~~          + ~~Reference data rate~~         + ~~Coding scheme~~         + ~~Repetition~~         + ~~With or without SFS~~         + ~~SSB or DSB~~   + X = {15 (M), 180 (O)}, other values are not precluded and reported by companies | |
| DOCOMO | [2a1] | Comment#1:  In our understanding, alternatives in the 3rd main bullet does not correspond to [2a1]-Alt1 and [2a1]-Alt2, i.e., regardless of [2a1]-Alt1 or [2a1]-Alt2, alternatives in the 3rd bullet can be selected.  Comment#2:  The applicable device type of each [2a1]-Alt1 and [2a1]-Alt2 can be further clarified.  Comment#3:  For Alt.2 in the 3rd main bullet, it is unclear for us how repetition would affect to the transmission bandwidth. |
| OPPO | [2a1] | [2a1]-Alt 1 should be mandatory, and [2a1]-Alt 2 optional.  … |
| Spreadtrum | [2a1] | We prefer Alt1 in [2a1].  We are OK with [0q], [2a2] and [2a3]. |
| vivo | [2a1] Transmission bandwidth | Prefer [2a1]-Alt1, consider two sidebands. Receiver of D2R signal should be able to employ both sidebands.  We prefer Alternative 2 for transmission BW X, i.e., up to company report. And the BW may relate to line coding scheme, data rate, etc. We are not sure whether company have aligned Tx BW value even if for the same signal generation. Since this value is not used in link budget calculation, the X value can be up to company report, and the details e.g., data rate, coding scheme, repetition are reported together in the link level simulation template. |
| Apple | [2a1] | Support and prefer Alt1 |
| Futurewei | [2a1] | * **[2a1]-Alt1:**    + DSB   + X kHz ~~(M) and Y kHz (O)~~ is considered for D2R transmission bandwidth.   + The value is for two sidebands, i.e., the total transmission bandwidth for DSB is X kHz ~~(M) and Y kHz (O)~~. * **[2a1]-Alt2:**    + SSB   + X kHz ~~(M) and Y kHz (O)~~ is considered for D2R transmission bandwidth.   + The value is for one sideband, i.e., the total transmission bandwidth for DSB is X kHz ~~(M) and Y kHz (O)~~.   ***Proposal: select DSB over SSB for device 1/2a in back scattering***.  Devices will need additional hardware to support SSB and consume additional energy.   * The value of X ~~and Y~~ is as follows, to be down-select from alternative 1 and 2   + Alternative 1:     - X = {15 (M), 180 (O)}     - ~~Y =180~~   + Alternative 2:     - X ~~and Y~~ reported by companies,       * the value may be related to, e.g.,         + Reference data rate         + Coding scheme         + Repetition         + With or without SFS         + SSB or DSB   We select Alternative 1 so the results can be compared easily among companies. |
| LGE | [2a1] | [2a1]: In our view, Alt1 should be considered since all types of AmIoT devices may not have capability to isolate one side band. Since the device architecture is not guaranteed, Alt1 should be considered as a baseline for LLS and Alt2 can be optional. Additionally, determining the value of X, we prefer Alternative 1 as a baseline for simplicity. |
| Huawei, HiSilicon | [2a2] | We are fine to add [2a2] | Add [2a2] |
| OPPO | [2a2] | We support to report chip rate (i.e. [2a2]). Given that, alternative 2 in [2a1] should be used, as the chip rate and transmission bandwidth are relevant to each other and should be derived from same sets of factors, i.e., reference data rate, DSB/SSB, repetition, |
| Futurewei | [2a2] | Ok with the proposed text |
| Huawei, HiSilicon | [2a3] | We are fine with the proposal and as we stated above, we think DSB should be the choice for D2R. | So far, we have no idea about how is the potential guard bands. FL added and further down-selection is not precluded.  Proposals  D2R receiver bandwidth is the bandwidth used at the reader side to filter out the D2R signals for calculating noise and interference (if any) power.   * Assume the receiver matches the transmitter's modulation, i.e., ~~to receiver uses SSB when transmitter uses SSB,~~ receiver uses DSB when transmitter uses DSB.   Companies to report the value, and further down-selection is not precluded. |
| vivo | [2a3] Receiver bandwidth | A limited received BW value(s) for evaluation purpose are needed to ensure same SINR definition across companies, since we have working assumption that ‘For the D2R LLS, the SINR/SNR is reported and it is defined as the ratio of signal power to noise and interference (if any) power in the receiver bandwidth.’  The Rx BW may include Tx BW + potential guard bands in our understanding. We are not sure whether companies would have the same Rx BW for the same D2R signal. If [2a3] receiver bandwidth is totally up to company report, it implies companies would have different SINR definition even for the same D2R transmission signal, if reported ‘receiver BW’ is not aligned across companies. |
| Apple | [2a3] | Fine |
| Futurewei | [2a3] | Ok with the proposed text |
| Futurewei | [3b] | ok |  |

In summary, the LLS table is revised as follows,

**[H][Proposal2-v2]**

The link level simulation table is updated as follows,

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Parameters** | | **Assumptions** | **Company result1** | **Company result 2** |
|  | **R2D/D2R common parameters** | | |  |  |
| **[0a]** | Carrier frequency | | Refer to link budget template |  |  |
| **[0b]** | SCS | | 15 kHz as baseline |  |  |
| **[0c]** | Block structure | | Blocks as agreed in 9.4.2.3, or other blocks reported by companies |  |  |
| **[0d]** | Channel model | | <Editor’s Note: will be updated according to the agreements made for channel model> |  |  |
| **[0e]** | Delay spread | | ~~[30, 150] ns~~   * An RMS delay spread of 30 ns and [150] ns is considered for TDL-A channel model. * An RMS delay spread of 30 ns is considered for TDL-D channel model. |  |  |
| **[0f]** | Device velocity | | 3 km/h |  |  |
| **[0g]** | Number of Tx/Rx chains for Ambient IoT device | | 1 |  |  |
| **[0h1]** | BS | Number of antenna elements | 2 or 4 |  |  |
| **[0h2]** | Number of TXRUs | 2 or 4 |  |  |
| **[0j1]** | Intermediate UE | Number of antenna elements | 1 or 2 |  |  |
| **[0j2]** | Number of TXRUs | 1 or 2 |  |  |
| **[0m]** | Reference data rate | | ~~[0.1, 1, 5] kbps~~  [0.1] kbps (M), [1] kbps (M), [2] kbps (O), [7] kbps (O), [large value] (O)   * Note1: companies to report the exact data rate. * Note 2: the exact data rate is close the values listed above. * Note 3: The data rate is calculated by dividing the total message size by the total transmission time. * Note 4: the data rate may be related to coding scheme, repetition and etc. |  |  |
| **[0n]** | Message size | | {20 bits, 96 bits, 400 bits} are considered for message size.   * Note 1: companies to report the M value and chip length used for each message size * Note 2: CRC is not included for the message size |  |  |
| **[0p]** | BLER target | | 1%, 10% |  |  |
| **[0q]** | Sampling frequency | | Sampling frequency is 1.92 Msps. Other values are not precluded and reported by companies.  Initial SFO (Sampling Frequency Offset) (Fe):   * [0.1 ~ 1] \* 10^5 ppm for device 1, * FFS device 2:   + [10^4] ppm   + [10^3] ppm   + [10^2] ppm   The timing drift ΔT over a time T is modelled as ΔT = ±Fe \* T.   * FFS: Accuracy after clock calibration for at least device 2. * Note: SFO corresponds to after clock calibration can be applied to Fe.   FFS: CFO for device 2b.   * [200ppm, 0.1ppm/s]   ~~Note: the values are for coverage evaluation purpose. A harmonized design approach for all devices should be considered when utilizing these values in the design.~~ |  |  |
| **[0r]** | Device 1/2a/2b | | Options are as follows,   * Device 1, RF-ED * Device 2a, RF-ED * Device 2b, RF-ED/IF-ED/ZIF   <Editor’s Note: will be updated according to agreements from 9.4.1.2> |  |  |
|  | **R2D specific parameters** | | |  |  |
| **[1a]** | Transmission bandwidth | | 180 kHz as baseline |  |  |
| **[1b]** | ~~FFS:~~ ED bandwidth | | The ED bandwidth is the bandwidth for calculating the noise/interference (if any) power:  For evaluations, the value(s) of ED bandwidth is 20 MHz for RF-ED, [180] kHz for IF/ZIF receiver.  Note: this does not imply that a A-IoT device supports sampling clock rate as large as RF ED bandwidth. |  |  |
| **[1c]** | ~~FFS:~~ BB LPF | | [X]-order Butterworth/RC filter with cutoff frequency at ~~[Y] kHz,~~ half of R2D transmission bandwidth.  Companies to report X = {3, 5}. |  |  |
| **[1d]** | Waveform | | OOK waveform generated by OFDM modulator |  |  |
| **[1e]** | Modulation | | OOK  Companies to report, e.g., OOK-1, OOK-4 with M chips per OFDM symbol |  |  |
| **[1f]** | Line code | | Companies to report, e.g., Manchester, PIE |  |  |
| **[1g]** | FEC | | No FEC as baseline |  |  |
| **[1h]** | ADC bit width | | 1-bit for device 1  4-bit for device 2 |  |  |
| **[1j]** | Detection/decoding method for Line code | | Companies to report |  |  |
|  | **D2R specific parameters** | | |  |  |
| **[2a1]** | Transmission bandwidth ~~(w.r.t. D2R data rate)~~ | | * **~~[2a1]-Alt1:~~**    + DSB   + X kHz ~~(M) and Y kHz (O)~~ is considered for D2R transmission bandwidth.   + The value is for two sidebands, i.e., the total transmission bandwidth for DSB is X kHz ~~(M) and Y kHz (O)~~. * **~~[2a1]-Alt2:~~**    + ~~SSB~~   + ~~X kHz (M) and Y kHz (O) is considered for D2R transmission bandwidth.~~   + ~~The value is for one sideband, i.e., the total transmission bandwidth for DSB is X kHz (M) and Y kHz (O).~~ * ~~The value of X and Y is as follows, to be down-select from alternative 1 and 2~~   + ~~Alternative 1:~~      - ~~X = {15 (M), 180 (O)}~~     - ~~Y =180~~   + ~~Alternative 2:~~     - ~~X and Y reported by companies,~~       * ~~the value may be related to, e.g.,~~          + ~~Reference data rate~~         + ~~Coding scheme~~         + ~~Repetition~~         + ~~With or without SFS~~         + ~~SSB or DSB~~   + X = {15 (M), 180 (O)}, other values are not precluded and reported by companies |  |  |
| **[2a2]** | [OOK/BPSK/BFSK chip rate] | | Companies to report |  |  |
| **[2a3]** | Receiver bandwidth | | D2R receiver bandwidth is the bandwidth used at the reader side to filter out the D2R signals for calculating noise and interference (if any) power.   * Assume the receiver matches the transmitter's modulation, i.e., ~~to receiver uses SSB when transmitter uses SSB,~~ receiver uses DSB when transmitter uses DSB.   Companies to report the value, and further down-selection is not precluded. |  |  |
| **[2b]** | Waveform (CW) | | Companies to report waveform, e.g., unmodulated single tone, multi-tone(multiple unmodulated single tone) |  |  |
| **[2d]** | Modulation | | Companies to report modulation, e.g., OOK, BPSK, BFSK |  |  |
| **[2e]** | Line code | | Companies to report, e.g., Manchester encoding, FM0 encoding, Miller encoding, no line coding |  |  |
| **[2g]** | FEC | | Companies to report, e.g., CC, No FEC |  |  |
| **[2h]** | ADC bit width | | Companies to report, e.g., 11-bit |  |  |
| **[2j]** | D2R receiver | | ~~FFS: Reader receiver, e.g., coherent receiver / non-coherent receiver~~  Companies to report, e.g., coherent receiver / non-coherent receiver |  |  |
|  | **Other assumptions** | | |  |  |
| **[3a]** | Other assumptions | | To be reported by company |  |  |
| **[3b]** | Note: Companies to report required SINR/SNR/CINR/CNR according to BLER target. | | |  |  |
| Note**:**   * These values are for evaluation purpose and any differences among device types (if any) are not intended for harmonized design approach. | | | | | |

|  |  |  |
| --- | --- | --- |
| **Company** | **Which item?** | **Comments** |
| Xiaomi | [0q] sampling frequency | Initial SFO (Sampling Frequency Offset) (Fe):   * [0.1 ~ 1] \* 10^5 ppm for device 1, * FFS device 2:   + [10^4] ppm   + [10^3] ppm   + [10^2] ppm   The timing drift ΔT over a time T is modelled as ΔT = ±Fe \* T.   * FFS: Accuracy after clock calibration for at least device 2. * Note: SFO corresponds to after clock calibration can be applied to Fe.   We have two questions.  Q1: in the model ΔT = ±Fe \* T, Fe is the SFO corresponds to after clock calibration(for example, when device receive R2D self-clocking signal, its clock is synchronized with R2D signal, and is Fe is the SFO after receiving R2D signal, and then when it transmit D2R, device’s clock is drifting by drifting rate Fe ). In this model, there is no “initial SFO”. So what is the usage of the listed initial SFO values? And what is the assumption for the value of Fe after clock calibration?  Q2: Are we assuming the Fe is always kept the same during the whole transmission duration for D2R?  From our point of view, 10^5 ppm SFO is a quite large value and that means the clock is not stable and may fluctuate severely, the experienced SFO during a D2R transmission may be varied especially when the D2R transmission is long(e.g. 400bits message size). We share similar view as ZTE that the Fe value for different chips within a D2R transmission may be different. |
|  |  |  |