**3GPP TSG-RAN WG1 Meeting #110bis-e R1-2210592**

**e-Meeting, October 10th – 19th, 2022**

**Agenda Item: 9.7.1**

**Source: Moderator (Huawei)**

**Title: FL summary#4 for R18 NW\_ES**

**Document for: Discussion and Decision**

# Introduction

This triggers the email discussion of the following:

|  |
| --- |
| [110bis-e-R18-NW\_ES-01] Email discussion on performance evaluation by October 19 – Yi (Huawei)   * Check points: October 14, October 19 |

Please search for ‘FL7’ for your input, by UTC 06:00am, Oct. 18th.



## Recommendations for GTW/email approval:

|  |
| --- |
|  |

## Outcome of GTW/email discussion

|  |
| --- |
|  |

# Energy consumption model for BS

## Total energy consumption

OPPO clarifies that, the total BS energy can be calculated as below.

Where includes the energy consumption of each power state and additional transition energy and and are relative power value and time duration in unit of slot for power state *i*, and are transition energy and the number of transitions for sleep mode *i*.

### Initial round

|  |  |
| --- | --- |
| **FL1 Proposal 2.6.1:**  Clarify and capture the below formula into TR as calculation of total energy consumption.  Where includes the energy consumption of each power state and additional transition energy and and are relative power value and time duration in unit of slot for power state *i*, and are transition energy and the number of transitions for sleep mode *i*. | |
| **Company** | **Comments** |
| Huawei, HiSilicon | We generally support the proposal. However, there needs some clarification: the unit of *Ei* is (power unit\*ms). So, we think a scaling factor should be introduced in the equation to convert slot number to number of ms:  , where is the subcarrier spacing. |
| LG Electronics | We support the proposal. |
| DOCOMO | We are generally fine with the proposal and the revision by HW seems reasonable. |
| Nokia/Nsb | Not sure if we need it |
| Spreadtrum | Basically fine |
| vivo | We think that there may not be need to capture this since the total energy is the sum of energy for all slots. |
| ZTE, Sanechips | Same view with Nokia, vivo, not sure whether it is needed. |
| Samsung | Share same view as Nokia. |
| OPPO | We support the proposal. |
| CATT | We don’t see the need of including this. |
| FL2 | This may have relationship with Qualcomm clarification question on power model per symbol level or not. So please QC check if the response from Huawei/HiSi can clarify that. |
| Intel | We agree with Nokia and some other companies that there is no need to agree on this. For scaling model to apply, we assume relative power values represent slot-level power according to resource usage based on reference configurations. |
| InterDigital | Ok with the proposal |
| CMCC | Not needed. |
| China Telecom | We are fine with the equation but don’t think it is needed. |
| Samsung | For the clarification on time unit, we can compromise with FL’s proposal with updates as follow:  **Updated-FL1 Proposal 2.6.1:**  Clarify and capture the below formula into TR as calculation of total energy consumption.  Where includes the energy consumption of each power state and additional transition energy and and are relative power value and time duration in unit of slot for power state *i*, given reference configuration of a set. and are transition energy and the number of transitions for sleep mode *j*. |
| MediaTek | Agree with Huawei proposal which ensures the energy components are all in the same unit of (relative power x ms) |
| Fujitsu | We are OK with the proposal. |
| QCOM2 | We don’t see the need of this proposal for now. It seems the proposal assumes the power is per slot which is not agreed yet.  @FL2: could you point to Huawei/HiSi comments? We provided our view in 2.2.2. |
| Apple | We are fine with the proposal |

### Second/Third round

Given what FL observed when discussing the transition energy, all companies including symbol level proponents use the power values defined in the power model table to multiply the transition time in millisecond. Thus, FL’ observation is the relative power values in power model table in section 2.2 are slot/ms level. In this manner, both symbol level and slot level has aligned values over a same time duration. Thus, FL considers the proposal above modified by Huawei is fine, and can clarify LGe question. Given the discussion, perhaps need to capture this clearly for evaluation.

**FL3 Proposal 2.6.2:**

Clarify and capture the below formula into TR as calculation of total energy consumption.

Where includes the energy consumption of each power state and additional transition energy , and and are relative power value and time duration in unit of slot for power state *i*, and are transition energy and the number of transitions for sleep mode *j* and is the subcarrier spacing.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QCOM3 | We don’t agree with the FL summary and don’t support this proposal at this moment. In particular, from our perspective, it is not correct to say “all companies including symbol level proponents use the power values defined in the power model table to multiply the transition time in millisecond”.  Once we have common understanding on the granularity of power consumption, we can discuss whether this proposal is needed or not. |
| Intel | Formula is not needed to be captured in TR. It is sufficient to clarify that relative power value in the table are per slot. |
| Ericsson2 | We do not see the need for this proposal. Agree with Qualcomm that the granularity of power consumption should be addressed first. |
| Samsung | Fine with the FL3 proposal. |
| FL3 | @QCOM3  *“all companies including symbol level proponents use the power values defined in the power model table to multiply the transition time in millisecond”*  The above statement is referring to the discussion in section 2.3 and previous discussion on this item, where my observation is that both QCOM3 and Ericsson2, even if prefer different number of values, have the same understanding on E=P\*T in ms.  Then, back to the granularity of power values,   * + When the values are per slot, the per-symbol value can be obtained by P\_symbol=P/14, and the P\_symbol can be used in SLS with scaling based on reference configuraions.   + Can the above address QCOM3 concern?   @ALL  On the other hand, if we assume the P values in section 2.2 is per symbol, for slot-level modeling proponents, one can obtain the values by P\_slot=P\*14. Then in the evaluations, one can still use slot-based averaged values for various scheduling resources. Is there any concern? |
| vivo | We don’t see the need of capturing this equation into TR.  On the granularity of power values, we are fine with either per slot or per symbol. Agree with FL that symbol-level and slot-level power value can be derived from each other. |
| MediaTek | We think the formula is correct and support capturing it explicitly in the TR. In previous UE power saving study, companies spent some time in calibration to ensure aligned evaluations. Given there are more complicated numerologies involved (Sets 1, 2 and 3) in NW ES evaluations, this formula helps avoid misalignment in companies’ evaluations. |
| DOCOMO | Fine with the proposal. We share similar view with MTK. Capturing the formula would be helpful for future reference. |
| Spreadtrum | Fine |
| Nokia/Nsb | Following parameter description should be revised:  is the ~~subcarrier spacing~~ numerology  @FL, still we are not convinced why this is needed for our modelling framework? |
| LG Electronics | We are fine with the proposal and it can be captured in TR if the majority supports this proposal. |
| China Telecom | Though the formula is correct, but we don’t see the need to capture it into TR. However, we can follow the majority’s view. |
| Apple | We would be fine with this proposal. Alternatively, we can simply clarify that P\_i defines the relative power per ms, given how the transition energy was derived (approximately). Once this is clarified, the equation is not needed any more, because it becomes obvious. |

### 4th round

FL’s original intention is not only to capture the equation for information, but also noticed that this equation may be able to address the discussion point about time-scale of the power values.

Since now we have a specific discussion point for that, let’s use this section for further exchange of understanding. Previous agreement is as below.

*Agreement*

*For evaluation purpose, the BS energy consumption model should at least include the power consumption of BS on slot-level.*

* *Note that symbol-level power consumption to reflect different BW (or RB utilization) / time-occupancy / tx-rx direction of different symbols in a slot is considered.*
  + *FFS details (e.g. explicit symbol-level power modelling, scaling slot-level power to symbol level power for various cases, etc.)*
  + *Note: system simulation evaluations can be per slot regardless of detailed approach for calculating symbol-level power consumption*.

And regarding the example QC provided,

*Now talking about symbol-level vs. slot-level modelling. Let’s start with slot-level modelling and an example scenario where a slot has PDSCH for 3 UEs:*

* + ***Allocation 1****: Sym0 and Sym1: PDCCH occupying 40MHz*
  + ***Allocation 2****: Syms 2-7: UE1 PDSCH occupies 25MHz while UE2 PDSCH occupies 25MHz. UE1 PDSCH and UE2 PDSCH are FDMed (no frequency overlap but there could be frequency gap in between).*
  + ***Allocation 3****: Syms 8-13: UE1 PDSCH occupies 25MHz, UE2 PDSCH occupies 20MHz, and UE3 PDSCH occupies 20MHz. PDSCH from 3 UEs are FDMed.*

*Now it is our understanding that we need to scale the reference power model in time/frequency (& possible power) domain for each of the above allocations for computing the power for each one. Then the slot energy consumption is the summation of the energy consumption of each allocation. The computation complexity becomes higher when we have more complicated slot composition. Note that simply counting the number of DL symbols or UL symbols in a slot is not sufficient.*

**FL4 Question 2.4.3-1: Can the scaling by symbol-level and scaling by slot-level derived by each other?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QCOM4 | It can but they have different complexities in implementing in evaluation especially when symbols in the same slot have different spatial, frequency and power allocations. We found out slot-level modelling is simpler and we don’t need to have discussion on time domain scaling in Section 2.5. Note that since symbols in the same slot have different spatial, frequency and power allocations, the formula () in the proposal in Section 2.5 is not always correct. It will be much involved than that.  Furthermore, companies should use the same framework for evaluation. If some companies use slot-level modelling while others use symbol-level modelling, it may be possible that the observations across companies may not be consistent – just similar to the concerns from some companies on inconsistent observations in power model Cat 1 and power model Cat 2. |
| Intel | In our view, the agreed relative power values are expressed at the slot level (i.e., energy consumed over a slot) based on the reference configurations. Then, in the scaling formula, symbol level energy consumption can be obtained based on the slot level relative power model. We think this is cleaner approach. |
| Samsung | Please see our comments for the details in Q2.4.3-3. |
| Apple | We need to clarify the time unit for the defined P\_i. Given how the transition energy was defined (approximately), our assumption is that P\_i is the energy consumption over one ms. If no transition energy were involved, symbol-level or slot-level does not really matter. But we have the transition energy defined in certain way, and we need to be consistent. Otherwise the results would not be correct.  QC’s comment that the formula is not always correct is not clear to us. Maybe QC can elaborate what they consider as the right way to do it. |
| ZTE, Sanechips | We think the scaling by symbol and by slot are convertible. However,we tend to agree with Apple that for the agreed transition energy, it is more like slot level power consumption model is assumed. Otherwise, the energy defined in millisecond with symbol level power consumption model will be much larger. |
| vivo | Yes, we think the power value in symbol-level and slot-level can be derived from each other. The scaling is better to be in symbol level to handle the case QC mentions whether the table is in symbol-level or slot-level.  According to current discussion, there are the following two different alternatives:  Alt .1: Power value is in unit of symbol and where is the power in the *i*th symbol after scaling corresponding to the power state;  Alt. 2: Power value is in unit of slot. The symbols with the same power state and the same allocation in frequency, spatial and power domain are grouped together, i.e.  **+ where**  is the ratio of symbols in power state *i*, is the ratio of symbols of the kth DL allocation and is the ratio of symbols of the mth UL allocation. is the power of the kth DL allocation after scaling and is the power of the mth UL allocation after scaling. Note =1  We agree that the final total energy value for one technique is different by adopting the above two alternatives. Actually, the total energy value resulting from Alt. 1 is always 14 times over that from Alt. 2 for a certain evaluation. If power saving gain is reported for one technique over baseline, the gain will be the same for both the above two alternatives.  We are fine with either alternative and slightly prefer Alt. 1 for simplicity. If it is hard to achieve a consensus between these two, we suggest to agree these two alternative implementation approach that will result in the same results for power saving gain. |
| LG Electronics | We share the same view with Intel and Apple. When we calculating the transition energy based on the formula, we think that multiplying the relative power by the total transition time in ms (i.e., relative power\*(duration in ms)) means that the implicitly agreed relative power values are slot/ms level. |
| Nokia/Nsb | Yes, by performing the right scaling in time and frequency |
| DOCOMO | Yes, symbol-level energy relative power can be derived from slot/ms-level relative power by scaling. |
| Spreadtrum | Somehow agree with QC. If scaling is too flexible, how can companies compare the evaluation results? We have no strong position. If the evaluation results can be compared without too much controversial, it is OK. |
| InterDigital | We share similar views with Apple on the defined time units. And yes, per symbol level relative power can be calculated by scaling the slot-level relative power. |
| Huawei, HiSilicon | Yes, symbol-level energy relative power and slot-level relative power can be derived by each other. We agree with Apple’s observation that our power consumption values are defined per ms, considering the unit of agreed additional energy overhead is (power unit\*ms). Assuming the power value is Pi, it is the same of Pi\**Nsym*\**sym\_length* and Pi\**Nslot*\**slot\_length*, where *sym\_length* and *slot\_length* are the time length in milliseconds per symbol and per slot, *Nsym* and *Nslot* are the symbols number and slots number within the same time duration. |
| Fujitsu | We think scaling by symbol level can be derived from that by slot level. In addition, we share the same view with other companies that the time unit need to be consistent with that of the agreed relative power values which is slot/ms level. |
| Ericsson4 | It should be possible, but it is not the case for the formulation based on (#DL syms,#UL syms, etc), as Qualcomm points out. |
| CATT | We don’t need the formula. We don’t agree with the formulation with number of DL and UL symbols since the gNB power still have DL consumption of cross-slot signal processing and controller when UL is transmitted.  The slot level power consumption is the straight forward since it includes the energy consumption of RF and baseband signal processing at each symbol, transition energy consumption at between symbol, and cross-symbol energy consumption, such as channel encoder and gNB controller. |

**FL4 Question 2.4.3-2: Can the slot-level scaling be able to reflect different BW (or RB utilization) / time-occupancy / tx-rx direction of different symbols in a slot?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QCOM4 | See our reply in Question 2.4.3-1 and the listed example. |
| Intel | Yes. For example, if there are two DL transmissions in a slot occupying different BW, then  would need to be calculated separately for each DL transmission and weighted separately based on number of symbols occupied for calculating overall scaled energy consumption in the slot. Such as  ,where holds |
| Samsung | Please see our comments for the details in Q2.4.3-3. |
| Apple | We think it is possible, like what Intel described. |
| ZTE, Sanechips | Slot-level scaling is enough to reflect different BW (or RB utilization) / time-occupancy / tx-rx direction of different symbols in a slot.  In the discussion of the slot level modeling, the power consumption of a slot can be calculated based on the proportion of DL symbols, UL symbols and unoccupied symbols in the slot, as it is provided by Intel. Each field is scaled for only occupied symbols. Therefore, for the slot-level scaling , different BW (or RB utilization) / time-occupancy / tx-rx direction of different symbols in a slot has been already considered. |
| LG Electronics | Yes, and we think Intel has explained that it is possible with a good example. What’s important is that we should have a common scaling method for consistent observations in the evaluation |
| Nokia/Nsb | Yes |
| DOCOMO | We think it is possible and what Intel explains is a good example. |
| InterDigital | Yes |
| Huawei, HiSilicon | Intel gives a good example. |
| Fujitsu | Yes, as described by Intel and ZTE, slot-level scaling is capable of reflecting different BW (or RB utilization) / time-occupancy / tx-rx direction of different symbols in a slot. |
| Ericsson4 | With current proposal for slot-level scaling, this part is unclear. Intel gives one example which we agree with, but then it should also work for other cases including the example pointed out by Qualcomm. |
| CATT | If no change in RF BW and FFT size, The gNB power consumption would barely change when different numbers of PRBs are transmitted. This has been studied and concluded in Rel-10 Network Energy Saving study. Thus, we don’t see the benefit of having scaling model for different number s of PRB transmission. |

**FL4 Question 2.4.3-3: Is any additional handling required on previously agreed power values/additional transition energy for any/both of symbol-level scaling and slot-level scaling? E.g., the power value needs to be divided by 14? Note the energy value is agreed as unit in relative power\*(duration in ms)).**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QCOM4 | Regarding the note: No, the unit of the energy value is for the duration of the transition latency. It does not mean that the power is measured in ms or slot or symbol at this stage. The agreed energy number was agreed as compromise for progress – It did not mean the number follows any equation.  Without clarification, companies may have different modelling approaches; leading to different energy consumption computation. Please see our reply in Question 2.4.3-1. |
| Intel | We do not think any additional handling is needed. Our understanding is that the relative power values based on following agreement is at the slot level. Per symbol level power can be obtained by scaling based on the slot-level power model.  Agreement  For evaluation purpose, the BS energy consumption model should at least include the power consumption of BS on slot-level. |
| Samsung | From our point of view, as the calculation mechanism for transition energy, e.g. relative power \* transition time[ms], we are assuming relative power is also per 1ms. Under the assumption, if we evaluate set1 with SCS = 30kHz, we think half of relative power are considered per slot. In the slot level, to consider the symbol level scaling as case mentioned by QC, total power consumption per slot would be calculated, like (2/14)\*half of (Pstatic+Pdynamic,1)+ (6/14)\*half of (Pstatic+Pdynamic,2)+ (6/14)\*half of (Pstatic+Pdynamic,3) for DL slot. In the BS perspective, we don’t need to consider each of power consumption of channels and signals which are FDMed, but the total activated TxRUs and thecombined BW and PSD should be taken into account for the scaling. For S slot and U slot, we are considering same mechanism to calculate the total power consumption. Lastly, we can calculate the total energy consumption over duration except for transition per slot level. Based on the above mechanism, we can reflect the whole time/frequency domain for evaluation purpose. |
| Apple | Given how the transition energy was defined (approximately), our assumption is that P\_i is the energy consumption over one ms. We need to be consistent in the calculation. |
| ZTE, Sanechips | The additional transition energy of the sleep states is approximated by the formula in time units of ms. Therefore, the currently defined power states value does not match the additional transition energy if the symbol level power consumption model is used. There are two solutions to solve this problem. Solution 1: define new additional transition energy for symbol-level NW power consumption model. For example, the additional transition energy of symbol level is 14 times that of slot level.  Solution 2: the same additional transition energy is used, but the power state value needs to be divided by 14.  But for slot level power consumption model, no additional handling is needed. |
| LG Electronics | No additional handling is needed. We think it is only necessary to clearly specify that the agreed relative power values are slot-level. |
| Nokia/Nsb | No need for additional handling, we agreed on the slot-level modeling, we think it is sufficient. |
| DOCOMO | We share the same understanding as Intel. |
| Huawei, HiSilicon | No need to change previously agreed power values/additional transition energy. |
| Fujitsu | Additional handling is not required. |
| Ericsson4 | Energy calculation needs to be consistent so that like things are added up properly. |
| CATT | No need of having power consumption of additional handling |

### 5th round

If agreeable, the following can be considered. Note that instead of slot-level, ms-level is used which matches a slot in case of 15kHz SCS. For symbol level scaling or other SCS, unit and value translation needs to be done by proponents’ in the evaluations.

FL consider it may be beneficial to have a baseline modeling approach as QC suggested. However, the benefits to use symbol level modeling is also demonstrated as discussed above. In case that symbol level modeling is performed, likely something needs to be done for energy consumption as mentioned by ZTE, which can be reported/confirmed by the reporting company.

**FL5 Proposal 2.4.4:**

* **The agreed relative power values in power model table are at ms-level.**
* **Use slot-level modelling as baseline. Optionally use symbol-level modelling as an explicit modelling approach.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QCOM5 | We provide our suggestion for time domain scaling in Section 2.5.3. If such suggestion is agreed, there is no need to discuss 2nd bullet of this proposal.   * **~~Use slot-level modelling as baseline. Optionally use symbol-level modelling as an explicit modelling approach.~~**   For the 1st bullet, we don’t think the ms-level unit makes sense since we model the power based on the reference configuration sets. Each set has different slot duration. Furthermore, the relative power is unit-less. For the progress, we suggest updating the first bullet as   * **The power consumption for reference configurations is provided per slot level** |
| LG Electronics | This proposal is a little confusing. The ms-level and slot-level are different at least for reference configuration set 3 since there is no 15kHz SCS in FR2. Therefore, just delete the first bullet and agree only on the second bullet or it should be updated as Qualcomm's suggestion. |
| Intel | We think the proposals in two bullets are not consistent. If we are using slot-level modeling, it is a much cleaner approach to assume relative power values in the table are expressed for per slot. Note that in principle we are adapting relative power based model developed in TR 38.840 for NWES EVM (according to SID), and in TR 38.840 relative power values are expressed per slot. It would also simplify time domain scaling approach. Moreover, as Qualcomm mentioned, model is based on reference configuration which is function of SCS. We suggest following version. We do not think second bullet is needed.  **The agreed relative power values in power model table are expressed at slot-level** |
| ZTE, Sanechips | For the first bullet, we have the same consideration with QCOM that the relative power values in power model table should be at slot-level considering the power values are defined corresponding to the reference configuration sets. |
| DOCOMO | We share similar concern on the proposals with other companies. The ms-level concept does not make sense as the reference configuration sets have different SCS, especially due to Set 3 for FR2. We are fine with the updated version from Intel and to remove the second bullet. |
| vivo | We also think current proposal is confusing. We are OK with Intel’s proposal  **The agreed relative power values in power model table are expressed at slot-level** |
| Samsung | We are fine with FL’s proposal, and also fine with Intel’s proposal |
| China Telecom | We can live with the current proposal, and the Intel’s proposal looks better for us. |
| Nokia/Nsb | We support the FL’s proposal. |
| Fujitsu | Both FL’s proposal and Intel’s updated version are fine to us, and Intel’s version looks better from the perspective of consistency. |
| Huawei, HiSilicon | We support the FL’s proposal. |
| MediaTek | The difference between slot-level model and symbol-level model, from our view, is to average the power consumption over BS operation in a slot or in a symbol. In this regard, we would like to suggest the following revision to Intel proposal:  **The agreed relative power values in power model table are based on BS operations in a slot** |
| Ericsson5 | We are OK with the first bullet. We don’t see need for 2nd bullet.  If slot-level is to be used as reference, we think it would result in revision/translation of transition energy values when the reference slot is taken as 0.5ms. |

### 6th round

Since the power value is unit-less, it only has meaning when multiplied with a time duration. Therefore, referring to the agreements of below, can companies confirm there is no additional adjustment needed, or e.g. the value needs to be doubled in case of evaluations with 30kHz slots?

**Agreement**

For set 1/2/3, the additional energy (unit in relative power\*(duration in ms)) is

|  |  |  |
| --- | --- | --- |
| **Power state** | **Additional transition energy** | |
| Category 1 | Category 2 |
| Deep sleep | ~~1350~~ 1000 | ~~22500~~ 17000 |
| Light sleep | 90 | 1088 |

**FL6 Proposal 2.4.5:**

* **The agreed relative power values in power model table are expressed at slot-level.**
  + **No additional handling needed for the agreed additional transition energy per reference configuration.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | We are OK with the proposal. However, this is not the critical aspect to be agreed. |
| DOCOMO | We are fine with the proposal. |
| FL6 | The following can also be considered  **FL6 Proposal 2.4.5-rev:**   * **The agreed relative power values in power model table are expressed at slot-level.**   + **Alt 1: No additional handling needed for the agreed additional transition energy per reference configuration.**   + **Alt 2: The additional transition energy needs to be scaled per the numerology of reference configuration in terms of slot vs. millisecond.** |
| Intel | We think the first bullet is sufficient   * **The agreed relative power values in power model table are expressed at slot-level.** |

### 7th round

Given the discussion over GTW, it might be worth of re-consideration to clarify the calculation based on both of the below. For companies who does not prefer the second bullet, could you please also clarify where the formula is not accurate given the first bullet.

**FL7 Proposal 2.4.6:**

* **The agreed relative power values in power model table are expressed at msec-level.**
* **Clarify and capture the below formula into TR as calculation of total energy consumption.**
  + Where includes the energy consumption of each power state and additional transition energy , and and are relative power value and time duration in unit of slot for power state *i*, and are transition energy and the number of transitions for sleep mode *j* and is the numerology.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia/Nsb | As already agreed, the BS power modeling framework is based on the slot-level modeling, and we should stick to it as agreed. Moreover, the power value is unit-less, but when multiplied by a time duration expressed in msec, we need to convert it to msec per the numerology of reference configuration.  This implies the following changes/updates:   * **In FL7 Proposal 2.4.6: The agreed relative power values in power model table are expressed at slot-level.** * **The proposed formula shall be updated as follows:**   where the relative power value and time duration are expressed in unit of slot (no need to convert to ms)   * By considering of different numerology, the early agreed additional energy (unit in relative power\*(duration in ms) needs to be scaled per the numerology of reference configuration in terms of slot vs. millisecond, i.e. with (unit in relative power\*\*(duration in ms))   For instance, for Set 1 (30 Khz SCS) where we convert the relative power (unit per slot) multiplied by (to obtain a unit per ms).  **Additional Transition Energy values for SCS=30kHz.**   |  |  |  | | --- | --- | --- | | **Power state** | **Additional transition energy** | | | Category 1 | Category 2 | | Deep sleep | 500 | 8500 | | Light sleep | 45 | 544 | |
| ZTE, Sanechips | We share similar views with Nokia that slot-level power consumption model is preferred. The reasons are as below:   1. If the power consumption model is per-millisecond, before the calculation of NW energy for **ALL** the baselines and enhanced schemes, the power values should be scaling to slot-level to align with the operation granularity in SLS. 2. For the agreed scaling rule, the P\_static, and P\_dyn are derived from P3 and P4. If the power model is per millisecond, it may need to clarify whether the scaling for different domains can be directly applied to the slot-level operations/assumption in SLS. 3. For the formula in the second bullet, only 5 power states are assumed, including three sleep states, two full active states. However, the active states that derived based on scaling rule is not accounted. 4. We also think the power consumption model should be per slot based on the discussion about the transition energy. For the determination of transition energy, even it it not strictly observed, we think one of the considered rules is that it should be more energy efficient for gNB to enter into a deeper sleep if a time period is larger than the transition time.   With a per-slot power model, the only exception case is the set 2 with cat 2. However, with the assumption of per-millisecond power model, all the sets with cat 2 power model break the above principle. In this case, we are wondering whether the transition energy is consistent with per-ms cat 2 power model.  Table A   |  | | --- | | Per slot power consumption model: total energy of the sleep mode for set 2 with cat 2 | | Light sleep for 10s = 2\*10000 + 1088 = 21088  Deep sleep for 10s = 1\*10000+17000 = 27000  NOTE: entering into the light sleep is more energy efficient than entering into deep sleep |   Table B   |  | | --- | | Per-ms power consumption model :total energy of the sleep mode for set 1 with cat 2 | | Light sleep for 10s = 2.1\*10000 + 1088= 22088  Deep sleep for 10s = 1\*10000+17000 = 27000  NOTE: entering into the light sleep is more energy efficient than entering into deep sleep | |  | | Per-ms power consumption model :total energy of the sleep mode for set 2 with cat 2 | | Light sleep for 10s = 2\*10000 + 1088 = 21088  Deep sleep for 10s = 1\*10000+17000 = 27000  NOTE: entering into the light sleep is more energy efficient than entering into deep sleep | |  | | Per-ms power consumption model :total energy of the sleep mode for set 2 with cat 2 | | Micro sleep for 640ms = 3\*640= 1920  Light sleep for 640ms = 1.8\*640 + 1088 = 2240 | | Light sleep for 10s = 1.8\*10000 + 1088 = 19088  Deep sleep for 10s = 1\*10000+17000 = 27000  NOTE: entering into the light sleep is more energy efficient than entering into deep sleep |  1. Thanks Nokia for the proposed solution for the adjustment. Based on our calculation, if the transition energy is divided by 2^u. The issue in Table A still exits. Moreover, another issue is that for set 3 cat 1 power model, the 6ms-light sleep is more energy consuming than 50ms-deep sleep.It seems more consistent with our understanding, either.  |  | | --- | | Set 3 cat 1 | | Micro sleep for 6ms = 38\*6\*8 = 1824  Light sleep for 6ms = 20\*6\*8 + 90/8 = 971.25 | | Light sleep for 50ms = 20\*50\*8+90/8 = 8090  Deep sleep for 50ms = 1\*50\*8+1000/8 =525 |   To this end, due to the compromised transition energy and power value, we think it is safer and simpler to conclude the power model is per slot, and the transition energy doesn’t need to be updated either. |
| Spreadtrum | In our understanding, we initially follow the principle of UE power saving to define the relative power with unit of slot. Also, we follow the principle of UE power saving to define the additional transition energy with unit of millisecond. It seems we can use the different unit in UE power saving. I think we can still use these two different units in NES too. The equation of total energy consumption may not be necessary. In UE power saving, we don’t have such equation, but we can evaluate the power saving gain without any ambiguity. |
| QCOM7 | **On msec-level vs. slot-level power**, we think slot-level is more reasonable. We fully agree with comments from ZTE. It seems companies supporting msec-level power provide argument based on the unit of the additional transition energy (i.e., relative power \* duration in msec). From our understanding, this unit is to indicate the energy consumed in “duration in msec” which is the transition latency. For example, for deep sleep Cat 1, the additional transition energy is 1000 over 50ms (transition latency). Furthermore, the transition latency is absolute number which was agreed to be identical across different configuration sets which have different numerologies. Hence, scaling the additional transition energy is not needed.  **On the formula**, similar to discussion on computing the power in slot earlier, the current formula does not cover all cases. For example, during a duration Di, scaling of power in different domains may be needed. In general, we don’t need to agree on a formula for overall energy computation. |
| Apple | On the proposal to assume the power values are per slot and no adjustment on the additional transition energy for any SCS, we have strong concern. For example, if we just compare 15kHz and 30kHz in FR1, it is reasonable to assume the additional transition energy is the same in terms of absolute number. However, if the reference value of 1 refers to the power consumption in a slot, because the slot duration of 15kHz is double of the slot duration of 30kHz, it means the absolute power of the reference value 1 for 15kHz is roughly 2x that for 30kHz. Then if we keep the transition energy numbers unchanged, it implies that the absolute transition energy for 15kHz is 2x that for 30kHz. This does not sound reasonable to us.  Two approaches have been put on the table: (1) FL’s proposal here; (2) the power values are assumed per slot, and the transition energy is scaled according to SCS. To us, there is no difference between the two mathematically at all, so we are fine either way. For FL’s proposal, the only thing that needs to be done is to create a slot-level table by converting the agreed table according to the numerology. It seems that there is difference understanding on how the transition energy was derived, whether it assumed the power numbers are per ms or per 30kHz slot (0.5 ms). This seems to be one of the reasons that created diverging views, which needs to be aligned somehow to resolve the issue here. We had assumed the power numbers were considered to be per ms when deriving transition energy. |
| Samsung | We share same views as Nokia and ZTE, we support Nokia’s proposal. |
| Intel | We also agree to assume to relative power values are expressed in slot level, which is a unit that is amenable for use in scaling method and also it can be directly applied in SLS evaluation.  Regarding calculation of overall energy, we do not agree to scale additional transition energy based on SCS. The value is provided over an absolute duration in ms and this applies regardless of numerology. The unit is expressed as relative power \* ms. Note that we did not assume any specific value of relative power and we directly agree upon a consumed additional transition energy associated with light or deep sleep transition. In our view, to be consistent, relative power unit here is Joule/ms so that a duration in ms can be multiplied and the product what we call additional energy is expressed in Joule (unit of energy). On the other hand, for energy consumption of active state, relative power values are expressed in slot (i.e., unit is Joule/slot), and they are multiplied by slots which is consistent. The unit of product is Joule. So we do not see any inconsistency even if different units for relative power is assumed in calculating energy consumption of active state and additional energy consumption. Agree with Spreadtrum on this one.  We agree with Qualcomm that the proposed formula only assumes there are 5 states but in practice, there can be lot of different relative power values exist at the slot, such as due to scaling. The formula is not general enough. As mentioned multiple times, there is no need to agree on the formula |
| Samsung2 | For the further clarification, we have same views as Nokia and ZTE about the agreed relative power with slot level. So, we support the Nokia’s updates in the first bullet and formula.  In terms of additional transition energy, we don’t think it is necessary the additional updates. The additional transition energy had already agreed with (relative power \* duration in msec). So, we would like to keep the agreed additional transition energy values in the agreement. |
| DOCOMO | For slot-level vs. msec-level, we share the same view as Nokia/ZTE/Intel.  Regarding the additional transition energy, we agree with Intel that scaling with numerology is not needed. The values of the additional transition energy are absolute values in msec and it was agreed that same values are applied to all the set. In our understanding, it means the same values are applied regardless of numerology in reference configuration set. |
| CMCC | We also prefer to assume slot-level power consumption model.  For transition energy consumption, it is calculated based on the msce-level transition time, it is an absolute value, which is independent of SCS. |
| MediaTek | * Power value represents a “density”, and, for BS TX, we can relate it to PSD. For the two case of different numerologies, **the following energy consumption outcomes will be the same since the transmission times are the time**, and the is the reason the numerology scaling will be needed.   + 15 kHz SCS: Energy consumption of active DL over 1 slot or 1 ms =   + 30 kHz SCS: Energy consumption of active DL over 2 slot or 1 ms = * With the numerology scaling included, which ensures the same energy consumption unit as that additional transition energy, i.e., , we think current formula can be used directly:   + Note: For accumulating the additional transition energy for sleeps, we just count the number of a targeted sleep time, i.e., . There is no need to multiply the sleep duration. * While Nokia proposal is technically correct, we prefer to keep the same definition on additional transition energy and leave the numerology conversion included for accumulating active power. In this way, we don’t need to additional agree scaled tables.      * The power values are analysed and defined from BS operations in slot level. With the numerology conversion included, there should be no confusion in calculating the total energy consumption. But, to clarify, the following revision is suggested * **The agreed relative power values in power model table are expressed at slot-level.** * **Clarify and capture the below formula into TR as calculation of total energy consumption with unit of (relative power unit ms).** |

## Scaling details

Two alternatives (Alt 1 or its variation, and Alt 3 or its variation) were extensively discussed in the post meeting email discussion of RAN1#110 in R1-2208312.

*Conclusion*

*Companies are encouraged to check discussion in section 2.2.2 of* [*R1-2208312*](file:///D:\Users\erdem.bala\Downloads\Docs\R1-2208312.zip) *for scaling discussion in the next meeting.*

According the contributions submitted in this meeting:

**Based on (revised) Alt 1,**

* Huawei/HiSilicon considers the power of static part shall equal to the power of micro sleep mode, i.e. given no scaling applied for the static part and it is no active transmission (same definition as micro sleep) when the dynamic part power is zero. It also considers that the PA efficiency can be non-linearly modelled if needed, with formula provided in this case.
* Nokia/NSB considers the power of static part shall not equal to the power of BS in Micro sleep mode as Tx may still be scalable in BS micro sleep, and there is a BW factor applied to the dynamic part of active DL power (which can be assumed to be 1 for evaluations). Also, the dynamic Tx antenna element adaptations may require a further delay/interruption which may needs to be considered when performing scaling or calculating the energy consumption.
* Spreadtrum wants to discuss the profile of each part of e.g. Alt 1 on .e.g., whether the static part power include the transmission for common signal and consider it could be beneficial if the power consumption of micro sleep is lower than that of the static part.
* vivo, MediaTek, NTT DOCOMO consider and other dynamic parts for DL should meet the constraint that the sum of all components equals (similar constraints applies to UL).
* China Telecom considers both Alt 1 and Alt 3 has similar structure and need to consider some constraints similar to vivo.
* As a second preference, CATT could also consider this approach with consideration that 1) the power of static part should include additionally power consumed by cross-symbol processing, network control function, and data processing, in addition to the power of BS in micro sleep, 2) PA can be 1 or 0.34 and 3) value s\_f should be defined as the ratio of RF BW and maximum system BW.
* Fujitsu shares that in Alt 1 the Pstatic can be set as a same or close value with the relative power of micro sleep, which is also useful considering the gap of P3 and P4 is similar between two categories and the results can be more aligned.
* Intel proposes an unified scaling including both UL and DL split by time domain symbols, and considers and PA efficiency can be 1 by default.
* ZTE consider Pstatic can be the power of BS in micro sleep, and that the same scaling factors applies between Cat 1 and Cat 2.
* CMCC consider Pstatic can be the power of BS in micro sleep.
* MediaTek consider the PA efficiency can be set as 0.5 from RAN1 evaluation perspective and LS to RAN4 for providing suggested power consumption scaling for PA-related transceiver processing enhancements.
* Samsung consider Pstatic can be the power of BS in micro sleep, PA efficiency of 0.34 as a reasonable/practical value, and provides candidate values for scaling factors of each domain.
* Ericsson (2nd) considers adjustment is needed in order to better reflect the antenna scaling w.r.t. network load for the interest of this study. In time domain, since symbol level is proposed the total energy consumption is the summation of powers of symbols in a slot, so as to reflect the effects of different BW per symbol, etc.

**Based on (revised) Alt 3,**

* Vivo, NTT DOCOMO consider it can be optionally reported.
* China Telecom consider that there is conflicts in the current Alt 3 formula and modification is needed to satisfy the constraint P3<0.03\*P4.
* OPPO supports this approach and consider the power of static part equals P3.
* LGE and Rakuten consider this approach is easier/simpler and accurate enough from discussion point of view compared to Alt 1.
* Qualcomm consider this is applied in DL, and the static power is P3 and the total power is P4. With that the dynamic part power (P4-P3) is further scaled jointly (or separately when scaling factor for some domain=1). A ratio between a reference PA efficiency and actual PA efficiency is defined and used.

**Other Alternatives, e.g. Alt 2 where power scaling in time, frequency, spatial, and power domain are defined based on the framework of the power model defined for UE power consumption in TR38.840**

* Supported by CATT(1st), Ericsson(1st), Qualcomm (for UL)

The following summarizes the scaling approaches and relative power values submitted from contributions.

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| Huawei/HiSilicon | *Proposal 5:* *For active DL with revised Alt1-update, and are recommended to set as 7.3 and 9.6 respectively, while or a fixed value.*  *Proposal 6: For active UL, the BS power consumption can be provided as , where and is recommended as 1.*  *Proposal 7: For Set 2 and Set 3 reference configuration, the same scaling formula as Alt 1 is reused and*  *where is the respective relative power value of BS micro-sleep. Other parameters are recommended as below:*   * *For Set 2, ,,* * *For Set 3, ,,* * *can be either non-linearly modelled or a fixed value, for simplicity.* |
| Nokia/NSB | and assuming the following parameters:   * fixed feeder loss=0,8 dB * fixed PA efficiency factor =35%   Table 3: DL power scaling coefficients with Set 1 and Set 2 for Cat.2   |  |  |  | | --- | --- | --- | | Parameters | Set 1 FR1 | Set 2 FR1 | |  |  |  | |  |  |  | |  |  |  |   Table 4: UL power scaling coefficients with Set 1 and Set 2   |  |  |  | | --- | --- | --- | | Parameters | Set 1 FR1 | Set 2 FR1 | |  |  |  | |  |  |  |   In time domain,  +  For CA,  where >1  For multi-TRP, |
| vivo | *Proposal 6: Value of in the Revised Alt 1-update is the same as power value of Micro sleep power state.*  *Proposal 7: Value of*  and  *in the Revised Alt 1-update should meet the condition that the sum of and* *is the same as power value of Active DL power state.*  *Proposal 8: Support the following scaling method for BS UL reception*   * + - = power *value of Micro sleep power state (i.e. P3)*     - =*power value of Active UL power state (i.e. P5) - power value of Micro sleep power state (i.e. P3)*   *Proposal 9: For time domain scaling, the following formula is used when slot level model is provided:* (1-alpha-beta)\*P3 + alpha\*P4+beta\*P5 |
| China Telecom | |  |  |  |  | | --- | --- | --- | --- | |  |  |  |  | | Category 1 | 55 | 100 | 180 | | Category 2 | 5.5 | 10 | 22 | |
| OPPO | Proposal 5: When a slot-level model is used, the BS power consumption over a slot can be scaled by , where is the ratio of the number of active DL symbols within a slot. |
| CATT | * + - : a static part of which the power is not scaled based on reference configurations. Value is to be determined based on       * Category 1: [140]       * Category 2: [16]     - : a dynamic part of the power that is scaled based on reference configurations based on , where       * + is   Category 1: [110]  Category 2: [12]   * + - * + is   Category 1: [30]  Category 2: [4]   * + - * + is the PA efficiency   For initial evaluations, ,  The and should be reported along with , which may not be perfectly the candidate values in the current list  FFS whether/how to use a non-linear function to represent.   * + - * + , , is the percentage of active TxRUs, the radio of RF bandwidth and maximum system BW in frequency domain and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively. |
| Intel | ,  where,   * = P3, a static part for which the power does not scale based on the reference configurations. P3 refers to Micro-sleep state power value.   + should be 55 and 5.5 for Category 1 and Category 2 models, respectively. * and represents the ratios of the number of active DL and UL symbols within a slot to the number of symbols within a slot, respectively. * , where   + , , refer to the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively.   + is the PA efficiency, for which default value is 1. Other values < 1 can be optionally evaluated   + refers to component of dynamic power that is scaled based on number of active set of antennas only     - We suggest value of 110 for this part for Category 1   + refers to component of dynamic power that is scaled based on both number of active set of antennas and amount of occupied BW     - We suggest value of 115 value for this part for Category 1 * , where P5 refers to active UL state relative power for the reference configuration. |
| ZTE | * : * Category 1: [55] * Category 2: [5.5]  * : * Category 1: [103] * Category 2: [12.5]  * : * Category 1: [61] * Category 2: [7] * as the PA efficiency: * =0.5   Proposal 10: The time domain scaling is (1-alpha)\*P3 + alpha\*P4 where alpha represents the ratio of the number of active DL symbols within a slot to the number of symbols within a slot  Proposal 11: In frequency domain, for at least inter-band CA, the total power consumption of BS is calculated as the sum of the power consumption of each cell. |
| LGE | Proposal #3: For the time domain scaling, the formula α\*P4+(1-α)\*P3 can be used, wherein P4 is the power for active DL, P3 is the power of micro-sleep, α is the ratio of active DL symbols within a slot.  Proposal #4: For the frequency domain scaling, the power consumption can be calculated as the sum of the power consumption of each cell for inter-band CA while a proper scaling factor for dynamic power can be considered for the intra-band CA. |
| MediaTek | DL   * is chosen so that Active DL power when = 1 while = 0   + Accordingly, the following values are utilized for different BS categories and Set 1/2/3  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Value of | | | | | | | Category 1 BS | | | Category 2 BS | | | | Set 1 | Set 2 | Set 3 | Set 1 | Set 2 | Set 3 | | 57 | 46 | 22.8 | 7.3 | 11 | 0.36 |  * is chosen so that Active DL power when   + Accordingly, the following values are utilized for different BS categories and Set 1/2/3  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Value of | | | | | | | Category 1 BS | | | Category 2 BS | | | | Set 1 | Set 2 | Set 3 | Set 1 | Set 2 | Set 3 | | 84 | 72 | 45.6 | 9.6 | 12 | 2.52 |   UL   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Value of | | | | | | | Category 1 BS | | | Category 2 BS | | | | Set 1 | Set 2 | Set 3 | Set 1 | Set 2 | Set 3 | | 55 | 40 | 42 | 1 | 0.8 | 1.2 |   Time domain |
| Samsung | * the BS power consumption for active DL is provided by   + - : a static part of which the power is not scaled based on reference configurations. Value is to be determined based on       * Category 1: 55       * Category 2: 5.5     - : a dynamic part of the power that is scaled based on reference configurations based on , where       * + is   Category 1: 15  Category 2: 1.5   * + - * + is   Category 1: 71  Category 2: 8.5   * + - * + is the PA efficiency   For initial evaluations, 0.34   * + - * + , , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively.         + The percentage of active TRxRUs : {1 for 64 TRxRUs, 0.67 for 32 TRxRUs, 0.67^2 for 16 TRxRUs, 0.67^3 for 8 TRxRUs}         + The ratio of RF bandwidth : 0.35+0.65\* Xf /100MHz, Xf [MHz] = {10, 20, 40, 50, 80, 100}         + The ratio of PSD per TxRU between the DL transmission and reference configuration : 0.67^(Xp /3[dB]), Xp = {0, 3[dB], 6[dB]} * the BS power consumption for active UL is provided by   + - : a static part of which the power is not scaled based on reference configurations. Value is to be determined based on       * Category 1: 55       * Category 2: 5.5     - : a dynamic part of the power that is scaled based on reference configurations based on       * Category 1: [FFS]       * Category 2: 1         + The percentage of active TRxRUs : {1 for 64 TRxRUs, 0.67 for 32 TRxRUs, 0.67^2 for 16 TRxRUs, 0.67^3 for 8 TRxRUs} |
| Ericsson | For Set 1, downlink Cat 1, downlink active power P = P4 \* ( [0.4] + [0.6] \* sf\*sp) \* ([0.4] + [0.6]\*sa), where , , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively  [Alternate proposal to Proposal 5 ] For Set 1, downlink Cat 1, downlink active power with the dynamic power defined as ,   * 1. *, , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively.*   2. *is the PA efficiency*   Antenna adaptation delay is explicitly modeled with a transition time of [1-3] ms.  For Set 1, uplink Cat 1, uplink active power P = P5 \* ( [0.8] + [0.2] \* sf) \* ([0.4] + [0.6]\*sa), where , , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW, respectively |
| NTT DOCOMO | * + In CA case     - For intra-band CA, a scaling factor is applied to considering RF is shared among CCs.     - For inter-band CA, the power consumption is the sum of the power consumption of each cell considering different RFs are used among CCs. |
| Qualcomm | DL   * *and are relative power values of micro sleep and active DL transmission based on reference configuration, respectively* * *is the ratio between the actual number of TxRUs and the reference number of TxRUs for DL transmission* * *is the ratio between the actual number of frequency resources and the reference number of frequency resources for DL transmission* * *is the ratio between PSD of the actual DL transmission and PSD of the reference DL transmission.* * *is the ratio between a reference PA efficiency and actual PA efficiency*   + - *when = 1*     - *α and are provided in the below table*  |  |  |  | | --- | --- | --- | | *Parameters* | *FR1* | *FR2* | |  | *[31%]* | *[8%]* | |  | *[0.86]* | *[0.24]* | |  | *[0.025]* | *[0.01]* |   UL  *Power consumption of an active UL reception is adapted in spatial and frequency domain as*   * *is the power consumption of the active UL reception based on the reference configuration.* * *is the ratio between the actual number of RxRUs and the reference number of RxRUs for UL reception* * *is the ratio between the actual number of frequency resources and the reference number of frequency resources for UL reception.*   *For CA, the total power consumption is the sum of the power consumption of configured cells*   * + *For intra-band CA with contiguous CCs, the power consumption of the Scell is scaled by [0.75].*   *For multi-TRP, the total power consumption is the sum of the power consumption of configured active TRPs.* |

### Initial round

Based on the above, general support of Alt 1 can be observed while there is slightly increased support for Alt 3 compared to last meeting. Majority including the proponents of Alt 3 consider a static part shares the power as BS in micro sleep. This could be a baseline for evaluations while we allow for other values for the interest of study. Regarding the component values of , it is observed that companies of Cat 2 have proposals for Cat 1 while companies of Cat 1 mainly propose a different/modified scaling (modified Alt 1 or Alt 3). Therefore, FL does not pick up the values proposed by Cat 2 companies for Cat 1 while only take one value directly from a Cat 1 company. It might be beneficial to allow for different values in small, medium or larger level respectively to further account for different implementations and various PA efficiency, therefore multiple candidate values remain without down-selection at this stage. Particularly, one or an averaged one is taken for each PA efficiency to reduce the workload. DL and UL can be unified based on majority preference, and also due to the fact that UL does not contribute to a significant part of power consumption at least for the study of this release.

|  |  |
| --- | --- |
| **FL1/FL2 Proposal 2.4.1:**   * **The BS power consumption in a slot is provided by**   + - For slot-level modelling, represents the ratios of the number of active DL and UL symbols within a slot to the number of symbols within a slot and ; for symbol-level modelling, represents the number of active DL and UL symbols within a slot and .     - : a static part of power for BS in active, which is not scaled based on reference configurations.       * Baseline:       * Other values can be optionally reported     - : a dynamic part of power for BS in active, which is scaled based on reference configuration.       * Baseline: , where , , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively, and         + is the PA efficiency. For evaluation purpose, .         + : [1.5] for , [9.9] for , [110] for         + : [8.5] for , [8.3] for , [115] for       * Other values can be optionally reported, satisfying when , ,.       * Optional for other approaches, e.g. **,** or where  is the ratio between a reference PA efficiency and actual PA efficiency, up to company report       * Baseline:       * Other values can be optionally reported, satisfying when .   + For multi-carrier: for inter-band multi-CC, the total power consumption of BS is calculated as the sum of the power consumption of each CC; for intra-band with contiguous CCs, the power consumption of each additional CC is scaled by [0.75].   + For multi-TRP with separate RF chains, the total power consumption of BS is assumed as the sum of the power consumption of each TRP   + Antenna adaptation delay is explicitly modelled with a transition time of [1-3] ms, if not fall into micro-sleep.   + Other scaling, e.g. cell-load dependent scaling can also be reported. * Send LS to RAN4 about the above, and ask for feedback, with details of proposed in Alt 3 also captured in the LS. | |
| **Company** | **Comments** |
| Huawei, HiSilicon | We are in general fine with the framework and proposal, with the following detailed comments:   1. For the PA efficiency of , we are wondering this is realistic value and can be achievable. Therefore, we propose not to assume in the evaluation. We are fine to keep 0.34 and 1 as typical PA efficiency values; 2. Antenna adaptation delay may or may not zero depends on whether fall into micro sleep. Therefore,    * Antenna adaptation delay is zero if the transition-to state if micro-sleep state. Antenna adaptation delay can be reported ~~is explicitly modelled~~ with a transition time of [1-3] ms, if not fall into micro-sleep. 3. For intra-band CC, we think the value of 0.65 would be more accurate.    1. For multi-carrier: for inter-band multi-CC, the total power consumption of BS is calculated as the sum of the power consumption of each CC; for intra-band with contiguous CCs, the power consumption of each additional CC is scaled by [0.~~7~~65]. |
| LG Electronics | We are generally fine with the proposal but we would like to clarify the follows.   * + Why is the baseline in ?   + Whether the scaling for the power consumption of each additional CC is applied only to the dynamic part for the intra-band CA case   + Which formula Alt 3 in the last bullet refers to?   In addition, if is up to company report, isn't there no need to send LS to RAN4? |
| DOCOMO | We are basically fine with the proposal. For PA efficiency, we share similar view with HW that may not be realistic value. |
| Nokia/Nsb | Regarding “P\_static”, we propose to use “P\_static = P3 - A”, where the factor A depends on the reference configuration, and companies may report different values, i.e. A=0 or other values.  Regarding “multi-carrier”, we propose to have the following to be captured:  For inter-band CA, separate RFs are used, so the total power consumption of BS is calculated as the sum of the P\_dynamic of each CC. The P\_static should be accounted once.   * + For intra-band CA, the scaling factor of 0,75 is to be applied on the P\_dynamic (by considering that some RF components are shared), and P\_static factor is accounted once.   Regarding “multi-TRP”, we could like to clarify that, the P\_static is assumed common for all TRPs.  Regarding “Antenna Adaptation Delay”,   * + Antenna adaptation delay is explicitly modelled with a transition time of [1-3] ms~~, if not fall into micro-sleep~~. E.g. if there is the antenna adaptation applied in the active state, or if there is transition to micro-sleep with antenna configuration change, it shall include an Additional Antenna Adaptation delay of (1-3) ms.   + Moreover, we may need to discuss whether there is the BS Tx/Rx interruption during such antenna adaptation delay? And what could be the transition energy when BS turns on and off the spatial elements.   Apart from the adaptation delay in spatial domain, the adaptation delay in other domain, i.e. frequency adaptation delay, should also be discussed. |
| Spreadtrum | Generally fine. Some comments:   1. We still like static part is higher than P3, otherwise, we do not understand the so-called symbol-level sleep has additional gain, since gNB does not transmission is equal to micro sleep. Is there any possibility that an advanced gNB can enter a more power efficient state than static part for duration of several symbols? 2. Joint equation for DL/UL may not meaningful |
| vivo | We are generally fine with the direction of the proposal and with the following comments:   1. It seems the static power part is missing for DL and UL symbols, the equation should be   ) that can be simplified as  )   1. For value of PA efficiency , if it is a fixed value, there is no need to have multiple values since it is anyway a scaling value over **.** We suggest to adopt =0.5. Meanwhile, and should be determined for Cat 1 and Cat 2 value respectively. Here is our proposal:   Cat 1 (=0.5): =110, =57.5  Cat 2 (=0.5): =9.9, =8.3  For , the baseline should be =55 for Cat 1 and =1 for Cat 2 |
| ZTE, Sanechips | We are okay with the principle of proposal. The comments are   1. We also think =1 is too idealist. The value of 0.34, 0.5 is closer to implementation.   For the calculation of , the value of , and should be defined for cat1 and cat 2 respectively, because of the different power values for the active states.  In addition, considering that the resultant scaling factors for DL power consumption calculated by Category 1 and Category 2 should be similar in different domain adaptation.Therefore, the proposal can be modified as follows.   * + - * + is the PA efficiency. For evaluation purpose, (if considered):   for cat 1: [75] for , [80 ~~9.9~~] for , [110] for  for cat 2: [11.5 ~~1.5~~] for , [9.9] for , [13.5 ~~110~~] for   * + - * + :   for cat 1: [51] for , [72.5 ~~8.3~~] for , [115] for  for cat 2: [5.1 ~~8.5~~] for , [8.3] for , [13 ~~115~~ ] for   1. For inter-band CA, we think the total power consumption is separately calculated for each CC, including the static part. 2. Transition time of zero should also be considered.   For Antenna adaptation delay is explicitly modelled with a transition time of [0-3] ms~~, if not fall into micro-slee~~p. |
| Samsung | We are fine with FL’s proposal in general. For our understanding on , ,, we would like to further clarify how to calculate the , ,. |
| OPPO | For the baseline approach of the dynamic part, we have a concern that when there is no transmission, e.g., , the dynamic part of the power will be . However, according to our agreed BS power consumption model, the BS can enter into micro sleep immediately when there is no transmission. In this case, the dynamic part should be instead of . Thus, we prefer Alt3 to avoid this issue. |
| Huawei, HiSilicon2 | Some feedback on OPPO’s comment:  In the agreed template table agreed in RAN1#110, it was agreed that for micro sleep, There is neither DL transmission nor UL reception.  Therefore, during micro sleep, besides to be zero, the should be also zero because is also zero. Therefore, in this case, both  **and** are zero. So the micro sleep power is still **Pstatic.** There is no issue. |
| CATT | We don’t agree with the proposal to incorporate both DL and UL power consumptions in the formula since the DL Tx and UL Rx chains are separated and both active at the time. The gNB power consumption for both DL and UL are in active state in Tx, Rx or standby in each OFDM symbol. Thus, the proposal is not technical correct to have scale the value based on the ratio of DL and UL symbols. In addition, we agree the power model is based per slot power consumption. Even for TDD with DL/UL symbols in a slot, components related for DL Tx and UL Rx are all active (e.g., coupler in switching the Tx/Rx path, controller). There are other signal processing cross-symbols, such channel coding, with power consumption within a slot.  For the static component, the power consumption of active transmission should be higher than the P3 value (micro sleep) since power consumptions of components for signal processing are static component and required for both with and without scaling in time/frequency/spatial/power domain, such as baseband processing, controller, and RF components (e.g., filter, ADC). Thus, the value of P3 for static component ignores the fact of those static components for active transmission/reception. The values should be between micro sleep and DL active transmission (e.g., 140 which is about 38% of added power from micro sleep power consumption 55 to active DL Tx power consumption 280)  If we can agree the power scaling similar to that defined for UE power saving, it will be simpler to use a table for each domain and not the joint formula. |
| Vodafone | For the modelling of the PA in Alt.1, for clarification, how will depend on if it is assumed fixed values for the evaluation? |
| FL2 | To LGe:   * + because the Pstatic=5.5 and P5=6.5   + I think what QC proposes is for the entire SCell.   + Please also refer to QC proposal which is   *is the ratio between a reference PA efficiency and actual PA efficiency*  To Nokia:   * + Ok to introduce a factor, however the baseline should still be A=0 in order to reflect the majority preference and for alignment in evaluation as much as possible   + I will wait for a bit for QC to clarify as LGe also commented. Note it is still to be multi-CC instead of CA to be inclusive, since some techniques are not replied on CA.   + I’m not sure it is the intention, as the sum of each TRP means P\_static is not shared?   + I’m a bit unsure on the comments for antenna adaption delay. What is the difference if we assume dynamic antenna adaptation is applied at symbol level, such that the BS go to micro sleep without explicit transition time? What is the further difference between antenna adaptation delay and interruption delay? Is it talking about UE side not BS side?   To Spreadtrum:   * + It is not so clear what is the concern. Regarding the statement that symbol level sleep has ‘additional’ gain – what is compared to as “additional”? When BS does not perform transmission, even symbol level, it goes to micro sleep, and has corresponding energy savings. For example, for a transmission with 4 SSB symbols and no other transmissions within a slot, the BS is active at the 4-OS with SSB and immediately goes to micro sleep at remaining OS within that slot. That is the assumption and that is not a technique being proposed - technique that has additional gain would be e.g. use even reduced number of SSBs to enable more time duration without SSB transmission.   + In order to consider the TDD slot with both UL and DL in a slot, it is needed. Of course, we can still separately discuss DL and UL, but if the technical logic is the same, it may be rather simpler to determine DL and UL at the same time.   To vivo   * + Thanks for spotting. Will reivew the formula in next round of update.   + Ok to narrow down the candidate values for PAE and ok to have respective values for Cat 1 and Cat 2. For now because Cat 1 companies mainly propose other Alternatives, I’m not sure there could be values suitable for them, so in the initial round, just picked up Intel’s value without differing categories. Thus, PAE=0.34 and 0.5 is from Cat 2 and PAE=1 is from Intel, Cat 1. This can be clarified and differed later.   To ZTE,   * + For Cat 1 vs. Cat 2, see FL response to vivo above.   + [11.5 ~~1.5~~] for ==> the original value is picked up from Samsung proposal, without adjustment. I will wait for a bit more response. |
| Intel | We are OK in principle with the above framework. Few suggestions for corrections/revisions   1. For the following:    * + For slot-level modelling, represents the ratios of the number of active DL and UL symbols within a slot to the number of symbols within a slot and ; for symbol-level modelling, represents the number of active DL and UL symbols within a slot and .   For to hold, we think and should be replaced by and , respectively, which include both static and dynamic components. Revised equation should be either one of the following   * + (1)   + (2),   + where  1. For the following, we prefer that it is clarified which combinations apply for which Category of power model.    * + - * : [1.5] for , [9.9] for , [110] for          * : [8.5] for , [8.3] for , [115] for 2. Similarly, for the following, proposed value seem to apply for Category 2 only. We need a separate value of for Category 1, such as 55.      * + - * Baseline:  1. It is not clear how the following can be incorporated with the agreed model, where transition time only applies to light and deep sleep modes. We suggest to put this in bracket and more discussion is needed.   Antenna adaptation delay is explicitly modelled with a transition time of [1-3] ms, if not fall into micro-sleep |
| InterDigital | We are generally ok with FL’s proposal. We also share similar view with ZTE and vivo on having the values scaled for and for Cat 2. |
| CMCC | 1. We also share similar view with ZTE and vivo on having separate values of and for Cat 1 and Cat 2. 2. Regarding the formula, we support to use the original version in FL’s proposal. represents the static power when BS neither transmission nor reception but is ready for transmission or reception without transition time. For the symbols of DL transmission or UL reception, or part is enough.      1. Regarding the antenna adaptation delay, since the transition time is 0 for micro sleep, if BS transit from micro sleep to active DL/UL, no additional antenna adaptation delay is needed. |
| China Telecom | We are generally fine with the proposal. We agree with vivo’s motivation of modification on the equation, but it’s better not to simplify the equation for easier comprehension the meaning of each part and coefficient ‘a’ is not a constant. Just keep the equation as  )  Or the equation can be as follows since the static part always exists.  Also, we agree with ZTE, vivo, InterDigital that the values should be separately defined for Cat1 and Cat 2. |
| Ericsson1 | An initial comment :  On the a,b, c formulation for DL, UL, empty symbols : This does not reflect the setting where different symbols may have different BW occupancy, which was discussed in previous meetings. *Note that symbol-level power consumption to reflect different BW (or RB utilization) / time-occupancy / tx-rx direction of different symbols in a slot is considered.*  Symbol-level modeling should also be captured – “*In time domain, If an explicit symbol level model is provided, scaling is not applied*”. |
| QC1 | Reiterating our response from multiple times in last meeting, is NOT the PA efficiency since some reference PAE is already captured in the power consumption  In a similar manner as to the scaling factors in other domains, it is important to see how the actual PAE is relative to the reference PAE; hence PAE scaling factor is the ratio between a reference PA efficiency and actual PA efficiency depending on the actual transmit power and actual frequency domain usage. Therefore we support the optional approach.  Taking indicates that the reference PA efficiency, that was captured in the power consumption **,** is the same in all the scaling conditions. Most companies agree that PA efficiency changes with transmit power. Modeling PA efficiency to be constant (hence, linear), would provide misleading evaluation for the PA power consumption:   * + For TX power reduction of 3dB and 6dB, keeping PA efficiency as constant (, linear) would have the PA power consumption to be scaled to 0.5 and 0.25 respectively   + Our calculations (and measurements), provided by our formula have the PA power consumption to be scaled to 0.66 and 0.48 respectively, largely different than the linear     - Taking Samsung’s formula from its Tdoc (0.67^(Xp/3[dB])), would have similar results as ours - the PA power consumption to be scaled to 0.67 and 0.45 respectively   We therefore suggest the following, after aligning definition amongst companies   * + - : a dynamic part of power for BS in active, which is scaled based on reference configuration.       * Baseline: , where , , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively, and         + is the PA scaling factor. For evaluation purpose, would indicate that the reference PA efficiency is constant value throughput the scaling factors (e.g., frequency, power)         + : [1.5] for , [9.9] for , [110] for         + : [8.5] for , [8.3] for , [115] for       * Other values can be optionally reported, satisfying when , ,.       * Optional for other approaches, e.g. **,** or where  is the ratio between a reference PA efficiency and actual PA efficiency, up to company report         + In order to simplify, instead of a formula, several numbers for can be used for certain ,:   For :  For :  For : |
| FL2-2 | To Vodafone: the proposed LS to RAN4 intends to ask for guidance whether a fixed value is sufficient, or a more detailed non-linear modeling is required.  To Qualcomm: the in Alt 1 might have different definition as that in Alt 3 – thus, FL has explicitly capture the fitting definition for Alt 3 in the optional case. There may be no need to revise the definition for other approach now.  Given several companies input, FL will consider to down select some values in the next update, per Category, and also try to address comments about symbol level vs slot level, scaling factors calculation. |
| Samsung | We are fine with FL’s proposal in general.  Regarding the , we considered it was (P4 - ) for both categories. With the in Cat 2, we determined 1.5 for based on the portion of power consumption between and calculated by the measured power consumption of gNB with 64T64R (i.e. ). Afterwards, we derived as 8.5 under the and the fixed PAE 0.34, which is averaged value of products. Based on our assumption, took small portion of , and most of power was consumed in related to PA.  In terms of the last sub-bullet for LS to RAN4, we are wondering whether we can reflect the RAN4’s response within the limited time for SID. So, we’d like to use the fixed candidate values for PAE.  For the multi-TRP, as mentioned by Nokia, we also would like to be clear whether can be same for all TRPs. From our assumption, can be same for all TRPs for simplification. Hence, in m-TRP case, the can be updated as below:  , where nrofTRP is the number of TRPs during m-TRP operation. |
| MediaTek | Regarding FL1/FL2 Proposal 2.4.1,   * For DL transmission power consumption scaling   + Support as a good starting point to merge Alt 1 and Alt 3   + Support setting a baseline model with first set to a constant (of multiple candidate values). **To include more sophisticated model on , we agree with FL to send LS for RAN4’s check and potential input because RAN4 has dedicated experts on BS RF** (and it is strange for RAN1 to make decision without checking with the respective RAN4 experts)   + For deciding the values and , we would suggest to consider two boundary conditions so that the values can be “calculated” for Category 1/2 and Set 1/2/3 BS settings (too slow to be decided one-by-one). The following can be potentially considered:     - **Power low bound for few RBs, e.g., = [0.4] Active DL power when and , which determines**     - **Full-RB power condition, i.e., = Active DL power when and , which further determines** * For UL reception power consumption scaling   + Setting is more reasonable since we have a common sleep model across DL and UL   + With **,** can be calculated by the boundary condition:  **Active UL power when** |
| Nokia/Nsb | To FL:  Regarding “I’m not sure it is the intention, as the sum of each TRP means P\_static is not shared?”, to our view and proposal, in case of multi-TRP, even with separate RF, the BB is shared among TRPs, and it should be accounted once (as part of the P\_static) and should not be cumulated when aggregating TRPs.  Regarding “I’m a bit unsure on the comments for antenna adaption delay”, our intention is proposing on how to include the antenna adaptation delay in the modeling.  For instance, if there is the antenna adaptation from 64Trx to 32 Trx, the [1~3]ms antenna adaptation delay can be considered similarly as gNB entering the micro-sleep state, where during the micro-sleep state period, the gNB will turn-off the Tx-Rx chains from 64-to-32. And after the antenna adaptation delay, the gNB re-enters the active-state with 32Trx and resumes its normal activity  We may need to discuss and agree on the BS behavior during the time of spatial elements (de-)activation, such that the BS operation with transmission/reception could be interrupted during this time period. And that could be exactly modelled as gNB in micro-sleep state, with no Tx and Rx services available (as assumed and explained above). |
| Fujitsu | We are fine the principle of the proposal.  It seems that the definitions of a, b and c are only applicable for TDD case. Then it should make it clear in this proposal. We suggest the following modifications:   * **The BS power consumption in a slot is provided by**   + - For the TDD with slot-level modelling, represents the ratios of the number of active DL and UL symbols within a slot to the number of symbols within a slot and ; for the TDD case with symbol-level modelling, represents the number of active DL and UL symbols within a slot and .   Regarding “Antenna adaptation delay”, we share the same view with ZTE that the value of zero should also be considered. |
| Vivo2 | The simplified equation is not correct in our previous comment and it should be updated in red as follows, which is also mentioned by China Telecom.  It seems the static power part is missing for DL and UL symbols, the equation should be  ) that can be simplified as |
| QCOM2 | **Discussion on**  Reiterating our response from multiple times in last meeting, is NOT the PA efficiency since some reference PAE is already captured in the power consumption . In a similar manner as to the scaling factors in other domains, it is important to see how the actual PAE is relative to the reference PAE; hence PAE scaling factor is the ratio between a reference PA efficiency and actual PA efficiency depending on the actual transmit power and actual frequency domain usage.  Taking indicates that the reference PA efficiency, that was captured in the power consumption **,** is the same in all the scaling conditions. Most companies agree that PA efficiency changes with transmit power. Modeling PA efficiency to be constant (hence, linear), would provide misleading evaluation for the PA power consumption:   * + For TX power reduction of 3dB and 6dB, keeping PA efficiency as constant (, linear) would have the PA power consumption to be scaled to 0.5 and 0.25 respectively   + Our calculations (and measurements), provided by our formula have the PA power consumption to be scaled to 0.66 and 0.48 respectively, largely different than the linear     - Taking Samsung’s formula from its Tdoc (0.67^(Xp/3[dB])), would have similar results as ours - the PA power consumption to be scaled to 0.67 and 0.45 respectively   As a summary, from PAE modelling perspective, we should consider the PAE ratio between reference PAE and actual PAE – similar to and . In addition, the PAE ratio should not be limited to just a single value. Instead, the power model should have support for multiple PAE ratio values depending on (). The values can be based on a formula (e.g., ones proposed by Huawei, Samsung, our Tdoc or some new function) or directly based on a set of values for some combinations of () e.g., for the case of scaling in power domain:   * For : * For :   **Overall active power consumption discussion**   * We do not agree to putting all UL/DL together in “” at this stage since we still don’t have answer on the power granularity yet – please see our related discussion in 2.2.2. * We suggest separately discussing active DL/UL power consumption in spatial, frequency and power domains first. We agree on the principle of scaling which considers all dimensions: frequency, power, number of antennas and PAE. Scaling in time domain can be decided later if needed. * We suggest discussing a scaling methodology that should be generic for all configuration sets. * For the dynamic part of active DL power consumption as , could the proponents show which BS components are being used to come up with the numbers for and , respectively? We understood as the constraint for these numbers. * Alternatively, we can simply design scaling for each domain similar to UE power mode or the scaling proposal from E/// with the update. This approach is generic and could be at appliable to all configuration sets.   where is the ratio between a reference PA efficiency and actual PA efficiency.  Therefore, the FL’s proposal needs revision. |
| Ericsson2 | To add to our previous comment, if intention is to have simpler model for scaling, we are OK to consider updates to our proposed model. It avoids getting into the detailed calculations of several variables such as for each set and category. |
| Spreadtrum | Generally fine. Response for the earlier FL’s answer: it seems the so-called “symbol-level turning off” is just micro sleep. It is fine for us. Thanks for clarification.  As a suggestion, if some variables are divergent, we may have the rough formulation of the scaling model with the details FFS. |
| LG Electronics 2 | Thanks, FL for the clarification. We have a few additional comments as below.   * We also share similar view with ZTE and vivo on having separate values of and for Cat 1 and Cat 2. * The equation for the BS power consumption in a slot should be updated as to reflect the static power part for DL and UL symbols, as mentioned by vivo and China Telecom. * Regarding the antenna adaptation delay, the value of zero (i.e., 0 ms) should also be considered for the transition time. * For LS to RAN4, it seems that there is not enough time to receive the response and reflect it. Therefore, it is recommended that RAN1 determine a fixed candidate value for parameters including and report what value was used to evaluate. |

### Second/Third/4th round

FL thanks for all the very good discussion and comments.

@QCOM2, Ericsson2,

Thanks QCOM for the detailed explanation.

FL understanding is that PA efficiency is different thing as PAE strictly speaking. Nevertheless, no objection is observed for the change of PA efficiency for now. Updated as suggested.

As for the comments below and a similar comment from Ericsson and CATT,  the modeling itself below from UE power saving has its benefits in simplicity. However the discussion when adapting for BS energy saving, from discussion point of view, the parameters in square bracket is also questionable in terms of how it comes and is determined per BS components. It might be more questionable if it does not fit BS components which could be quite different from UE.

* *For the dynamic part of active DL power consumption as , could the proponents show which BS components are being used to come up with the numbers for and , respectively? We understood as the constraint for these numbers.*
* *Alternatively, we can simply design scaling for each domain similar to UE power mode or the scaling proposal from E/// with the update. This approach is generic and could be at appliable to all configuration sets.*

@Fujitsu,

For FDD case, the UL part is omitted per previous agreements. So time domain scaling of the formula still holds.

@MTK

Thanks for providing the good suggestions for progress. FL was thinking a similar, hence the following is suggested.

@ALL

In order to avoid cumbersome discussion on determination of , , and considering we are for study purpose, FL tends to directly suggest some candidate values based on estimate of company’s proposals. For example, in Samsung and Nokia proposed values, the part can be very small. In Huawei/MTK/ZTE proposals or Intel proposal, a relative medium value is observed. For CATT’s value, when focusing on the part of  , , seems contributes to a very large portion of dynamic part. Therefore, in order to be comprehensive while keep reasonable workload, three candidate values are proposed for determining the power factor within the dynamic part.  FL consider to avoid concrete number of values in order to be able to be used whatever BS category and set of reference configurations.

**FL3/FL4 Proposal:**

* **The BS power consumption for active DL transmission is provided by**
  + - : a static part of power for BS in active, which is not scaled based on reference configurations.
      * Baseline:
    - : a dynamic part of power for BS in active, which is scaled based on reference configuration.
      * Baseline: ,
        + where , , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively,
        + is the PA ~~efficiency~~ scaling factor.
        + For evaluation purpose,

.

= **A\*** ~~when~~ ~~and~~ , where A=[0.1, 0.4, 0.7]

* + - Other values for the above scaling formula, and other scaling approaches can be optionally reported, satisfying when ,,, e.g.
      * **,** or
      * where  is the ratio between a reference PA efficiency and actual PA efficiency, up to company report.
* **The BS power consumption for active UL transmission is provided by**
  + - : a static part of power for BS in active, which is not scaled based on reference configurations.
    - : a dynamic part of power for BS in active, which is scaled based on reference configuration and is the percentage of active TRxRUs
    - Baseline
      * when no scaling is applied (i.e. scaling factor is 1)
    - Other values can be optionally reported
* For multi-carrier: ~~for inter-band multi-CC,~~ the total power consumption of BS is calculated as is the sum of the power consumption of each CC;
  + for intra-band multi-carrier with contiguous CCs, the power consumption of each additional CC is scaled by [0.75].
  + ~~Company to report whether Pstatic is shared among CCs (if shared, Pstatic is accounted once)~~
* For multi-TRP, the total power consumption of BS is assumed as is the sum of the power consumption of each TRP
  + Company to report whether Pstatic is shared among TRPs (if shared, Pstatic is accounted once)
* Company to additionally report whether antenna adaptation delay is explicitly modelled with a transition time of [1-3] ms, if not assumed as immediate transition.
* In time domain,
  + If an explicit symbol level model is provided, scaling is not applied. The power of BS in a slot is the sum of the power of each symbol within that slot.
  + If slot level modeling is provided, , where represents the ratios of the number of active DL and UL symbols within a slot to the number of symbols within a slot and
* [Send LS to RAN4 about the above, and ask if there is concern for the above, with details of proposed in Alt 3 also captured in the LS]

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QCOM4 | In general, we should have a common scaling method for consistent observations in evaluation. Hence, we strive to avoid statement like “other values are optionally reported” in the proposal.  **On dynamic part of active DL transmission power consumption**  We appreciate FL’s effort on the updated proposal especially on defining as PA scaling factor. From our perspective, it is beneficial to provide the meaning of PA scaling factor. In particular, similar to definition of other scaling factors (, ,), we propose to clarify that is the ratio between the PA efficiency at evaluation point and the PA efficiency at reference configuration i.e., . From our understandings, the value of η =0.34 in the previous discussions of the proponents meant for absolute PA efficiency. For simplicity and progress, we think that the following values of should be used (depending on the power scaling factor ).   * *,* = 0.76 and = 0.52   Another update is on computing and , we think that partition i.e., the dynamic power consumption at the reference config for and by parameter A. In our proposal, A = 0 while other A values are borrowed directly from the FL proposal – we are open to discuss/select one value from the list for evaluation.  Hence, we suggest the following update on the baseline:   * + - where , , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW, ~~and~~ the ratio of PSD per TxRU between the DL transmission and reference configuration and the ratio between the PA efficiency at evaluation point and the PA efficiency at reference configuration respectively,     - For evaluation purpose,       * *,* = 0.76 and = 0.52       * = ()       * – to be down-selected to a single number in this meeting.   With this update, we can remove the following bullet in “Other values for the above scaling formula”   * + - * ~~where~~ ~~is the ratio between a reference PA efficiency and actual PA efficiency, up to company report.~~   **On time domain scaling**  We prefer to have just one common modelling to have consistent observations later.  “If slot level modeling is provided, , where represents the ratios of the number of active DL and UL symbols within a slot to the number of symbols within a slot and ” – This is not accurate. Counting the number of UL or DL symbols in a slot is not sufficient since different symbols in a slot can have different frequency and/or power allocations – see our explanation in 2.2.2 and 2.4.  This discussion and discussion in Section 2.4 are highly correlated. We suggest discussing it together with discussion in Section 2.4. Alternatively, we can come back to this discussion after getting some conclusion in Section 2.4.  **On scaling in CA**  We suggest making the following update:   * For multi-carrier, the total BS power consumption is calculated as is the sum of the power consumption of each configured CC.   + For intra-band multi-carrier with contiguous CCs, the power consumption of each additionally configured CC is scaled by [0.75].   **On scaling in mTRP**  We suggest making the following update:   * For multi-TRP, the total power consumption of BS is assumed as the sum of the power consumption of each configured TRP   **On LS on details of**  We don’t see the need of the LS. The value is not an absolute value. It is just like other scaling in frequency, antenna and power domains. |
| Intel | We have concern on the following formulation  = **A\*** when and , A=[0.1, 0.4, 0.7]  First of all, we need to include values of and in general for non-zero values of scaling factors. We suggest to use values used in previous round   * + - * + is the PA efficiency. For evaluation purpose, .         + : [1.5] for , [9.9] for , [110] for         + : [8.5] for , [8.3] for , [115] for   Moreover, it is not clear what implies. In our view, scaling factors are non-zero. We agree with other companies that antenna adaptation delay should not be treated differently than micro-sleep. |
| Samsung | We are generally fine with FL4’s Proposal.  According to the value of A, we think the effectiveness of and would be affected. So, if A is 0.7, we may not acquire any gains from adaptation of and . In addition, the difference observations would be shown due to different values of A. So, we would like to select a value of A in candidates [0.1, 0.4, 0.7], and we suggest 0.1 for A. |
| FL4 | There seems to be a mistake in the formula that when determining A, “when and ” is not needed. Updated in blue in the proposal which somewhat similar as QC suggested.  Some other update per QC suggestions as well, except: a bit unclear whether each CC/TRP is ‘configured’ CC/TRP as that is from UE perspective.  Before further changes are made per QC suggestions, FL thinks two points are pending:   1. **Definition of the ,** which could have impact on the candidate values/approaches for down selection. Companies are invited to check QC detailed elaboration. 2. **Scaling granularity**, as separately questioned in 2.4.3. They are related so it’s reasonable to discuss them together. However, it seems for the moment the focus of the above is the value and relationship with . Thus, if needed, FL can combine them later. |
| Ericsson3 | If intention is to include multiple options, instead of the compromise formulation that we attempted (based on Pstatic, etc), we prefer our earlier proposed simpler formulation below.  PUL = P5 ([0.8] + [0.2] sf) \* ([0.4] + [0.6]sa)  We are also OK to include update suggested by Qualcomm for DL into it, i.e.  For antenna adaption, we suggest below update.   * Company to additionally report the assumption for ~~whether~~ antenna adaptation delay, e.g. immediate, ~~is explicitly modelled~~ with a transition time of [1-3] ms, etc ~~if not assumed as immediate transition~~. |
| FL4-2 | Multiple options are definitely possible and to be allowed, if cannot converged. But clearly not the intention by FL to encourage such. Therefore, if Ericsson prefers the proposal below most, it can be used as the optional case instead of the current optional one in FL proposal.  PUL = P5 ([0.8] + [0.2] sf) \* ([0.4] + [0.6]sa)  Additionally, FL would like to check with Ericsson whether of below shares the same definition with QC suggestion above – as such this formula is converged a bit more.  The other comments will be reflected. |
| ZTE, Sanechips | We are okay with current formula for unified framework for cat 1 and cat 2.  For , it is better to clarify =P4-P3, as UL.  For the following A value set [0.1, 0.4, 0.7], will we down select with one value, or keep all on the table? |
| vivo | We are generally fine with the proposal. It seems how to obtain is missing in the proposal. We suggest the following update to guarantee that when ,,   * + - * + For evaluation purpose,   .  = **A\*** ~~when~~ ~~and~~ , where A=[0.1, 0.4, 0.7]  = \*(1-**A**) **\*** where A=[0.1, 0.4, 0.7] |
| Nokia/Nsb | We are generally fine with the proposal in which  We note that by assuming the following, the static part of power for BS in active would be scaled based on reference configurations (if option 1 in 2.2 is agreed).  =  We would like to clarify the values of and to be considered for evaluation purpose.  We could use the proposed formula = **A\*** when , , and =1, where A=0,1 is our preferred value and defines the contribution of the factor in the total dynamic power . With that, (1-A) **\*** refers to the contribution of the factor in the total dynamic power which reflects the PA power consumption expected to be the most energy consuming part of the BS.  In general, we shall use the following formulation:   * = **A\*** * = **(1-A)\*** |
| Vodafone | We agree with the QC statements on dynamic part of active DL transmission power consumption for the common definition for the scaling factors, thus we agree with QC’s definition for the factor . |
| Huawei, HiSilicon | For the Baseline: , the is in the denominator. Therefore, it is not a scaling factor.  We still think in the baseline it is a PA efficiency, and the recommended value is {0.34, 0.5}.  It is fine to take as PA scaling factor if is taken and reported by a company.  We suggest the following update:   * + - * Baseline: ,         + where , , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively,         + is the PA ~~efficiency scaling factor~~ efficiency.         + For evaluation purpose,   . |
| Spreadtrum | Generally fine with the formulation of scaling |
| InterDigital | We are generally fine with the revised proposal and the scaling values for the proposed factor A for calculating . For Cat-2, we think the value indicated by Samsung for calculating and are reasonable. |
| Ericsson4 | Regarding FL4-2 comment,  For , our view is that value 1 and one or two more additional values could be allowed. For definition, it can be according to QCOM2 comment, but we think needs to be clarified further in general. |
| CATT | First, there are static power consumptions, such as backhaul data reception/transmission, RRC/RLC/MAC processing, gNB controller processing, and RF/baseband signal processing when gNB is in active DL Tx or UL Rx comparing to that of micro sleep. The static power consumption Pstatic = P3 implies that there is no additional static gNB power consumption. Thus, we believe that the Pstatic = P3 is over-optimistic without including the additional static power consumption for all signal processing during active Tx/Rx. We will suggest to have Pstatic = P3 + Δ.  Potential Δ values are [ 1.5\*P3, P3, 0.5\*P3]  We also need to define Pdyn, joint value as (1-**A)\*** |

### 5th round

@ZTE

For baseline case it is P4-P3. Otherwise it may not be.

@vivo, Nokia

Updated.

@QC, Vodafone

Updated.

@Huawei, HiSilicon

Updated, except for the PA definition.

@Ericsson

Thanks for clarification. FL agree the PA definition is one discussion point.

@CATT

For static part power, Nokia has proposed something similar. FL observation is that there is vast support of Pstatic=P3 for which reason it is likely the same situation if we take more options to down select. There was once an attempt from FL in previous meeting to conclude that this study does not consider the power consumption of BH to simplify the discussion. Considering the above, it is not accommodated. There are still factors pending down selection, which can make the evaluation quite diverse.

@ALL

Since only Huawei objects to revise the PA definition while Vodafone and QC supports that, update as -rev.

From evaluation perspective, would be good to down-select to one value for both and **A**.

Now it seems three companies (Nokia, Samsung, Interdigital) prefer A=0.1. One company proposed two more values of (for down-selection?).

**The things to FL is that, can we take the majority view? Or from implementation point of view, would it be good to allow multiple values?**

**FL5 Proposal 2.5.3-rev1:**

* **The BS power consumption for active DL transmission is provided by**
  + - : a static part of power for BS in active, which is not scaled based on reference configurations.
      * Baseline:
    - : a dynamic part of power for BS in active, which is scaled based on reference configuration.
      * Baseline: ,
        + where , , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively,
        + is the ~~PA efficiency scaling factor.~~ ratio between the PA efficiency at evaluation point and the PA efficiency at reference configuration.
        + For evaluation purpose,

. – to be down-selected in this meeting

~~when~~ ~~and~~ ,

where A=[0, 0.1, 0.3, 0.4, ~~0.7~~]– to be down-selected to a single number in this meeting

* + - Other values for the above scaling formula, and other scaling approaches can be optionally reported, satisfying when ,,, e.g.
      * **,** ~~or~~
      * ~~where~~ ~~is the ratio between a reference PA efficiency and actual PA efficiency, up to company report.~~
* **The BS power consumption for active UL transmission is provided by**
  + - : a static part of power for BS in active, which is not scaled based on reference configurations.
    - : a dynamic part of power for BS in active, which is scaled based on reference configuration and is the percentage of active TRxRUs
    - Baseline
      * when no scaling is applied (i.e. scaling factor is 1)
    - Other values can be optionally reported
* For multi-carrier: ~~for inter-band multi-CC,~~ the total power consumption of BS is calculated as is the sum of the power consumption of each CC;
  + for intra-band multi-carrier with contiguous CCs, the power consumption of each additional CC is scaled by [0.75].
  + ~~Company to report whether Pstatic is shared among CCs (if shared, Pstatic is accounted once)~~
* For multi-TRP, the total power consumption of BS is assumed as is the sum of the power consumption of each TRP
  + Company to report whether Pstatic is shared among TRPs (if shared, Pstatic is accounted once)
* Company to additionally report the assumption for ~~whether~~ antenna adaptation delay, e.g. immediate, ~~is explicitly modelled~~ with a transition time of [1-3] ms, etc ~~if not assumed as immediate transition~~.
* In time domain,
  + If an explicit symbol level model is provided, scaling is not applied. The power of BS in a slot is the sum of the power of each symbol within that slot.
  + If slot level modeling is provided, , where represents the ratios of the number of active DL and UL symbols within a slot to the number of symbols within a slot and
* [Send LS to RAN4 about the above, and ask if there is concern for the above~~, with details of proposed in Alt 3 also captured in the LS~~].

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QCOM5 | **Discussion on**  @Huawei/HiSi: “For the Baseline: , **the is in the denominator. Therefore, it is not a scaling factor**.” – It is interesting to see **this reasoning**. Mathematically, the scaling can be anywhere in a mathematical formula. We suggest you review our comment under “QCOM2” on  @FL: depends on values of . We prefer to have a function for this relationship to get closer to the measurement in practice. However, for simplicity and progress, we suggested to have 3 values for different power levels only. If companies prefer to support 0.34 for a certain power and/or frequency resource, we are fine. So, we suggest the following update on :  ~~. – to be down-selected in this meeting~~   * + - * *,* = 0.76 and = 0.52   We don’t see the value of LS to RAN4 especially as we do not pursue formula-based modeling for anymore. The initial intention of the LS was to check the feasibility of the formula we proposed per our understandings. It is the same exercise as one that was done by companies evaluating the reference power consumption at full transmit power, where the PA efficiency was (even if implicitly) evaluated without an LS to RAN4. The same exercise can be repeated for -3dB and -6dB reduction in the reference transmit power.  **On time domain scaling**  As discussed in 2.4, the formula “” is not always correct since each symbol in the slot may have different frequency, power (and possible spatial) allocations. Hence the number of DL or UL symbols in a slot in terms of (a, b, c) is not sufficient. Intel’s formula in response to **FL4 Question 2.4.3-2** is just for one example but can’t cover a general case.  To move forward, we suggest the following text which technically reflect the power computation for the slot in both “IF” under the main bullet “In time domain,”   * **The power consumption in a slot is the sum of the power consumption associated with symbols in the slot. The symbol may correspond to uplink symbol, downlink symbol, or symbol without uplink and downlink.** * ~~In time domain,~~    + ~~If an explicit symbol level model is provided, scaling is not applied. The power of BS in a slot is the sum of the power of each symbol within that slot.~~   + ~~If slot level modeling is provided, , where represents the ratios of the number of active DL and UL symbols within a slot to the number of symbols within a slot and~~   With this, we don’t think there is a further need to discuss whether the modelling is slot level or symbol level as the current text in the proposal. |
| LG Electronics | For multi-carrier, it is better to clarify whether the scaling for the power consumption of each additional CC is applied only to the dynamic part for the intra-band CA case. For time domain, if we agreed on the granularity of the agreed relative power values as slot-level in 2.4, the first bullet can be removed. Regarding sending LS to RAN4, we think it is not necessary. |
| Intel | Some correction/revision is needed in the following part   * + - * + is the ~~PA efficiency scaling factor.~~ ratio between the PA efficiency at evaluation point and the PA efficiency at reference configuration.         + For evaluation purpose,   . – to be down-selected in this meeting  ~~when~~ ~~and~~ ,  where A=[ 0.1, 0.3, 0.4, ~~0.7~~]– to be down-selected to a single number in this meeting  We are not OK to have A = 0 as potential value. |
| ZTE, Sanechips | We are generally fine with the proposal.  And we think the current A values are too small, we think A=0.7 should be taken as a candidate.   * + - * + For evaluation purpose,   . – to be down-selected in this meeting  ~~when~~ ~~and~~ ,  where A=[0, 0.1, 0.3, 0.4, 0.7]– to be down-selected to a single number in this meeting |
| vivo | We are fine with the proposal and also QC’s revised proposal for time domain scaling.  We don’t agree with Intel that is removed for calculation of . Multiplication of here is to guarantee that when ,, |
| Samsung | We are generally fine with FL’s proposal with updates on the definition of .  Regarding the we share the same view as HW. We also object to change the definition of We suggest that is the PA efficiency. In addition, we would like to suggest 0.34 for PA efficiency   * + - * + is the PA efficiency ~~scaling factor. ratio between the PA efficiency at evaluation point and the PA efficiency at reference configuration.~~   Regarding the A, we would like to suggest 0.1 for calculating and . |
| China Telecom | We are generally fine with the proposal. Since and a + b + c=1, the total power level for the slot-level simulation formula can be further simplified to , to make the already very complex scaling a little bit easier. |
| Nokia/Nsb | Same view as HW and Samsung. We are fine with the original FL’s proposal with as PA efficiency factor, and we prefer to have a fixed value of 34%, regardless of evaluation points .  Same proposal as Samsung, we propose A=0.1. |
| Fujitsu | We are fine with the proposal with QC’s revision for time-domain scaling. |
| Huawei, HiSilicon | For the PA scaling factor or the PA efficiency, we think PA efficiency is more proper terminology.  For the QC’s proposal on “, = 0.76 and = 0.52”, this would make the evaluation complicated, what would be the value of if <1? Or our modelling does not support scaling in frequency domain? If we would like to follow this way, this is clearly out of RAN1 expertise and needs RAN4 input.  There can be two ways to move forward considering current situation:   * Alt.1: Define the PA ratio between the PA efficiency at evaluation point and the PA efficiency at reference configuration as Qualcomm suggested, and send LS to RAN4 for an input of the function of with the variations of ; * Alt.2: define as PA efficiency and we pick up a value for evaluation in RAN1;   For Huawei’s view, we prefer Alt.2 as the evaluation assumption. We would like to also hear other companies’view. |
| ZTE, Sanechips | Different with original Alt3, our understanding of the original Alt1 is that the P formula is used to calculate the outcome of consumed power by gNB with implementation of different adaptations, is more like an absolute factor. If there is no consensus about the definition, we can be more generic, like  is a power factor.  Furthermore, we agree with QC’s proposal that the LS to RAN4 about this is not needed, this is for RAN1 evaluation purpose.  We also okay with QC’s proposal about time domain. |
| QCOM6 | @**Samsung, Huawei and Nokia**: Thanks for further discussing the definition of . We strongly disagree with the definition of as PA efficiency. It has been explained xplained multiple times on why it should not be the PA efficiency. Instead, it should be the ratio – similar to the definition of . We have not seen any reasonable discussion why needs to be PA efficiency.  Now, let’s explain one more time in a different way: When the power consumption for active DL transmission is measured, it already includes the power consumption of PA. It has been well-known that the power consumption of PA is a function of the transmission power and the PA efficiency. In particular, **it is directly proportional to the transmission power and inversely proportional to the PA efficiency**. You can find similar discussion in Nokia contribution (**R1-2203224**) that discussed the relationship between transmission power and PA efficiency at a **power operation point** in RAN1#109e as follows:  “In order to define such scaling, it is noted that the scaling would have to be applied to certain subcomponents within the radio unit. For example, the power consumption of the RF power amplifier (PA) may be modeled as follows:  where = no. of active transmit antenna elements, ' = transmitted power per antenna element (in linear scale) corrected with feeder losses (~0.6-1.5 dB), is the PA efficiency when operating at and Base (W) is a base power factor that depends on the PA operation point.  **Observation-5: The power consumption of the PA within the radio unit can be scaled linearly with the number of transmit antennas and as a function of the transmit power and the PA efficiency. “**  If we use as the PA efficiency again in the scaling formula, the PA power consumption is inversely proportional to the **square of PA efficiency**, which is technically wrong. Objecting companies may mistakenly take as transmission power (e.g., in Nokia contribution).  **@Huawei**: Thank you for the question “what would be the value of if <1” on our proposal.  From our understanding, as , are jointly scaled to (providing the TX power of the evaluated point), then = 0.76 is also applicable for nd actually applicable for every evaluated point in which .  **Hence, we can clarify the values of in the proposal as follows:**   * **when , when and when**   Regarding LS to RAN4, the evaluation is in the expertise of RAN1, in similar manner as the selection of the reference PAE to evaluate the power consumption which didn’t call for RAN4. RAN4 expertise may be required for formulation of a formula for entire evaluation conditions. |
| Ericsson5 | Regarding the scaling based on antenna/frequency/power, the following updates are suggested.  For the downlink,   * + - Other values for the above scaling formula, and other scaling approaches can be optionally reported, ~~satisfying when ,,, e.g.~~ including       * **~~,~~** the BS power consumption for active DL transmission is provided by *,* At least = 1 is supported. Additional one or two more values are FFS.   For the uplink,   * + - Other values can be optionally reported, including the BS power consumption for active UL transmission is provided by PUL = P5 (0.8+ 0.2 sf) \* (0.4+ 0.6\*sa), where sf is the ratio of RF bandwidth and maximum system BW   Regarding time-domain scaling for slot-level modeling, it does not consider the symbol-level power consumption to reflect different BW (or RB utilization). For this, we support QCOM5 proposal copied below.  *In time domain,*   * ***The power consumption in a slot is the sum of the power consumption associated with symbols in the slot. The symbol may correspond to uplink symbol, downlink symbol, or symbol without uplink and downlink.*** |

### 6th round

Thanks for all the good discussion!

@QC, Fujitsu, ZTE, CTC, Ericsson

For the time domain removal proposed by QC, FL thanks QC’s constructive texts and consideration of progress. Honestly however, FL is a bit concerned as it may make it a bit vague in terms of how to evaluate. If it is clearly slot level or symbol level, is there any other approach? FL is open to other approaches but prefer to clarify this. The slot-level scaling, as explained in previous round of discussion in section 2.4, can reflect different BW.

For the time being, FL will remove it as suggested, while add to ask company to report the details.

@LGE

The current proposal implies that 1CC+1CC=1.75 CC wherein 0.25 is part of commonly shared power. Perhaps in this manner there is no need to further consider scaling on dynamic part or not. Also, as FL missed Huawei proposal of change of 0.75->0.65, now 0.7 as a middle is used.

@Who is concerned with RAN4 LS

It seems the original proponent of RAN4 LS might be OK without LS now. From FL perspective, there is potential risk that RAN4 may not be able to reply in time next meeting. If majority consider it is sufficient to evaluate this within RAN1, FL appreciate to ACK.

Now for the PA related aspects, FL consider QC has demonstrated a lot. Although it is considered within RAN1 expertise, FL feel it could require several more rounds of clarification if in order to make it clear to everyone. On the other hand, as RAN1 evaluation does not require such detailed split, using a text without mentioning the exact definition might be acceptable. The needed determination in RAN1 is the numbers.

With this, FL modified the texts a bit, and check the number and removed 0 and 0.3 from A: 0 has an essential difference with other values, and 0.3 is too close to 0.4. Further down-selection is still possible, or we allow multiple values for the benefits of diversity.

**FL6 Proposal 2.5.4:**

* **The BS power consumption for active DL transmission is provided by**
  + : a static part of power for BS in active, which is not scaled based on reference configurations.
    - Baseline:
  + : a dynamic part of power for BS in active, which is scaled based on reference configuration.
    - Baseline: , where , , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively
      * + is the power part related to PA.
        + For simplicity (to be down-selected in this meeting)
      * A = [0.1, 0.4, 0.7]
* **The BS power consumption for active UL transmission is provided by**
  + : a static part of power for BS in active, which is not scaled based on reference configurations.
  + : a dynamic part of power for BS in active, which is scaled based on reference configuration and is the percentage of active TRxRUs
  + Baseline
    - when no scaling is applied (i.e. scaling factor is 1)
* For multi-carrier: the total power consumption of BS is calculated as is the sum of the power consumption of each CC;
  + for intra-band multi-carrier with contiguous CCs, the power consumption of each additional CC is scaled by [0.7].
* For multi-TRP, the total power consumption of BS is assumed as is the sum of the power consumption of each TRP
  + Company to report whether Pstatic is shared among TRPs (if shared, Pstatic is accounted once)
* Company to additionally report the assumption for antenna adaptation delay, e.g. immediate, with a transition time of [1-3] ms, etc.
* In time domain,
  + The power consumption in a slot is the sum of the power consumption associated with symbols in the slot. The symbol may correspond to uplink symbol, downlink symbol, or symbol without uplink and downlink.
  + Company to report how the summation is performed along with evaluation results.
* Other values for the above scaling formula, and other scaling approaches can be optionally reported, including
  + At least = 1 is supported. Additional one or two more values are FFS.
  + PUL = P5 (0.8+ 0.2 sf) \* (0.4+ 0.6\*sa).

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | First, there are static power consumptions, such as backhaul data reception/transmission, RRC/RLC/MAC processing, gNB controller processing, and RF/baseband signal processing when gNB is in active DL Tx or UL Rx comparing to that of micro sleep. The static power consumption Pstatic = P3 implies that there is no additional static gNB power consumption. Thus, we believe that the Pstatic = P3 is over-optimistic without including the additional static power consumption for all signal processing during active Tx/Rx. We will suggest to have Pstatic = P3 + Δ.  Potential Δ values are [ 1.5\*P3, P3, 0.5\*P3]  The RF component ON/OFF has the most impact on the gNB power consumption as it has been verified in Rel-10 LTE network energy saving. Thus, Pdyn,ante value should occupy large fraction. The value of A should not be less than 0.7.  The PA efficiency value η should be set to 1 since the power consumption and the PA efficiency is not linear. |
| Intel | Qualcomm’s concern on the formula for obtaining overall power consumption in a slot is not clear to us. It should be a “weighted sum”, not just “sum” of power consumption over the symbols. We didn’t see any concern on the example we provided earlier. For generalization, we could try the following formula.  Where . This is just for considering the most general case where different DL and UL symbols in the slot may occupy different amount of resources. |
| QCOM 1 | Although it is understandable that the goal is to have a simplified scaling model – which is also supported – the most important criterion of the modeling is that the modeling should be correct. Only with a correct BS power consumption model the right conclusions can be made. It is known in the group that PA consumes most of the power within the BS; it is also known in the group that PA efficiency changes when the PA output power level changes. Hence, in the formula above, the term η is the scaling factor (of the PA efficiency), similarly to the terms *sf, sp*. Therefore, it is suggested to replace in the formula the term *η* with the term s*η*.  The most important though is that a single fixed value for *η* (or s*η)* is going to lead into wrong results and conclusions. As an example, consider that a single fixed value for *η* (or s*η*) equal to 1 is considered. If the proposed formula is used for the evaluation of dynamic bandwidth or for dynamic power adaptation, then, the final result will be a network power consumption value which will be lower than the actual/real network power consumption. The group will be making conclusions on the basis of over-optimistic results favoring these adaptation techniques. This is misleading and against our role, since all the companies are aware of this “biased outcome” with the single fixed *η* (or s*η)*. The proposal is that the scaling factor of PA efficiency gets 3 different values [0.5, 0.76, 1] which correspond to different *sf\*sp* ratios, namely s*η* = 1 when *sf\*sp* = 1, s*η* = 0.76 when *sf\*sp* = 0.5 and s*η* = 0.5 when *sf\*sp* = 0.25. |
|  |  |
|  |  |

### 7th round

For the below agreements,

|  |
| --- |
| **Proposal 2.5.4:**   * **The BS power consumption for active DL transmission is provided by**   + : a static part of power for BS in active, which is not scaled based on reference configurations.     - Baseline:     - Optional:   + : a dynamic part of power for BS in active, which is scaled based on reference configuration.     - Baseline: , where , , is the fraction of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively       * + is the power part related to PA.         + For simplicity (to be down-selected in this meeting)       * A = [0.1, 0.4, 0.7] * **The BS power consumption for active UL transmission is provided by**   + : a static part of power for BS in active, which is not scaled based on reference configurations.   + : a dynamic part of power for BS in active, which is scaled based on reference configuration and is the percentage of active TRxRUs   + Baseline     - when no scaling is applied (i.e. scaling factor is 1) * For multi-carrier: the total power consumption of BS is calculated as is the sum of the power consumption of each CC;   + for intra-band multi-carrier with contiguous CCs, the power consumption of each additional CC is scaled by [0.7]. * For multi-TRP, the total power consumption of BS is assumed as is the sum of the power consumption of each TRP   + Company to report whether Pstatic is shared among TRPs (if shared, Pstatic is accounted once) * Company to additionally report the assumption for antenna adaptation delay, e.g. immediate, with a transition time of [1-3] ms, etc. * In time domain,   + The power consumption in a slot is the sum of the power consumption associated with symbols in the slot. The symbol may correspond to uplink symbol, downlink symbol, or symbol without uplink and downlink.   + Company to report how the summation is performed along with evaluation results. * Other values for the above scaling formula, and other scaling approaches can be optionally reported, including   + At least = 1 is supported. Additional one or two more values are FFS.   + PUL = P5 (0.8+ 0.2 sf) \* (0.4+ 0.6\*sa).     - Sf is the ratio of RF BW to the maximum system BW |

**FL7 Question 2.2.5: Please further indicate your understanding and preference of highlighted part**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Company** | **Understanding of** | **Preferred/ acceptable value(s) of** | **Preferred/ acceptable value(s) of** | **Other comments** |
| Nokia/Nsb | PA efficiency factor. | **34%** | **0.1** | Thanks to Qualcomm for the reference to our early Tdoc, but for the sake of progress of the study, and limited of TU left, we considered a simplified approach with a fixed value of defined as the PA efficiency factor, which is independent from the transmit power and RF bandwidth occupancy.  The would not depend on the PA efficiency factor (to avoid accounting it twice).  Different companies may have different understand on how to call/derive this value, in the end let’s agree on a single number in percentage  Regarding below bullet item, the yellow highlight part is not clear for us. We proposal to reword it with “e.g. immediate adaptation , or with a transition time of [1-3] ms, etc.”: - Company to additionally report the assumption for antenna adaptation delay, e.g. immediate adaptation, or with a transition time of [1-3] ms, etc. |
| ZTE, Sanechips |  | Open to the value of 0.34, 0.5, or 1 | 0.7 | The power consumption due antenna de-activation should be more power efficient than other domains. Therefore, larger A value is preferred.  Based on the agreements, determination of yita values matters more than definition. |
| Spreadtrum | additional gain of scaling factor for frequency and power domain | 0.76 or 1 | 0.1 | In our understanding, A is weight for antenna domain, and (1-A) is weight for joint frequency and power domain. The weight for joint frequency and power domain may be larger.  1/ may be additional gain of scaling factor for joint frequency and power domain. 1/ may not impact the ratio b/w antenna domain and the joint domain. |
| QCOM7 | PAE scaling factor (the ratio between the evaluated and the reference PAE) | = [0.5, 0.76, 1]  for *sf\*sp* = 0.25, 0.5, 1 respectively |  | When , must be = 1, as in reference transmission power, the PA consumes as was estimated (already capturing the TX power and the PA efficiency), thus  **In case of a single value for** , then is used for evaluation points with smaller power () and / or frequency ().   1. Formula will provide linear reduction in the PA power consumption , which is known to be wrong.   E.g., when reducing power / frequency resources for 0.5 transmit power, (-3dB from reference), then PA power consumption will also be reduced by 0.5   1. Considerable error when comparing of (or any other fixed value) with proposed that reduces with the transmission power in accordance with PA nonlinearity:    1. For , is scaled by **0.66** (**32% increase** over fixed=linear that provides 0.5)    2. For , is scaled by **0.48** (**92% increase** over fixed=linear that provides 0.25)   **Last: we have responsibility towards other study items (e.g., SBFD) and people in the industry looking at the evaluation of gNB power consumption for reference and guidance** |
| Vodafone | PAE scaling factor (the ratio between the evaluated and the reference PAE) | Open for multiple value considering different *sf* and *sp* |  | As commented before, for a more accurate modeling of the PA we prefer to capture in the evaluation a non-linear model for the PA, and thus we prefer having multiple values for varying with *sf* and *sp* rather than a single fixed value. |
| Samsung | **PA efficiency** | **0.34** | **0.1** | We have same view as Nokia. Even if we have same understanding on relationship between PAE and (*sf*, *sp*) as QC, however with evaluation perspective, it is enough to use a value of for simplification of evaluation. In addition, for the details of PAE formula, it seems out of RAN1 scope.  For the value of A, as we mentioned during GTW, the most of power would be consumed in the part related to PA, i.e. . Hence, we suggest 0.1 for A. |
| Intel | PA efficiency factor. | Open to consider range, = 1 needs to be included in the range. | **0.4** | Choice of and A can be coupled. Note that if only a fixed of is used, it could potentially be absorbed into . We suggest to consider a range and companies can report which combination is assumed.  Agree with spreadtrum that the current formulation results in the following where fixed does not change the outcome regardless of value.  We are also OK for these values to be up to the companies to report if we cannot reach consensus. |
| CMCC | PA efficiency factor | 0.5 | 0.4 | For medium to high load, the ratio of PA energy consumption is larger than 50%, we prefer to use A=0.4. |
| MediaTek |  | **0.5** | **0.4** | From current scaling formula, A is related to the BS power when #RB is very small () while #antenna elements are fully enabled (). Given the information, AAU is critical power consuming part of NR BS, we suggest setting A = 0.4, representing certain power consumption whenever #antenna elements are kept large.  The value of is related to slope of scaling in frequency domain and power domain. Given the variety and large range of possible values, as suggested by Qualcomm, we would think 0.5 is a good middle point which is not too biased for different settings. |

## Power model feasibility/applicability

Nokia observes that the different Categories defined for BS power model may lead to different conclusions for a given technique, and propose to discuss the practical hardware feasibility of two types of implementations. Nokia also proposes that the TR to capture that the discussed BS power model is a simplified model from real BS power consumption, and is applicable to single-RAT BS only.

OPPO wants to discuss whether power scaling and sleep mode is supported by legacy BS to align the evaluation baseline for BS energy saving study.

Fujitsu observes similarly as Nokia w.r.t. the difference of categories, and further notes that the difference on the power of active DL compared to micro sleep is relatively small.

Samsung observes that the gap between micro and active UL in Cat 1 seems a bit high thus may need to be further investigated.

### Initial round

It was FL observation, based on previous discussion, that the different power states are closely related to implementations, and companies may not be able to dig into details on how each state is achieved, BS component wise. For now, it is unsure what FL can do for this discussion point to address companies concern. The following can be a starting point.

|  |  |
| --- | --- |
| **FL1/FL2 Proposal 2.5.1:**   * Capture in TR that, the BS power model defined in this study is a simplified model of the real BS power consumption, considering single-RAT NR BSs only. This does not mean a BS cannot benefit from the identified techniques when serving multi-RAT. * In TR, explicitly capture companies input of relative power values and transition times for different sets of reference configurations, as collected in the excel sheet of R1-xxx (*NOTE: if no update from source I, this will be x8312*), and Add a note in TR that an approximate average is performed for determining the entries of the power model table. * Capture that, different power states and transition times is possible for BS today, although different BS types with different number of power state levels, relative power values and transition times can exist. * Companies are invited to share more that can be discussed about feasibility of each category. For example, whether/how to capture hardware operations for state transition. | |
| **Company** | **Comments** |
| Nokia/NSB | By implementation, the multi-RAT BS can utilize the identified techniques defined in this study, even the study is targeting only on the single-RAT.  We could like the proponents of Cat-1 to clarify the HW feasibility in reality.  To our view, the hardware for supporting of the Category 2 can be achieved with the state-of-art components, where the hardware for supporting of the Category 1 targets on more advanced components, which is expected to be feasible in coming few years.  We would like to capture the discussion outcome in the TR for future reference. |
| Spreadtrum | Supportive. We suspect the evolution of gNB is quite fast. There could be some places to be deployed with newly developed gNB. The current power model may not reflect the future gNB. |
| ZTE, Sanechips | Okay for the discussion. |
| Samsung | As mentioned in 2.2.1, we are wondering if each of category gives different tendency on evaluation of NWES techniques, how to make the observation on the NWES techniques? |
| OPPO | As pointed out in our contribution, the power-consumption difference with and without power scaling/sleep mode is obvious even for the BS today, which may have an impact on the energy saving gains when evaluating the potential energy saving techniques. Therefore, for evaluations, whether power scaling and sleep mode can be used for legacy BS needs further discussion. |
| CATT | Both Cats 1 and 2 are the abstract power model for evaluation without any specific design. Thus, we should wait for the evaluation results to determine the outcome without any pre-set conclusion. |
| Vodafone | We are supportive of this proposal |
| Intel | Agree with first bullet. Second to fourth bullets do not seem strongly necessary. We may capture only agreed values of the model in TR |
| FL2 | The following modified texts can be considered:  **Capture in TR that,**   * The BS power model defined in this study is a simplified model of the real BS power consumption, considering single-RAT NR BSs only. This does not mean a BS cannot benefit from the identified techniques when serving multi-RAT. * Different power states and transition times is possible for BS today, although different BS types with different number of power state levels, relative power values and transition times can exist. * A reference to tdoc, instead of the explicit table, which contains companies input of relative power values and transition times for different sets of reference configurations, and a note that an approximate average is performed for determining the entries of the power model table, with minimized adjustment on individual entries in order to align with the dependency of different sets of reference configurations.   Company can continue the discussion on other feasibility aspect. |
| Ericsson1 | Regarding FL2 proposal, first bullet is OK. Other bullets don’t seem necessary – it is sufficient to capture the agreed model in the TR. |
| QC1 | The proposal is fine. Good to add though that even if the model is simplified, correct modeling in terms of factors affecting power consumption and the scaling of these factors is necessary. |
| FL2-2 | FL wants to clarify that the second bullet does not refer to the reported values and states, but a general statements that BS has different power states per different BS types is possible. This can be clarified if needed in TR.  The third bullet, FL considers it is now business as usual – the companies input (prior to averaging) should be recorded somewhere, at least with a reference. This is rather an editorial action which avoid companies outside the session to refer to each individual contribution. |
| Samsung | For the 3rd bullet, we would like to revise as follow for being clear:  **FL1/FL2 Proposal 2.5.1:**   * Capture in TR that, the BS power model defined in this study is a simplified model of the real BS power consumption, considering single-RAT NR BSs only. This does not mean a BS cannot benefit from the identified techniques when serving multi-RAT. * In TR, explicitly capture companies input of relative power values and transition times for different sets of reference configurations, as collected in the excel sheet of R1-xxx (*NOTE: if no update from source I, this will be x8312*), and Add a note in TR that an approximate average is performed for determining the entries of the power model table. * Capture that, transition among different power states, each associated with different transition time, is possible for a BS in today’s technology. It is noted that different BS types may support a different number of power states with different characteristics, i.e., power consumption values and required transition time. ~~Different power states and transition times is possible for BS today, although different BS types with different number of power state levels, relative power values and transition times can exist.~~ * Companies are invited to share more that can be discussed about feasibility of each category. For example, whether/how to capture hardware operations for state transition. |
| Fujitsu | We are fine with proposal modified by Samsung. |
| ZTE, Sanechips | Regarding FL2 proposal, we are okay to capture these into the TR for clarification.  For the determination of average values in the WA, some companies’ category was adjusted during the online session in the last meeting, which should also be reflected in reference Tdoc. |
| Apple | We feel the first bullet might be sufficient already, otherwise we may be just complicating things.  It is not clear to us how to discuss the feasibility of Cat ½. Probably the only possible way is to have the proponents of each category to describe on a high level which components are turned off in different states. It may be useful for our own understanding, but may not be an easy discussion and may be difficult to document. |

### Second/Third round

**FL3 Proposal 2.5.2:**

**Capture in TR that,**

* The BS power model defined in this study is a simplified model of the real BS power consumption, considering single-RAT NR BSs only. This does not mean a BS cannot benefit from the identified techniques when serving multi-RAT.
* Transition among different power states, each associated with different transition time, is possible for a BS in today’s technology. It is noted that different BS types may support a different number of power states with different characteristics, i.e., power consumption values and required transition time.
* A reference to tdoc, instead of the explicit table, which contains companies input of relative power values and transition times for different sets of reference configurations, and a note that an approximate average is performed for determining the entries of the power model table, [with minimized adjustment on individual entries in order to align with the dependency of different sets of reference configurations].

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Intel | OK |
| Ericsson2 | From our perspective it is sufficient to capture that model is for evaluation purposes. We prefer to avoid discussion on specific gNB implementation aspects.  Regarding the 3rd bullet, we don’t see utility of “approximate average”, which itself is a bit imprecise. Listing tdocs as reference is enough, and it would be clear to a reader that the model is based on inputs and discussions in RAN1.  Based on this our suggested updates are as follows:   * The BS power model defined in this study is a simplified model for the purposes of evaluations, considering single-RAT NR BSs only. This does not mean a BS cannot benefit from the identified techniques when serving multi-RAT. * A reference to tdoc, instead of the explicit table, which contains companies input of relative power values and transition times for different sets of reference configurations. |
| Samsung | Okay |
| vivo | We are fine with the proposal |
| ZTE, Sanechips | We are okay to capture these into the TR for clarification.  As we suggested before, some companies’ category was adjusted during the online session in the last meeting, which should also be reflected in reference Tdoc, otherwise, how to derive the final values by average operation is confusing by reading the reference Tdoc. |
| DOCOMO | We are fine with the proposal |
| Spreadtrum | Fine |
| Nokia/Nsb | We propose to have the following re-wording:  **FL3 Proposal 2.5.2:**  **Capture in TR that,**   * The BS power model defined in this study is a simplified model of the real BS power consumption, considering single-RAT NR BSs only. This does not mean a BS cannot benefit from the identified techniques when serving multi-RAT. * Transition among ~~different~~certain power states, each associated with ~~different~~certain transition time, ~~is~~may be possible for a BS in today’s technology. It is noted that different BS types may support a different number of power states with different characteristics, i.e., power consumption values and required transition time. * A reference to tdoc, instead of the explicit table, which contains companies input of relative power values and transition times for different sets of reference configurations, and a note that an approximate average is performed among the values of companies for determining the entries of the power model table, [with minimized adjustment on individual entries in order to align with the dependency of different sets of reference configurations]. |

### 4th round

@Ericsson, ZTE

FL shares that “approximate average” now may become imprecise given the adjustment we made for evaluation purpose.

However, the second bullet which is proposed to be removed from Ericsson might worthwhile being kept, as some companies view the power states/transition time/scaling etc are not supported today. The intention is to convey that today’s BS implementation can already do that, and possibly, FL feel a bit pity not be able to handle various types of BS that were originally interested and proposed by many companies. With the sentence in second bullet, it records that such interest.

**FL4 Proposal 2.6.3:**

**Capture in TR that,**

* The BS power model defined in this study is a simplified model for the purposes of evaluations, considering single-RAT NR BSs only. This does not mean a BS cannot benefit from the identified techniques when serving multi-RAT.
* Transition among certain power states, each associated with certain transition time, may be possible for a BS in today’s technology. It is noted that different BS types may support a different number of power states with different characteristics, i.e., power consumption values and required transition time.
* A reference to tdoc, instead of the explicit table, which contains companies input of relative power values and transition times for different sets of reference configurations.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Intel | ok |
| Samsung | Fine |
| Apple | OK |
| ZTE, Sanechips | Okay for the proposal. There is one typo in the original reference Tdoc x8312, our value of DL active should be cat 2, not cat1. |
| Vivo | OK |
| Vodafone | We’re generally fine with the proposal, however the last bullet on the previous proposal 2.5.1 seems to have been removed:   * Companies are invited to share more that can be discussed about feasibility of each category. For example, whether/how to capture hardware operations for state transition.   Would it be possible to clarify the concern on keeping this bullet? |
| Nokia/Nsb | We support.  Especially, we think it is important to capture the 2nd-subbullet in the TR as a reference for our future readers and customers.  Based on the comments/feedback received via the email discussions from companies, we do agree that the evolution of HW technologies is developing fast. But still at the moment when we are working on this study, we don’t see some of the HW components is there in reality today, especially HW components to support of Cat1. Therefore, to our view, we should make it clear in the TR that some of the HW components relate to this study is at the stage of “may be” there. Again, it is serving as the reference for future readers and customers of this study. |
| DOCOMO | OK |
| Spreadtrum | Fine |
| InterDigital | Ok with the text in Proposal 2.6.3 |
| Huawei, HiSilicon | We are fine with the proposal |
| Fujitsu | We are fine with the proposal.  Regarding the input in tdoc x8312, we would like to withdraw our input for Cat. 1 as we prefer Cat. 2 after further consideration in the perspective of HW feasibility. |
| Ericsson4 | 1st bullet : We are OK.  2nd bullet : We are not OK. This seems to imply that the power states in the power models are intended for capturing current/future/expected gNB behavior, preferred implementation, etc. This should be avoided.  3rd bullet : We are OK in principle assuming this is simply referring to listing the respective company Tdocs in the TR. Suggested change is below.   * *A reference to company contributions ~~tdoc, instead of the explicit table,~~ which contains companies input of relative power values and transition times for different sets of reference configurations.* |
| CATT | We are OK with 1st and 3rd bullets.  2nd bullet is not needed since the implementation are different for each vendor. |
| FL5 | @ Vodafone:  The sentence is used for inviting companies to extend such discussion, however it appears to be no following-up. With that, it was not focused anymore, while FL can keep the discussion open around that point, which does not affect what can be agreed to be captured into TR, as proposed here. Let’s continue the discussion in section 2.6.4 of 5th round.  @ ZTE, Fujitsu, Ericsson  Given the suggestion from Ericsson, an alternative is that FL simply refers to previous FL summaries – Note this is anyway needed as business as usual in the TR reference part. There is no need to update/withdraw then. There is also no need of a specific agreement for that purpose. FL as Editor will add that directly.  @Ericsson, CATT  Although the first sentence of the 2nd bullet is already ‘may be’, it can be removed since you are concerned.  Would the second sentence be Ok for Ericsson, CATT? It is actually speaking the same as CATT.  *It is noted that different BS types may support a different number of power states with different characteristics, i.e., power consumption values and required transition time.*  @ ALL  Additionally, FL consider that there is no hard requirement that a source company originally proposed e.g. Cat 2 cannot use the values from Cat 1 for their evaluations. It is certainly one of the benefits that a same company can evaluate both for enabling more insights.  **FL5/FL6 Proposal 2.6.3:**  **Capture in TR that,**   * The BS power model defined in this study is a simplified model for the purposes of evaluations, considering single-RAT NR BSs only. This does not mean a BS cannot benefit from the identified techniques when serving multi-RAT. * ~~Transition among certain power states, each associated with certain transition time, may be possible for a BS in today’s technology.~~ It is noted that different BS types may support a different number of power states with different characteristics, i.e., power consumption values and required transition time. * ~~A reference to tdoc, instead of the explicit table, which contains companies input of relative power values and transition times for different sets of reference configurations.~~ |
| Samsung | Okay |
| Ericsson5 | OK. |

### 5th /6th round

**FL5/FL6 Point 2.6.4:**

**Companies are invited to continually share more that can be discussed about feasibility of each category. For example, whether/how to capture hardware operations for state transition.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Intel | BS power model category 2 requires cell to have much longer periods of non-activity, e.g. in the order to 640 msec to 10 sec, before deeper sleep modes can be leveraged. Since the user traffic are generated on average of 200 msec, cells that have any active user may not be able to leverage deeper sleep modes. This creates difficulty in obtaining insightful observations even at low load scenarios. |
| ZTE, Sanechips | We need to response to Intel that based on current agreed traffic model, the mean arrival time for IM is 2s,instead of 200ms.  Meanwhile, proper adjustment of package arrival time or size, is also not precluded based on the previous agreements. |
| Nokia/Nsb | We don’t agree to delete the sentence of the 2nd-bullet.  To our view, during the study, we have openly considered that different companies may have different HW implementation preferences, and that’s why we had the two Categories being agreed in the power modelling for the evaluation purpose. However, in the SI phase the related implementation issues are typically open based on companies’ choice, and companies have different understanding on this issue. In order to capture the above in the TR properly, we should have the generic description to capture these aspects. |
| CATT | The power model is to characterize and emulate the gNB power consumption. The value defined in power model is for evaluation only and has nothing to do with technologies used in gNB. In particular, the gNB HW implementation usually use for much longer time than the mobile device. The technologies of 5G base station in the field might use the hardware technologies 4 years ago from the inception of 5G base station. Thus, we don’t agree to include 2nd bullet. |

### 7th round

Please only indicate if you object this below.

**FL7 Proposal 2.6.5:**

**Capture in TR that,**

* The BS power model defined in this study is a simplified model for the purposes of evaluations, considering single-RAT NR BSs only. This does not mean a BS cannot benefit from the identified techniques when serving multi-RAT. Different BS types may support a different number of power states with different characteristics, i.e., power consumption values and required transition time.

**FFS whether to have a general note as**

* Transition among certain power states, each associated with certain transition time, may be possible for a BS in today’s technology.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia/Nsb | @Ericsson, CATT, FL: we have the following re-wording proposal regarding the removed 2nd-bullet point, we hope the re-wording addresses the concern from Ericsson and CATT. And conclude together with Proposal 2.6.5.   * Transition among power states, transition time, are implementation specific, and it is noted that different BS types may support a different number of power states with different characteristics, i.e., power consumption values and required transition time. |
| Apple | We are fine with the FL proposal. |
| Samsung | We are okay with FL’s proposal without FFS. |
| Intel | We are OK with FL propsoal |

# Methodology

## Simulation assumption

Huawei/HiSilicon and Intel: add channel model for FR1.

Nokia: proposes SLS assumptions for different sets of reference configurations.

OPPO: clarify the channel model and percentage of high loss and low loss building type.

CATT: baseline configuration and normal network operation should be defined in order to obtain the energy consumption of normal network operation and to identify the potential network energy saving technique.

MediaTek: propose detailed configurations for common signals of SSB and SIB1.

Nokia provides a relatively complete table includes FR2 SLS assumptions, and Samsung, Lenovo consider the proposal in the FFS of previous agreements is reasonable and considerable, with small clarification for BS antenna configurations traffic model, and total Tx power etc in order to address potential concern raised in the previous discussion w.r.t. prioritized Urban Micro. Ericsson view Table A2.1-1 of TR 38.802 can be used as the baseline for FR2.

Qualcomm consider that***:*** *the actual total DL transmission power is adjusted according to the actual bandwidth and the number of active TxRUs as follows*

* *, and are total DL power level, bandwidth, and the number of TxRUs in the reference configuration, respectively.*

*and are the actual bandwidth and the number of active TxRUs, respectively*.

### Initial round

For FR1, since there are baseline SLS assumptions ready, FL tends to identify the delta parts that would be additionally needed. Given what Nokia/NSB is proposing, it seems more configurations can be clarified, which meanwhile can be partially served as a ‘normal network operation’ as preferred by CATT, except that the paging transmission, CORESET configuration, UL control resources, CA/DC configurations (including PDCCH and CSI-RS configuration in SCell) are still missing.

For FR2 SLS assumptions, proposals are available based on a few contributions. FL takes Nokia’ proposal which is a complete set on the table.

As for the reference configuration, if there are other parameter used than the agreed reference configurations, Qualcomm proposed formula could be considered. Note if we can agree on a set of unified power values and transition time as being proposed by FL in section 2.2, the proposal from Qualcomm will not have impact on other relevant calculation, e.g. transition energy, scaling etc.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Companies are invited to share your view on which of the rows are needed for alignments; otherwise, the corresponding parameters could be up to company report.  **FL1/FL2 Proposal 3.2.1-rev1:**   * **For FR1 SLS assumptions, add parameters in the below table as additional SLS parameters.**  |  |  |  |  | | --- | --- | --- | --- | |  |  | Set 1 FR1 | Set 2 FR1 | | **1** | **Channel model** | 3D-Uma as in TR 38.901 | 3D-Uma as in TR 38.901 | | **2** | **percentage of high loss and low loss building type** | 100% low loss | 100% low loss | | **3** | **Guard band ratio on simulation bandwidth** | TDD: 2.08% (272 RB for 30kHz SCS and 100 MHz bandwidth) | FDD: 6.4% (104RB for 15kHz SCS and 20 MHz BW) | | **4** | **HARQ scheme** | Ideal | Ideal | | **5** | **Max HARQ retransmission** | 3 | 3 | | **6** | **Target BLER** | 1~~2~~0% of first transmission | 1~~2~~0% of first transmission | | **7** | **Power control parameters** | Open loop, Alpha=1, P0=-106 dBm | Open loop, Alpha=1, P0=-106 dBm | | **8** | **CSI acquisition** | Periodic, CQI on 2 ms period | Periodic, CQI on 2 ms period | | **9** | **SSB periodicity** | 20 ms, 80ms, 160ms | 20 ms, 80ms, 160ms | | **10** | **SS blocks per SSB burst** | 8 for 3 GHz < FR1 <= 6 GHz | 4 for FR1<=3GHz | | **11** | **SSB time resource** | 2 SSBs per slot  4 symbols for each SSB | 2 SSBs per slot  4 symbols for each SSB | | **12** | **SSB frequency resource** | 20 RBs | 20 RBs | | **~~13~~** | **~~Number of SIB1~~** | ~~1 SIB1 per SSB~~ | ~~1 SIB1 per SSB~~ | | **14** | **SIB1 transmission repetition periodicity** | 20 ms, ~~or~~ 80 ms, 160ms  multiplexing pattern 1 with SSB | 20 ms, ~~or~~ 80 ms, 160ms  multiplexing pattern 1 with SSB | | **15** | **SIB1 time resource** | 1 slot | 1 slot | | **16** | **SIB1 frequency resource** | 24 RBs for 20 ms periodicity,  48 RBs for 80 ms periodicity | 24 RBs for 20 ms periodicity,  48 RBs for 80 ms periodicity | | **~~17~~** | **~~RO periodicity~~** | ~~20 ms~~ | ~~20 ms~~ | | **~~18~~** | **~~RO time resource~~** | ~~2 slots~~ | ~~2 slots~~ |  * **For (Set 3) FR2 SLS assumptions, use Table 9 in x8518 as baseline assumptions** * **Other parameters can be optionally reported.** * **~~The actual total DL transmission power can be optionally adjusted according to the actual bandwidth and the number of active TxRUs as follows~~** * ~~, and are total DL power level, bandwidth, and the number of TxRUs in the reference configuration, respectively.~~ * ~~and are the actual bandwidth and the number of active TxRUs, respectively.~~ | |
| **Company** | **Comments** |
| Huawei, HiSilicon | There are cases where gNB could reduce the PSD and increase the bandwidth to keep the same transmission power. This cannot be covered by the equation of Pt. So, we would suggest not to agree the following bullet and ask company to report.   * **~~The actual total DL transmission power can be optionally adjusted according to the actual bandwidth and the number of active TxRUs as follows~~** * ~~, and are total DL power level, bandwidth, and the number of TxRUs in the reference configuration, respectively.~~ * ~~and are the actual bandwidth and the number of active TxRUs, respectively.~~ |
| LG Electronics | In general, we support the proposal, but we have two comments.  Firstly, the last bullet doesn’t seem to be necessary since the effects of the actual bandwidth and the number of active TxRU are already reflected by the scaling method. Secondly, for row 6, we think 10 % BLER for the first transmission is more typical value.. |
| DOCOMO | We have several comments.   * For “6. Target BLER 20%”, usually we use 10%. If there is no specific reason, we can set target BLER as 10%.   For the calculation of “The actual total DL transmission power”, as we have power scaling discussion in AI 2.4 of this material, the sentence here is not necessary. |
| Nokia/Nsb | We would like to update the following parameters   |  |  |  |  | | --- | --- | --- | --- | | **9** | **SSB periodicity** | 20 ms | 20 ms | | **10** | **SS blocks per SSB burst** | 8 for 3 GHz < FR1 <= 6 GHz | 4 for FR1<=3GHz | |
| Spreadtrum | Basically support. Comment: if we define the common signal/channel which is not accounted into the load, we should also provide OSI/paging assumption? |
| Vivo | We are fine with the proposal. For the transmission power, agree with Huawei that it could be reported by company. |
| ZTE, Sanechips | The following two rows are not consistent, i.e., the SIB periodicity in row 14 can be larger than SSB, but in row 13, it implies the periodicity is the same. Therefore,the row 13 can be removed.   |  |  |  |  | | --- | --- | --- | --- | | **13** | **Number of SIB1** | 1 SIB1 per SSB | 1 SIB1 per SSB | | **14** | **SIB1 transmission repetition periodicity** | 20 ms or 80 ms,  multiplexing pattern 1 with SSB | 20 ms or 80 ms,  multiplexing pattern 1 with SSB | |
| Samsung | Fine with FL’s proposal. The very last subbullet contains typos – they should be ‘B’ and ‘N’. |
| CATT | We are OK with the proposal |
| Intel | We suggest to update the following:   |  |  |  |  | | --- | --- | --- | --- | | **9** | **SSB periodicity** | 20 ms, 80ms, 160ms | 20 ms, 80ms, 160ms | | **14** | **SIB1 transmission repetition periodicity** | 80 ms, 160ms  multiplexing pattern 1 with SSB | 80 ms, 160ms  multiplexing pattern 1 with SSB | | **17** | **RO periodicity** | Depends on paging configuration | Depends on paging configuration | |
| InterDigital | We share same view with LG and DOCOMO that target BLER (row 6) should be 10% |
| FL2 | Please continue to check the **Proposal 3.2.1-rev1** above.  For Spreadtrum comments: it might be difficult to have a commonly agreeable configurations for OSI/paging. Thus they could be up to company report.  As for Intel comments: added more candidate values to be representative. However, if we modify the RO periodicity as suggested, there may be no need to have this row, as it would up to report.  As for BT comment below: this was discussed in previous meetings but not agreeable to majority. Instead, FL added that other optional values can be reported, such that companies can simulate and report configurations with 4T. |
| Ericsson1 | Rows 8-18, we think should be left for proponents to report. The settings proposed do not appear to be suitable configurations for current system from energy efficiency perspective (e.g., aperiodic CSI can be used, SIB1 periodicity can be longer).  Rows 5,6,7 should also be left to proponents to report. |
| FL2-2 | Rows 8-18: FL consider having candidate values for at least some of the rows can reduce the workload significantly. Meanwhile, the current candidates, e.g. SSB up to 160ms can already reflect the possible cases.  Rows 5-7 are also very typical and widely used in many 3GPP studies. It is really unclear how this cause concern. |
| ZTE, Sanechips | For row 8~16, more candidates values are added in the table, which seems no difference in letting companies to report these values. Therefore, we suggest to remove these rows.  For the row 7 of power control, we are not sure about the source of these values.  In TR 36.897, table A.4, the following values are assumed, which can be reused.   |  |  | | --- | --- | | Power control | P0=-80dBm, alpha=0.8 | |
| Samsung | Also, we would like to add SSB periodicity: 20 ms for Set 2 in row 9. |
| QCOM2 | @ Huawei, HiSilicon: Intention of the last bullet that you crossed out is to have fair comparison between the baseline and the enhancement in the evaluation. It does not prevent gNB implementation – similar to all other discussions in this modelling and evaluation methodology item. If the formula is not preferred, we can update the bullets as   * **Companies report the actual total DL transmit power allocation for the baseline and the proposed technique.**   For TDD frame structure of DDDSU, we suggest clarifying the structure of the S slot as S = 10 DL symbols : 2 Guard symbols :2 UL symbols. |
| Ericsson2 | Rows 8-18: while we understand the FL intention to reduce workload, our concern is that some proposed settings do not appear to be suitable configurations for current system from energy efficiency perspective (e.g., aperiodic CSI can be used, SIB1 periodicity can be longer).  Regarding the proposal for FR2, perhaps it would be helpful if an explicit list of entries of table 9 is shown.   * For example, some of the entries should be left to proponent– at least CSI * There are a few items such as ISD, traffic model and CDRX configuration (Table 7?), etc that might need to be clarified. |

### Second/Third/4th round

Based on the comments above, the following is suggested. Please also provide your view on Ercisson2 comments on the Table 9 for FR2.

**FL3/FL4 Proposal 3.2.2:**

* **For FR1 SLS assumptions, add parameters in the below table as additional SLS parameters.**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Set 1 FR1 | Set 2 FR1 |
| **1** | **Channel model** | 3D-Uma as in TR 38.901 | 3D-Uma as in TR 38.901 |
| **2** | **percentage of high loss and low loss building type** | 100% low loss | 100% low loss |
| **3** | **Guard band ratio on simulation bandwidth** | TDD: 2.08% (272 RB for 30kHz SCS and 100 MHz bandwidth) | FDD: 6.4% (104RB for 15kHz SCS and 20 MHz BW) |
| **4** | **HARQ scheme** | Ideal | Ideal |
| **5** | **Max HARQ retransmission** | 3 | 3 |
| **6** | **Target BLER** | 1~~2~~0% of first transmission | 1~~2~~0% of first transmission |
| **7** | **Power control parameters** | Open loop, ~~Alpha=1, P0=-106 dBm~~  P0=-80dBm, alpha=0.8 | Open loop, ~~Alpha=1, P0=-106 dBm~~  P0=-80dBm, alpha=0.8 |
| **~~8~~** | **~~CSI acquisition~~** | ~~Periodic, CQI on 2 ms period~~ | ~~Periodic, CQI on 2 ms period~~ |
| **~~9~~** | **~~SSB periodicity~~** | ~~20 ms(for alignment purpose)~~  ~~Other values are up to report~~ | ~~20 ms(for alignment purpose)~~  ~~Other values are up to report~~ |
| **10** | **SS blocks per SSB burst** | 8 for 3 GHz < FR1 <= 6 GHz | 4 for FR1<=3GHz |
| **11** | **SSB time resource** | 2 SSBs per slot  4 symbols for each SSB | 2 SSBs per slot  4 symbols for each SSB |
| **12** | **SSB frequency resource** | 20 RBs | 20 RBs |
| **~~13~~** | **~~Number of SIB1~~** | ~~1 SIB1 per SSB~~ | ~~1 SIB1 per SSB~~ |
| **~~14~~** | **~~SIB1 transmission repetition periodicity~~** | ~~20 ms(for alignment purpose), Other values are up to report~~  ~~multiplexing pattern 1 with SSB~~ | ~~20 ms (for alignment purpose), Other values are up to report~~  ~~multiplexing pattern 1 with SSB~~ |
| **~~15~~** | **~~SIB1 time resource~~** | ~~1 slot~~ | ~~1 slot~~ |
| **~~16~~** | **~~SIB1 frequency resource~~** | ~~24 RBs for 20 ms periodicity,~~  ~~48 RBs for 80 ms periodicity~~ | ~~24 RBs for 20 ms periodicity,~~  ~~48 RBs for 80 ms periodicity~~ |
| **~~17~~** | **~~RO periodicity~~** | ~~20 ms~~ | ~~20 ms~~ |
| **~~18~~** | **~~RO time resource~~** | ~~2 slots~~ | ~~2 slots~~ |

* **For (Set 3) FR2 SLS assumptions, use Table 9 in x8518 with update below as baseline assumptions**
* Table 9: System-level simulation parameters and assumptions

|  |  |
| --- | --- |
| **BS type** | Micro [9] |
| **Network layout and inter-site distance [6]** | 21 cells Wraparound (ISD=FFS) |
| **Channel model** | Umi |
| **Link direction** | Downlink |
| **Frequency range** | 30GHz |
| **Duplex** | TDD |
| **Frame structure** | DDDSU (S: 10D:2G:2U) |
| **Subcarrier spacing** | 120 kHz |
| **Simulation bandwidth** | 100 MHz |
| **Number of carriers** | 1 CC |
| **Slot size** | 14 OFDM symbols |
| **BS antenna configuration [7]** | ~~2Tx~~  ~~(M, N, P, Mg, Ng; Mp, Np) = FFS~~   2 TxRU (M, N, P, Mg, Ng; Mp, Np) = (4,8,2,2,2;1,1)   (dH, dV) = (0.5λ, 0.8λ) (dg,H, dg,V) = (4.0λ, 3.6λ) |
| **Total Tx power** | 33 dBm, EIRP limited to 63 dBm |
| **BS height [7]** | 10m |
| **BS noise figure** | FR2: 7 dB |
| **BS antenna element gain** | 8 dBi |
| **UE antenna configuration** | 2T/4R, (M, N, P, Mg, Ng ; Mp, Np) = (1,2,2,1,1 ;1,2),  (dH, dV) = (0.5λ, N/Aλ) |
| **UE max transmit power [7]** | 23 dBm |
| **UE BWP** | 100 Mhz |
| **UE height** | 1.5m |
| **UE noise figure** | FR2: 10 dB |
| **UE antenna element gain** | 5 dBi |
| **UE receiver** | MMSE-IRC |
| **UE deployment** | 20% Outdoor in cars: 30km/h,  80% Indoor in houses: 3km/h |
| **Traffic model and C-DRx configuration** | FTP traffic (as per Table 7) |
| **UE density/NW Load** | Follow previous RAN1 agreements |
| **Maximum supported Modulation and coding scheme** | Up to 256QAM |
| **Guard band ratio on simulation bandwidth** | FFS |
| **Channel estimation** | Ideal |
| **HARQ scheme** | Ideal |
| **Max HARQ retransmission** | 3 |
| **Target BLER** | 20% of first transmission |
| **Power control parameters** | Open loop, Alpha=1, P0=-106 dBm |
| **Scheduling algorithm** | PF |
| **Cell selection algorithm** | RSRP Slow Fading |
| **~~CSI acquisition~~** | ~~Periodic, CQI on 2 ms period~~ |
| **SSB periodicity** |  |
| **SS blocks per SSB burst** | 64 for FR2 |
| **SSB time resource** |  |
| **SSB frequency resource** |  |
| **Number of SIB1** |  |
| **SIB1 transmission repetition periodicity** |  |
| **SIB1 time resource** |  |
| **SIB1 frequency resource** |  |
| **RO periodicity** |  |
| **RO time resource** |  |

* **Other parameters can be optionally reported.**
* **Companies report the actual total DL transmit power allocation for the baseline and the proposed technique.**
* **For TDD frame structure of e.g. DDDSU, the S slot is assumed as S = 10 DL symbols : 2 Guard symbols :2 UL symbols.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Intel | If we intend to perform calibration of results, we can understand capturing 20ms SSB and SIB1 periodicities. Otherwise, we suggest these to be up to companies to report. From our perspective, we do not have enough meeting cycles to calibrate first (which is difficult to perform in SLS) and then check for enhancements. |
| Samsung | Generally, we are okay with the proposal.  For FFS in BS antenna configuration, we would like to suggest as below:   2 TxRU (M, N, P, Mg, Ng; Mp, Np) = (4,8,2,2,2;1,1)   (dH, dV) = (0.5λ, 0.8λ) (dg,H, dg,V) = (4.0λ, 3.6λ) |
| FL4 | Updated in blue.  Per Intel comments and previously Ericsson/ZTE’s, configurations for common signals are mostly removed. However, FL realized that SSB periodicity 20ms is already agreed last meeting, thus can also be removed from the proposal aiming for ‘delta’ part – please check whether it is possible to agree on some time/frequency SSB resource configurations.  For some of Ericsson comments for FR2, e.g. ISD=200m is what FL assumes as previously agreed in the prioritized FR2 scenario.  For consistency, perhaps the i\_BLER for FR2 should also be 10%.  I will wait for the proponents to further clarify. |
| Vivo | For Table 9, we have the following comments:   * **ISD** = 200m based the agreements in RAN1#110 meeting. * **UE noise figure** could be 13dB for FR2 aligned with 38.802 A.2.1 for baseline UE * **Traffic model and C-DRx configuration:** Suggest to change to “follow previous RAN1 agreement” * **Target BLER** should be 10% for first transmission that is consistent with FR1 |
| Nokia/Nsb | Regarding Set3 FR2 SLS, here are our updated values/view:   * Traffic model and CDRX configuration are provided in table 10 (in our Tdoc R1-2208518) and as per previous RAN1 agreements (assuming FTP model 3) * for micro deployment, ISD = 200m * Total Tx power=43 (as agreed in the Reference configuration Set 3 FR2) * BS antenna configuration (As per table 7.8-2 of TR 38.900)   + 2 TxRU   + (M, N, P, Mg, Ng; Mp, Np) = (4,4,2,1,2;1,1)   + (dH, dV) = (0.5λ, 0.5λ) (dg,H, dg,V) = (2.5λ, 2.5λ) * Guard band ratio on simulation bandwidth   + 4.8% (66 RB for 120kHz SCS and 100 MHz bandwidth) As per TS 38.104 * for CSI entry, no strong view, it could be reported by companies |
| InterDigital | We are fine with the revised SLS assumptions for FR1 and FR2 |
| Ericsson4 | For FR1, Rows 10, 11 : “up to” should be added to reflect the upper limits on number of SSBs. Number of SSBs can be reported by companies. |
| CATT | We are OK with the proposal |

### 5th /6th round

A few further suggestions are given for FR2 assumptions. Some of them suggest to follow previous agreement, which seems more consistent, so taken.

For others, since the original table is from Nokia, it might be with diversity to also take some of other companies suggestion into account. For the purpose, BS antenna configurations and UE noise figure from Nokia is not taken. Please comment if you have concern or other preference/reasons.

**FL5/FL6 Proposal 3.2.3-rev: (*only changes with color to reflect Intel&Ericsson’s comment*)**

* **For FR1 SLS assumptions, add parameters in the below table as additional SLS parameters.**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Set 1 FR1 | Set 2 FR1 |
| **1** | **Channel model** | 3D-Uma as in TR 38.901 | 3D-Uma as in TR 38.901 |
| **2** | **percentage of high loss and low loss building type** | 100% low loss | 100% low loss |
| **3** | **Guard band ratio on simulation bandwidth** | TDD: 2.08% (272 RB for 30kHz SCS and 100 MHz bandwidth) | FDD: 6.4% (104RB for 15kHz SCS and 20 MHz BW) |
| **4** | **HARQ scheme** | Ideal | Ideal |
| **5** | **Max HARQ retransmission** | 3 | 3 |
| **6** | **Target BLER** | 1~~2~~0% of first transmission | 1~~2~~0% of first transmission |
| **7** | **Power control parameters** | Open loop, ~~Alpha=1, P0=-106 dBm~~  P0=-80dBm, alpha=0.8 | Open loop, ~~Alpha=1, P0=-106 dBm~~  P0=-80dBm, alpha=0.8 |
| **10** | **SS blocks per SSB burst** | Up to 8 for 3 GHz < FR1 <= 6 GHz | Up to 4 for FR1<=3GHz |
| **11** | **SSB time resource** | ~~2 SSBs per slot~~  4 symbols for each SSB | ~~2 SSBs per slot~~  4 symbols for each SSB |
| **12** | **SSB frequency resource** | 20 RBs | 20 RBs |

* **For (Set 3) FR2 SLS assumptions, use Table 9 in x8518 with update below as baseline assumptions**

|  |  |  |  |
| --- | --- | --- | --- |
| **BS type** | Micro | **UE BWP** | 100 Mhz |
| **Network layout and inter-site distance [6]** | 21 cells Wraparound (ISD=200m, as agreed) | **UE height** | 1.5m |
| **Channel model** | UMi | **UE noise figure** | ~~10~~ 13 dB |
| **Link direction** | Downlink | **UE antenna element gain** | 5 dBi |
| **Frequency range** | 30GHz | **UE receiver** | MMSE-IRC |
| **Duplex** | TDD | **UE deployment** | 20% Outdoor in cars: 30km/h,  80% Indoor in houses: 3km/h |
| **Frame structure** | DDDSU (S: 10D:2G:2U) | **Traffic model and C-DRx configuration** | ~~FTP traffic (as per Table 7)~~  follow previous RAN1 agreement |
| **Subcarrier spacing** | 120 kHz | **UE density/NW Load** | Follow previous RAN1 agreements |
| **Simulation bandwidth** | 100 MHz | **Maximum supported Modulation and coding scheme** | Up to 256QAM |
| **Number of carriers** | 1 CC | **Guard band ratio on simulation bandwidth** | 4.8% (64 ~~66~~  RB for 120kHz SCS and 100 MHz bandwidth) As per TS 38.104 |
| **Slot size** | 14 OFDM symbols | **Channel estimation** | Ideal |
| **BS antenna configuration [7]** |  2 TxRU (M, N, P, Mg, Ng; Mp, Np) = (4,8,2,2,2;1,1)   (dH, dV) = (0.5λ, 0.8λ) (dg,H, dg,V) = (4.0λ, 3.6λ) | **HARQ scheme** | Ideal |
| **Total Tx power** | 33 dBm, EIRP limited to 63 dBm (as agreed in ref. conf. set 3) | **Max HARQ retransmission** | 3 |
| **BS height [7]** | 10m | **Target BLER** | ~~2~~10% of first transmission |
| **BS noise figure** | 7 dB | **Power control parameters** | Open loop, Alpha=1, P0=-106 dBm |
| **BS antenna element gain** | 8 dBi | **Scheduling algorithm** | PF |
| **UE antenna configuration** | 2T/4R, (M, N, P, Mg, Ng; Mp, Np) = (1,2,2,1,1;1,2),  (dH, dV) = (0.5λ, N/Aλ) | **Cell selection algorithm** | RSRP Slow Fading |
| **UE max transmit power** | 23 dBm | **SS blocks per SSB burst** | Up to 64 |

* **Other parameters can be optionally reported.**
* **Companies report the actual total DL transmit power allocation for the baseline and the proposed technique.**
* **For TDD frame structure of e.g. DDDSU, the S slot is assumed as S = 10 DL symbols : 2 Guard symbols :2 UL symbols.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Intel | We suggest to revise as follows:   |  |  | | --- | --- | | Guard band ratio on simulation bandwidth | 4.8% (64RB for 120kHz SCS and 100 MHz bandwidth) As per TS 38.104 |   This will be in line with values selected for Set 1 (272) and Set 2 (104), so that values are multiple of 16 or 8 to ease the simulation. |
| Samsung | Fine |
| Ericsson5 | For FR2, minor update for value of ‘SS blocks per SSB burst’ : change it to ‘up to 64’. |
| Intel2 | We should update the description of the bandwidth to be more precise.  7.84% ~~4.8%~~ (64RB for 120kHz SCS and 100 MHz bandwidth) ~~As per TS 38.104~~ |

### 7th round

Updated proposal with combining of the issue 4-1.

**FL7 Proposal 3.2.4:**

* **For FR1 SLS assumptions, add parameters in the below table as additional SLS parameters.**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Set 1 FR1 | Set 2 FR1 |
| **1** | **Channel model** | 3D-Uma as in TR 38.901 | 3D-Uma as in TR 38.901 |
| **2** | **percentage of high loss and low loss building type** | 100% low loss | 100% low loss |
| **3** | **Guard band ratio on simulation bandwidth** | TDD: 2.08% (272 RB for 30kHz SCS and 100 MHz bandwidth) | FDD: 6.4% (104RB for 15kHz SCS and 20 MHz BW) |
| **4** | **HARQ scheme** | Ideal | Ideal |
| **5** | **Max HARQ retransmission** | 3 | 3 |
| **6** | **Target BLER** | 10% of first transmission | 10% of first transmission |
| **7** | **Power control parameters** | Open loop,  P0=-80dBm, alpha=0.8 | Open loop,  P0=-80dBm, alpha=0.8 |
| **10** | **SS blocks per SSB burst** | Up to 8 for 3 GHz < FR1 <= 6 GHz | Up to 4 for FR1<=3GHz |
| **11** | **SSB time resource** | 4 symbols for each SSB | 4 symbols for each SSB |
| **12** | **SSB frequency resource** | 20 RBs | 20 RBs |

* **For (Set 3) FR2 SLS assumptions, use Table below as baseline assumptions**

|  |  |  |  |
| --- | --- | --- | --- |
| **BS type** | Micro | **UE BWP** | 100 Mhz |
| **Network layout and inter-site distance** | 21 cells Wraparound (ISD=200m, as agreed) | **UE height** | 1.5m |
| **Channel model** | UMi | **UE noise figure** | 13 dB |
| **Link direction** | Downlink | **UE antenna element gain** | 5 dBi |
| **Frequency range** | 30GHz | **UE receiver** | MMSE-IRC |
| **Duplex** | TDD | **UE deployment** | 20% Outdoor in cars: 30km/h,  80% Indoor in houses: 3km/h |
| **Frame structure** | DDDSU (S: 10D:2G:2U) | **Traffic model and C-DRx configuration** | follow previous RAN1 agreement |
| **Subcarrier spacing** | 120 kHz | **UE density/NW Load** | Follow previous RAN1 agreements |
| **Simulation bandwidth** | 100 MHz | **Maximum supported Modulation and coding scheme** | Up to 256QAM |
| **Number of carriers** | 1 CC | **Guard band ratio on simulation bandwidth** | 4.8% (64 RB for 120kHz SCS and 100 MHz bandwidth) As per TS 38.104 |
| **Slot size** | 14 OFDM symbols | **Channel estimation** | Ideal |
| **BS antenna configuration** | 2 TxRU: (M, N, P, Mg, Ng; Mp, Np) = (4,4,2,1,2;1,1); (dH, dV) = (0.5λ, 0.5λ) (dg,H, dg,V) = (2.5λ, 2.5λ) | **HARQ scheme** | Ideal |
| **Total Tx power** | 33 dBm, EIRP limited to 63 dBm (as agreed in ref. conf. set 3) | **Max HARQ retransmission** | 3 |
| **BS height** | 10m | **Target BLER** | 10% of first transmission |
| **BS noise figure** | 7 dB | **Power control parameters** | Open loop, Alpha=1, P0=-106 dBm |
| **BS antenna element gain** | 8 dBi | **Scheduling algorithm** | PF |
| **UE antenna configuration** | 2T/4R, (M, N, P, Mg, Ng; Mp, Np) = (1,2,2,1,1;1,2),  (dH, dV) = (0.5λ, N/Aλ) | **Cell selection algorithm** | RSRP Slow Fading |
| **UE max transmit power** | 23 dBm | **SS blocks per SSB burst** | Up to 64 |

* **Other parameters can be optionally reported.**
* **Company can optionally report the actual total DL transmit power allocation for the baseline and the proposed technique, if different from the agreed reference configuration.**
* **For TDD frame structure of e.g. DDDSU, the S slot is assumed as S = 10 DL symbols : 2 Guard symbols :2 UL symbols.**
* **Additionally, for FR1, include the following SLS assumptions as an optional scenario:**
  + **BS antenna configuration: 4T**
  + **BS Total Tx power: derived based on the scaling methodology (developed in section 2.5)**
  + **SS blocks per SSB burst: reduced to 1**
  + **Other assumptions are same as those corresponding to Set 2 reference configuration.**
  + **Additional transition energy is calculated similarly as the methodology used in UE power saving study**
    - **Company to report the used/calculated values**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia/Nsb | OK |
| ZTE, Sanechips | Okay. |
| Apple | OK |
| QCOM 2 | For Set 3 FR 2 simulations, the suggested BS Antenna configuration (M, N, P, Mg, Ng; Mp, Np) = (4,4,2,1,2;1,1), results in 4 TxRUs, a BS Antenna Configuration for 2 TxRuS should be this one (4,4,2,1,**1**;1,1) |
| Vodafone | OK |
| Samsung | We are fine with FL proposal with minor updates in row 10 for FR1 as below.   |  |  |  |  | | --- | --- | --- | --- | | **10** | **SS blocks per SSB burst** | Up to 8 ~~for 3 GHz < FR1 <= 6 GHz~~ | Up to 4 ~~for FR1<=3GHz~~ | |
| Intel | We commented above it seems not fully reflected. We suggest following revision   |  |  | | --- | --- | | **Guard band ratio on simulation bandwidth** | ~~4.8%~~ 7.8% (64 RB for 120kHz SCS and 100 MHz bandwidth) ~~As per TS 38.104~~ | |

# Others for performance evaluation, if any

|  |  |
| --- | --- |
| **Company** | **Comments** |
| BT | Base station 4T antenna configuration should be included in evaluation. |
| Vodafone | We’re also keen on including 4T antenna configurations in the evaluation |
| Nokia/Nsb | The same view as BT and Vodafone, the 4T antenna configuration is an important scenario to be considered in the evaluation. |
| Ericsson4 | We also support 4T as an additional evaluation scenario. |
| **FL5 Issue 4-1** | **Companies are invited to suggest minimum necessary parameters in order to enable 4T antenna configuration in FR1 FDD (FL assume) for the evaluations.**  Examples like:   1. In the table of SLS assumption for FR1, add to BS parameter=> antenna configuration: **or 4Tx**, and use the scaling approach for generating the power values for 4Tx 2. Or with “**Companies report the actual total DL transmit power allocation for the baseline and the proposed technique**”, to determine the reference configurations for 4Tx with other parameters same as the current SLS assumptions for Set 2. |
| Samsung | Support the suggestion from BT and Vodafone. Also, okay with FL’s proposal. |
| Nokia/Nsb | For 4T evaluation scenario, we suggest to derive the necessary parameters based on the current SLS assumptions for Set 2. For that we would need the following updates:   * BS antenna configuration: 4T * BS Total Tx power: using the scaling methodology (developed in section 2.5)   Additionally we may consider SS blocks per SSB burst: reduced to 1, where a wider beam can be assumedrather than separate narrow beams. |
| BT | We support FL proposal. |
| **FL6 4-1** | Is the following agreeable?  **For FR1, include the following SLS assumptions as an optional scenario:**   * **BS antenna configuration: 4T** * **BS Total Tx power: derived based on the scaling methodology (developed in section 2.5)** * **SS blocks per SSB burst: reduced to 1** * **Other assumptions are same as those corresponding to Set 2 reference configuration.** * **Additional transition energy is calculated similarly as the methodology used in UE power saving study**   + **Company to report the used/calculated values** |
| CATT | We don’t think the additional SLS optional scenario is needed. |

# Preliminary results

Many companies have provided their preliminary simulation results to this meeting. It would be good to take a look into those while it may be premature to capture observations into TR at this stage. Therefore, after discussed with Intel, FLs consider the preliminary results can be used as a discussion panel for companies to share questions/comments/clarifications, such that in future the simulations can be adjusted/verified if needed. When comments are received, it is preferred that proponents can clarify when possible. Note some results submitted to A.I. 9.7.2 are also gathered here. Before making comments/questions, companies are also invited to read each individual tdoc for details from the source companies.

### Initial round (FL1/FL2 with low priority)

#### Source 1: Nokia/NSB

|  |  |
| --- | --- |
| **Single carrier**   1. **Relaxed periodicity for both SIB1/SSB/RO**     Figure 1: ES gain and impact on UPT from relaxing SSB/SIB/RO periodicity   1. **Reduced number of SSBs per SS Blocks and per slot**     Figure 2: ES gain from reducing the number of SSBs  **Multi-carrier**   1. **SSB-less operation in the ES CC (as per release 17)**     Figure 3: ES gain and impact on UPT from SSB-less operation in ES CC   1. **SIB1-less operation in the ES CC**     Figure 4: ES gain and impact on UPT from SIB1-less operation in ES CC   1. **SSB&SIB1-less operation in the ES CC**      1. *RO periodicity=20 ms*      1. *RO periodicity=160 ms*   Figure 5: ES gain and impact on UPT from SSB&SIB1-less operation in ES CC | |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

#### Source 2: vivo

(Additionally, vivo has more results submitted also in [R1- 2208655](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208655.zip) in AI 9.7.2)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 2. Network resource utilization of different traffic loads   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Load** | **Zero load** | **Low load** | **Light load** | **Medium load** | | **RU** | 0.0% | 6.2% | 20.3% | 36.3% |   Table 3. The UPT and transmit latency performance under different loads   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | **Load** | **Transmit latency (ms)** | | | | **UPT (Mbps)** | | | | | **Mean** | **5%** | **50%** | **95%** | **Mean** | **5%** | **50%** | **95%** | | **Baseline** | Low load | 8.18 | 5.08 | 6.19 | 15.82 | 616.02 | 250.57 | 689.30 | 789.96 | | **ES scheme** | 9.23 | 5.83 | 7.43 | 16.30 | 541.83 | 251.79 | 588.92 | 719.47 | | **Baseline** | Light load | 12.05 | 5.52 | 8.50 | 26.58 | 524.03 | 216.85 | 535.17 | 750.73 | | **ES scheme** | 13.69 | 6.43 | 9.49 | 27.07 | 469.77 | 202.96 | 482.78 | 668.89 | | **Baseline** | Medium load | 21.56 | 6.22 | 12.72 | 53.88 | 436.73 | 165.77 | 424.40 | 699.71 | | **ES scheme** | 21.58 | 7.11 | 13.48 | 54.12 | 401.10 | 162.97 | 393.80 | 634.67 |   Table 4. Power consumption performance under different loads   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | **Load** | **BS power consumption** | | | | **UE power consumption** | | | | | **Mean** | **5%** | **50%** | **95%** | **Mean** | **5%** | **50%** | **95%** | | **Baseline** | Zero load | 75.52 | 75.52 | 75.52 | 75.52 | 89.00 | 89.00 | 89.00 | 89.00 | | **ES scheme** | 63.32 | 63.32 | 63.32 | 63.32 | 89.00 | 89.00 | 89.00 | 89.00 | | **ES gain** | 16.15% | 16.15% | 16.15% | 16.15% | 0.00% | 0.00% | 0.00% | 0.00% | | **Baseline** | Low load | 86.27 | 81.79 | 84.85 | 94.55 | 95.06 | 92.02 | 93.88 | 100.77 | | **ES scheme** | 74.23 | 69.59 | 72.72 | 83.28 | 94.95 | 92.01 | 93.88 | 100.33 | | **ES gain** | 13.96% | 14.92% | 14.30% | 11.92% | 0.11% | 0.01% | 0.00% | 0.44% | | **Baseline** | Light load | 110.61 | 98.72 | 108.07 | 123.93 | 96.09 | 92.22 | 94.74 | 103.39 | | **ES scheme** | 99.97 | 86.60 | 97.08 | 114.55 | 96.06 | 92.28 | 94.78 | 103.01 | | **ES gain** | 9.62% | 12.28% | 10.17% | 7.57% | 0.03% | -0.07% | -0.04% | 0.37% | | **Baseline** | Medium load | 138.35 | 121.48 | 136.23 | 161.79 | 97.76 | 92.73 | 96.18 | 106.74 | | **ES scheme** | 129.75 | 111.17 | 126.45 | 156.58 | 97.82 | 92.73 | 96.22 | 107.12 | | **ES gain** | 6.22% | 8.49% | 7.18% | 3.22% | -0.06% | 0.00% | -0.04% | -0.36% |   Figure 2. SLS result curves for baseline and energy saving scheme | |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

#### Source 3: OPPO

|  |  |
| --- | --- |
| Fig 3. RU, BO and ρ comparison for FTP3 model with 0.5MB packet size and 200ms inter-arrival time    Fig 4. Latency, UPT and energy consumption comparison for FTP3 model with 0.5MB packet size and 200ms inter-arrival time    Fig 5. RU, BO and ρ comparison for FTP3 model with 0.5MB packet size and 200ms inter-arrival time    Fig 6. Latency, UPT and energy consumption comparison for FTP3 model with 0.5MB packet size and 200ms inter-arrival time    Fig 7. Latency, UPT and energy consumption comparison for FTP3 IM model with 0.1MB packet size and 2s inter-arrival time      Fig 8. Latency, UPT and energy consumption comparison for FTP3 IM model with 0.1MB packet size and 2s inter-arrival time | |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

#### Source 4: CATT

(Additionally, CATT has more results submitted also in [R1-2208988](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208988.zip) in AI 9.7.2)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Reduction in the transmission of common control channel/signal in time domain Table 3: Energy saving gain of increasing common control channel periodicity with different system loads   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | SSB/SIB transmission periodicity | System loads | | | | | **Zero** | **9%(low)** | **15%(light)** | **30%(Medium)** | | Energy saving gain | 20ms(baseline) | - | - | - | - | | 40ms | 18.8% | 9.0% | 6.5% | 4.9% | | 80ms | 67.7% | 24.9% | 12.3% | 8.5% | | 160ms | 82.6% | 27.1% | 14.0% | 9.6% | | Note:  a) Category 1 power model is applied.  b) Relative power of SSB and SIB1 =280.  c) For number of beam sweeping L=4, i.e., 4 SSB within one SSB burst for FR1. | | | | | |  gNB DTX/DRX scheme Table 4: The energy saving gain (ESG) of the gNB DTX transmission under different system loads   |  |  |  |  | | --- | --- | --- | --- | |  | System load = 9% | System load = 15% | System load = 30% | | Average ESG of gNB DTX/DRX | 75.3% | 66.1% | 50.1% |  Cell ON/OFF scheme Table 5: The energy saving gain (ESG) of semi-static/dynamic cell ON/OFF   |  |  |  | | --- | --- | --- | |  | Percentage of Cell ON | Network Energy Saving gain of Cell ON/OFF scheme | | Cell without DTX | 63.1% | 23.8% | | Cell with DTX | 65.5% | 47.3% |   Spatial domain  Table 6: The energy saving gain (ESG) of the gNB with TxRU dynamic adaptation under different system loads   |  |  |  |  | | --- | --- | --- | --- | | System load | Average ESG | Average UPT loss | Average latency loss | | 9.0% | 6.9% | 1.2% | 1.7% | | 15.0% | 10.9% | 1.8% | 2.6% | | 30.0% | 10.8% | 1.7% | 2.88% | | |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

#### Source 5: ZTE

|  |  |
| --- | --- |
| Time domain  Figure 2 Evaluation results of SSB-less and SIB-less scheme  Frequency domain  Figure 3 Evaluation results of SSB-less for inter-band CA  Spatial domain  Figure 4 Energy saving gain and UPT impact of antenna reduction | |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

#### Source 6: InterDigital

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 2: Downlink Evaluation results**   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | User traffic load 1: { = {0.14, 0.33} | | | | User traffic load 2: { = {0.33, 0.67} | | | | | Baseline  (Always ON)  Mean UPT(Mbps) | NES  Mean UPT  (Mbps) | UPT gain/loss  (NES vs Baseline)  (%) | ESG  (NES vs Baseline)  (%) | Baseline  (Always ON)  Mean UPT  (Mbps) | NES  Mean UPT  (Mbps) | UPT gain/loss  (NES vs Baseline)  (%) | ESG  (NES vs Baseline)  (%) | | 47.51 | 45.27 | -4.93% | 54.59% | 23.81 | 22.67 | -4.78% | 25.65% |   **Table 3: Uplink Evaluation results – 40 ms gNB sleep cycle**   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | User traffic load: = 0.24 | | | | | | | | | | |  | | | |  | | | | | | | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | | | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs.  NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | | 21.35 | 23.77 | +11.34% | -3.00% |  |  | 21.92 | 22.92 | +4.56% | -3.12% |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | User traffic load: = 1.0 | | | | | | | | | | |  | | | |  | | | | | | | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | | | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs.  NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | | 23.03 | 24.11 | +4.70% | -1.67% |  |  | 22.20 | 22.90 | +3.15% | -1.82% |   **Table 4: Uplink Evaluation results – 160 ms gNB sleep cycle**   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | User traffic load: = 0.24 | | | | | | | | | | |  | | | |  | | | | | | | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | | | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs.  NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | | 17.51 | 23.84 | +36.14% | -5.95% |  |  | 17.37 | 23.07 | +32.78% | -6.20% |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | User traffic load: = 1.0 | | | | | | | | | | |  | | | |  | | | | | | | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | | | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs.  NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | | 19.76 | 24.27 | +22.83% | -3.03% |  |  | 18.83 | 23.56 | +25.14% | -3.08% | | |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

#### Source 7: Samsung

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Time domain  Table 3: Preliminary evaluation results of SSB adaptation   |  |  |  |  |  | | --- | --- | --- | --- | --- | | NW energy saving scheme | ESG for each traffic loads | | Evaluation methodology/baseline assumption | Note | | **Category 1** | **Category 2** | | SSB adaptation  From 8 SSBs to 2 SSBs | Light\_0 load: 5.20 %  Light\_1 load: 7.25 %  Low load: 10.60 % | Light\_0 load: 3.61 %  Light\_1 load: 4.71 %  Low load: 6.24 % | Baseline: {8 SSBs in burst, ssb-periodicity: 20 ms}  Reduced: {2 SSBs in burst, ssb-periodicity: 20 ms} | Traffic loads [RU]:  {28.56%, 17.42%, 6.03%} | | Light\_0 load: 2.82 %  Light\_1 load: 3.89 %  Low load: 6.30 % | Light\_0 load: 1.89 %  Light\_1 load: 2.43 %  Low load: 3.40 % | Baseline: {8 SSBs in burst, ssb-periodicity: 40 ms}  Reduced: {2 SSBs in burst, ssb-periodicity: 40 ms} | Traffic loads [RU]:  {28.56%, 17.42%, 6.03%} | | Light\_0 load: 1.01 %  Light\_1 load: 1.58 %  Low load: 3.66 % | Light\_0 load: 0.48 %  Light\_1 load: 0.62 %  Low load: 0.88 % | Baseline: {8 SSBs in burst, ssb-periodicity: 160 ms}  Reduced: {2 SSBs in burst, ssb-periodicity: 160 ms} | Traffic loads [RU]:  {28.56%, 17.42%, 6.03%} |   Frequency domain  Table 4: Preliminary evaluation results of BWP adaptation   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | NW energy saving scheme | ESG | UPT loss | Scheduling latency | Packet latency | Evaluation methodology/baseline assumption | Note | | BWP adaptation  from 100 MHz to 60 MHz. | Cat 1 with deep sleep: 39.41 % | 29.93 % | No increase | 41.34% | Baseline: 100MHz with 55 dBm  Reduced: 60 MHz with 53 dBm. | Baseline traffic load:  28.56 % RU  Reduced BW traffic load: 20.42 % RU | | |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

#### Source 8: NTT DOCOMO

|  |  |
| --- | --- |
| Evaluation on sleep modes     1. Relative power consumption (b) Packet throughput   Fig. 1 Power consumption and throughput performance on different sleep modes  Evaluation on power domain techniques    (a) Relative power consumption (b) Packet throughput  Fig. 2 Power consumption and throughput performance on static power reduction | |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

#### Source 9: Qualcomm

|  |  |
| --- | --- |
| Dynamic antenna port adaptation  Figure 1: Network energy consumption  Chart  Description automatically generated  Figure 2: Impact on UPT and coverage (DL SINR)  Dynamic TRP adaptation    Figure 3: Network energy consumption & UPT  Dynamic DL Tx power adaptation  Figure 4: NW energy consumption  Chart  Description automatically generated    Figure 5: Impact on UPT and coverage (DL SINR)  Dynamic UE-group PCell switching      **33%**  Figure 6: Comparison between 1-CC case and 2-CC case depending on cell loading | |
| **Company** | **Comments** |
| QC1 | What is missing is the result on “Light SSB” combined with cell WUS.   |  |  |  | | --- | --- | --- | | ***Energy/Power Consumption*** | ***“Light SSB” combined with on-demand SSB/RMSI/RACH*** | ***Compact SSB/PRACH bursts*** | | ***gNB Avg Power saving with respect to a legacy baseline*** | ***-28%*** | ***-14%*** | | ***UE’s Initial Access Power Consumption penalty or saving*** | ***+0.16 %*** | ***-4%*** | |
|  |  |

#### Source 10: Huawei/HiSilicon

([R1-2208425](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208425.zip), submitted in AI 9.7.2)

|  |  |
| --- | --- |
| Figure 4 Initial system-level simulation results for SSB/SIB1-less operation | |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

#### Source 11: Fujitsu

([R1-2209023](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209023.zip), submitted in AI 9.7.2)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| グラフ, 棒グラフ  自動的に生成された説明グラフ, 棒グラフ  自動的に生成された説明  Figure 5. Simulation results in terms of energy consumption and energy efficiency with and without TxRU adaptation  Table I. UPT performance with and without TxRU adaptation   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | 30% RUR | | 50% RUR | | | Baseline | Dynamic TxRU adaptation | Baseline | Dynamic TxRU adaptation | | 5% UPT [Mbps] | 27.1 | 27.5 | 17.6 | 17.6 | | 50% UPT [Mbps] | 55.2 | 53.5 | 42.3 | 41.6 | | Average UPT [Mbps] | 64.6 | 63.1 | 51.6 | 50.7 | | |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

#### Source 12: Intel

([R1-2209064](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209064.zip), submitted in AI 9.7.2)

|  |  |
| --- | --- |
| Time domain        Figure 17. Comparison of cell throughput and power consumption in load, light, and medium load scenarios with 20 or 160 msec SSB periodicity (Cat 1 BS Power Model)  Frequency domain    Figure 27. Comparison of slot utilization with average of 0.57 user per cell (corresponding to very low load of RU of 1.1% in case of full BW usage) and using 100%, 50%, and 25% of the system bandwidth    Figure 28. Comparison of slot utilization with average of 3.29 user per cell (corresponding to low load of RU of 7.9% in case of full BW usage) and using 100%, 50%, and 25% of the system bandwidth      Figure 29. Comparison of slot utilization with average of 7 user per cell (corresponding to light load of RU of 20.9% in case of full BW usage) and using 100%, 50%, and 25% of the system bandwidth  Spatial domain    Figure 30. Comparison of slot utilization with average of 3.28 user per cell (corresponding to low load of RU of 7.9% in case of full BW and full TxRx usage) and using 100%, 50%, and 25% of the number of antenna elements.    Figure 31. Comparison of slot utilization with average of 7 user per cell (corresponding to light load of RU of 20.9% in case of full BW and full TxRx usage) and using 100%, 50%, and 25% of the number of antenna elements.    Figure 32. Comparison of slot utilization with average of 11 user per cell (corresponding to medium load RU of 38.3% in case of full BW and full TxRx usage) and using 100%, 50%, and 25% of the number of antenna elements.  Power domain    Figure 33. Comparison of slot utilization with average of 3.28 user per cell (corresponding to low load of RU of 7.9% in case of full BW and full TxRx usage) and using 100%, 25%, and 6.25% of maximum transmit power.    Figure 34. Comparison of slot utilization with average of 7 user per cell (corresponding to light load of RU of 20.9% in case of full BW and full TxRx usage) and using 100%, 25%, and 6.25% of maximum transmit power.    Figure 35. Comparison of slot utilization with average of 11 user per cell (corresponding to medium load RU of 38.3% in case of full BW and full TxRx usage) and using 100%, 25%, and 6.25% of maximum transmit power. | |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

#### Source 13: MediaTek

([R1-2209501](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209501.zip), submitted in AI 9.7.2)

|  |  |
| --- | --- |
| Ref.  10.6%↓  Ref.  28.5%↓  Figure 2: BS power consumption comparison with aligned UE DRX offsets (VoIP traffic)  3.0%↓  Ref.  7.4%↓  0.3%↓  0.1%↓  Ref.  Figure 7: BS power consumption comparison with SSB/SIB1-less SCell (video traffic for CA setting)  Ref.  21.7%↓  20.3%↑  4.8%↑  Ref.  19.1%↓  Ref.  15.8%↓  16.3%↓  Figure 8: BS power consumption and data latency comparison with reduced #TxRU in light load (15% - 30%) case with video traffic  Ref.  6.8%↑  31.3%↓  25.3%↓  81.1%↑  36.6%↓  Ref.  Ref.  26.8%↓  Figure 9: BS power consumption and data latency comparison with reduced #TxRU in medium load (30% - 50%) case with video traffic  Figure 10: BS power consumption and data latency comparison with reduced PDSCH power/PSD-level in light load (15% - 30%) case with video traffic  Figure 11: BS power consumption and data latency comparison with reduced PDSCH power/PSD-level in medium load (30% - 50%) case with video traffic | |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

#### Source 14: CEWiT

([R1-2210113](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210113.zip), submitted in AI 9.7.2)

|  |  |
| --- | --- |
| Fig. 1: Energy savings by mandating transmission of lighter version of SSB by inactive gNBs for various loads | |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

# References

1. [R1-2208381](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2208381.zip) BS Sleep States FUTUREWEI
2. [R1-2208424](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2208424.zip) Discussion on performance evaluation for network energy saving Huawei, HiSilicon
3. [R1-2208518](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2208518.zip) NW energy savings performance evaluation Nokia, Nokia Shanghai Bell
4. [R1-2208561](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2208561.zip) Discussion on performance evaluation of network energy savings Spreadtrum Communications
5. [R1-2208654](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2208654.zip) Discussion on NW energy savings performance evaluation vivo
6. [R1-2208776](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2208776.zip) Discussion on network energy saving performance evaluation methods China Telecom
7. [R1-2208832](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2208832.zip) Discussion on NW energy savings performance evaluation OPPO
8. [R1-2208987](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2208987.zip) Evaluation Methodology and Power Model for Network Energy Saving CATT
9. [R1-2209022](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2209022.zip) Discussion on NW energy savings performance evaluation Fujitsu
10. [R1-2209063](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2209063.zip) Discussion on Network energy saving performance evaluations Intel Corporation
11. [R1-2209195](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2209195.zip) Discussion on NW energy saving performance evaluation ZTE, Sanechips
12. [R1-2209348](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2209348.zip) Discussion on network energy saving performance evaluation CMCC
13. [R1-2209452](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2209452.zip) Discussion on performance evaluation for network energy savings LG Electronics
14. [R1-2209500](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2209500.zip) On network energy savings performance evaluation MediaTek Inc.
15. [R1-2210239](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Inbox/R1-2210239.zip) On network energy savings performance evaluation MediaTek Inc.(Rev. of [R1-2209500](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2209500.zip))
16. [R1-2209617](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2209617.zip) Discussion on network energy savings performance Rakuten Symphony
17. [R1-2209653](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2209653.zip) Performance evaluation for network energy saving InterDigital, Inc.
18. [R1-2209742](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2209742.zip) NW energy savings performance evaluation Samsung
19. [R1-2209858](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2209858.zip) Network energy consumption modeling and evaluation Ericsson
20. [R1-2209913](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2209913.zip) Discussion on NW energy savings performance evaluation NTT DOCOMO, INC.
21. [R1-2209996](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2209996.zip) NW energy savings performance evaluation Qualcomm Incorporated
22. [R1-2210021](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2210021.zip) Performance evaluation for network energy saving Lenovo
23. [R1-2208382](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2208382.zip) Potential enhancements for network energy saving FUTUREWEI
24. [R1-2208425](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2208425.zip) Discussion on network energy saving techniques Huawei, HiSilicon
25. [R1-2208519](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2208519.zip) Network energy saving techniques Nokia, Nokia Shanghai Bell
26. [R1-2208562](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2208562.zip) Discussion on network energy saving techniques Spreadtrum Communications
27. [R1-2208655](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2208655.zip) Discussion on NW energy saving technique vivo
28. [R1-2208777](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2208777.zip) Discussion on potential network energy saving techniques China Telecom
29. [R1-2208833](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2208833.zip) Discussion on network energy saving techniques OPPO
30. [R1-2208988](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2208988.zip) Network Energy Saving techniques in time, frequency, and spatial domain CATT
31. [R1-2209023](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209023.zip) Discussion on network energy saving techniques Fujitsu
32. [R1-2209064](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209064.zip) Discussion on Network Energy Saving Techniques Intel Corporation
33. [R1-2209127](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209127.zip) Network energy saving techniques Lenovo
34. [R1-2209196](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209196.zip) Discussion on NW energy saving techniques ZTE, Sanechips
35. [R1-2209296](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209296.zip) Discussions on techniques for network energy saving xiaomi
36. [R1-2209349](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209349.zip) Discussion on network energy saving techniques CMCC
37. [R1-2209425](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209425.zip) Discussion on network energy saving techniques NEC
38. [R1-2209453](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209453.zip) Discussion on physical layer techniques for network energy savings LG Electronics
39. [R1-2209501](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209501.zip) On network energy savings techniques MediaTek Inc.
40. [R1-2209592](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209592.zip) Discussion on network energy saving techniques Apple
41. [R1-2209612](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209612.zip) On Network Energy Saving Techniques Fraunhofer IIS, Fraunhofer HHI
42. [R1-2209618](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209618.zip) Discussion on network energy saving techniques Rakuten Symphony
43. [R1-2209633](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209633.zip) Discussion on potential network energy saving techniques Panasonic
44. [R1-2209655](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209655.zip) Potential techniques for network energy saving InterDigital, Inc.
45. [R1-2209743](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209743.zip) Network energy saving techniques Samsung
46. [R1-2209859](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209859.zip) Network energy savings techniques Ericsson
47. [R1-2209914](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209914.zip) Discussion on NW energy saving techniques NTT DOCOMO, INC.
48. [R1-2209997](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2209997.zip) Network energy saving techniques Qualcomm Incorporated
49. [R1-2210031](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2210031.zip) Discussion on potential L1 network energy saving techniques for NR ITRI
50. [R1-2210113](file:///D:\01%20Standard\3GPP\ran1%20meetings\Docs\R1-2210113.zip) Discussion on Network energy saving techniques CEWiT

# Annex –

## A. Agreements@AI 9.7.1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| @RAN1#109-e  [**R1-2205308**](file:///C:\Users\w00250081\AppData\Local\Temp\Docs\R1-2205308.zip) **FL summary#1 for performance evaluation for NR NW energy savings Moderator (Huawei)**  Agreement  For evaluation purpose, the energy consumption modeling for a BS includes at least the following:   * Reference configuration   + FFS other details   + Note FR1 and FR2 to be separately considered for detailed parameters * Multiple power state(s) including sleep/non-sleep mode(s) with relative power, and associated transition time/energy * Scaling method to be applied at least for non-sleep mode.   + FFS other details including scaling for sleep mode   [**R1-2205402**](file:///C:\Users\w00250081\AppData\Local\Temp\Docs\R1-2205402.zip) **FL summary#2 for performance evaluation for NR NW energy savings Moderator (Huawei)**  Agreement  For evaluation purpose, the BS energy consumption model should at least include the power consumption of BS on slot-level.   * Note that symbol-level power consumption to reflect different BW (or RB utilization) / time-occupancy / tx-rx direction of different symbols in a slot is considered.   + FFS details (e.g. explicit symbol-level power modelling, scaling slot-level power to symbol level power for various cases, etc.)   + Note: system simulation evaluations can be per slot regardless of detailed approach for calculating symbol-level power consumption.   Agreement   * For evaluation, at least for non-sleep mode and TDD, the BS powerconsumption for DL and UL are separately modelled, allowing DL-only transmission or UL-only reception.   + FFS: whether UL-only reception energy consumption model can be derived/simplified from DL-only transmission energy consumption model * FFS: the impact of UL reception and/or DL transmission on sleep modes and associated transition time/energy * FFS: whether/how to define an idle state, where BS is neither transmitting nor receiving but also doesn’t enter into any sleep mode or define it as sleep mode * FFS: whether the model for FDD can be based on the model for TDD   Agreement   * For evaluation purpose,   + Study how to define sleep modes and determine the characteristics for each mode from one or multiple of the below     - Relative power     - Transition time     - Transition energy     - Other approaches are not precluded     - Note: BS components that can be turned off can be considered for discussion purpose when defining the specific values of the characteristics for sleep modes.   + Study whether sleep mode is defined for DL(TX) and UL(RX) jointly or separately   + Study the assumption of order for BS entering/resuming from a sleep mode to another mode (sleep or non-sleep) and the associated transition time and energy, i.e. state machine which may have impact on the transition energy.   Agreement   * For evaluation, the scaling in a BS energy consumption model can be considered based on one or more of the following,   + Number of used physical antenna elements, or TX/RX chains     - FFS: Mapping between used TX/RX chains and used antenna ports     - FFS: Mapping between physical antenna elements and TX/RX chains   + Occupied BW/RBs for DL and/or UL in a slot/symbol in one CC   + number of CCs in CA     - FFS dependency of RF sharing   + number of TRPs   + PSD or transmit power     - FFS dependency on BW scaling     - FFS: PA energy efficiency value   + number of DL and/or UL symbols occupied within a slot   + FFS other domain scaling   + FFS scaling is linearly or else, for each domain * Above does not necessarily imply that BS energy consumption model that takes into account all listed scaling factors will be developed   Agreement  For BS energy consumption evaluation, in addition to the energy saving gain,   * At least UPT/UE power consumption/access delay/latency should be considered for performance impact evaluation * Note: this doesn’t necessarily mean that all the above are considered for all evaluation results. However, multiple KPIs are expected to be evaluated for a given technique. And this does not preclude to consider other KPIs when found appropriate for certain techniques/scenarios.   Agreement  At least urban macro is prioritized for FR1. FFS the baseline deployment assumption for FR2.  Agreement   * FTP3 (0.5MB as packet size, 200ms as mean inter-arrival time), FTP3 IM (0.1MB as packet size, 2s as mean inter-arrival time) and VOIP can be considered in the evaluation * FFS: with possible further prioritization, different model between DL and UL, and/or other traffic models that can be optionally considered. * FFS associated scenarios/configurations, e.g. C-DRX.   [**R1-2205468**](file:///C:\Users\w00250081\AppData\Local\Temp\Docs\R1-2205468.zip) **FL summary#3 for performance evaluation for NR NW energy savings Moderator (Huawei)**  Agreement  For evaluation and BS energy consumption modeling purpose, for single CC case, at least the following in table should be considered for reference configuration   * + Note: other TX-RX RU number and corresponding BS antenna configuration can be considered in SLS assumptions  |  |  |  |  | | --- | --- | --- | --- | |  | Set 1 FR1 | Set 2 FR1 | Set 3 FR2 | | Duplex | TDD | FDD | TDD | | System BW | 100 MHz | 20 MHz | 100 MHz | | SCS | 30 kHz | 15 kHz | 120 kHz | | Number of TRP | 1 | 1 | 1 | | Total number of DL TX RUs | 64 | (working assumption) 32 | 2 | | Total DL power level | 55dBm | [49dBm] – to be further discussed and finalized in future meetings | 43dBm – to be further discussed and finalized in future meetings  EIRP limited to 78dBm – to be further discussed and finalized in future meetings | | Total number of UL Rx RUs | 64 | (working assumption) 32 | 2 |   Agreement  As a starting point,   * macro cell BS for FR1 is assumed for energy consumption model. * FFS: micro cell BS for FR2 is assumed for energy consumption model.   Agreement  The evaluation baseline for energy saving study/evaluation for BS includes at least NR R15 mandatory without capability features. Optional features from R15 onwards (e.g. CA, MIMO) as well as implementation-based energy saving techniques should be explicitly reported and described if used in the evaluation baseline.   * FFS: need of alignment for certain configurations/implementation-based schemes.   Agreement   * Similar to UE power saving study, percentage of energy consumption reduction from the baseline is used to express BS energy saving gain. * SLS is considered as baseline evaluation method. Other method, including numerical analysis and LLS can also be considered. At least one of the methods should be selected and used for evaluation of a specific technique (selection and criteria is up to proponent).   Working assumption  For evaluation, for energy consumption modelling for FDD and the case of simultaneous DL transmission and UL reception for non-sleep mode, study the following with potential down-selection in RAN1#110   * Option 1: the power consumption is the total of DL and UL power consumption * Option 2: the power consumption for UL is neglected * Other option is not precluded * Note the DL (or UL) power consumption can be obtained using a same approach as that obtained from the DL (or UL)-only in TDD model   Final summary in [R1-2205551](file:///C:\Users\w00250081\AppData\Local\Temp\Docs\R1-2205551.zip).  @RAN1#110  **Agreement**  For non-sleep mode, the relative power value in power model table for UL reception and/or DL transmission is provided based on reference configuration.  **Agreement**  For set 2 FR1 FDD TxRx reference configuration, confirm the WA as 32 in reference configuration.  **Agreement**  The total DL power level is 49 dBm for set 2 FR1 FDD reference configuration.  **Proposal 2.1.6-1 –rev2**  **For the purpose of evaluation, adopt the following as BS power consumption model. These entries for this table is per reference configuration set.**   * **FFS: One or multiple values for relative power and transition time.**  |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Power state** | **Characteristic** | Relative Power | Additional transition energy3 | **Total transition time** | | Deep sleep1 | There is neither DL transmission nor UL reception.  Time interval for the sleep should be larger than the total transition time entering and leaving this state. | P1=1 | E1 | T1 | | Light sleep | There is neither DL transmission nor UL reception.  Time interval for the sleep should be larger than the total transition time entering and leaving this state.  (P2>P1) | P2 | E2 | T2 | | Micro sleep | There is neither DL transmission nor UL reception.  Immediate transition is assumed for network energy saving study purpose from or to a non-sleep state. | P3 | 0 | 0 | | Active DL | There is only DL transmission. | P4 | NA | NA | | Active UL | There is only UL reception.  ~~FFS: Whether multiple P5 values are needed to address low power UL mode~~ | P5 | NA | NA | | Note 1: Depending on implementations, there could be a state that the power is lower than deep sleep and requires larger total transition time, e.g. hibernating sleep or Quasi-off, which is not explicitly modeled in this study for evaluation purpose.  Note 3: Unit in relative power times duration. FFS: Details on how transition energy is defined. | | | | |  * For simultaneous DL and UL transmission for FDD, the power for UL reception is neglected in this study. * FFS: Optionally, a state machine where BS may transit between sleep modes without entering non-sleep mode can be considered. Companies are to report the involved sleep modes and the assumptions for inter-sleep mode transition time used in their evaluations. * FFS: Details on how to use the above table for low power uplink reception (e.g. for WUS).   **Working Assumption**  **For reference configuration set 1, the values are provided as below. FFS set2 and set 3.**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Power state** | **Relative Power *P*** | | **Total transition time *T*** | | | Deep sleep | 1 | 1 | Cat 1:  50ms | Cat 2:  10s | | Light sleep | Cat 1: 25 | Cat 2: 2.1 | Cat 1: 6 ms | Cat 2: 640 ms | | Micro sleep | Cat1: 55 | Cat 2: 5.5 | 0 | 0 | | Active DL | Cat 1: 280 | Cat 2: 32 | N.A. | N.A. | | Active UL | Cat 1: 110 | Cat 2: 6.5 | N.A. | N.A. |   **Alternative Proposal 3.1.1.1-1**  For evaluation purpose,   * a load (L) of a cell is a percentage of resources used for UE specific PDSCH / PUSCH * The following load scenarios are considered  |  |  | | --- | --- | | Load scenario | Characteristics | | Idle/empty load | * Include cell-specific signals and channels, and * L = 0 | | low load | * Include cell-specific signals and channels, and * 0 < L≤15 | | Light load | * Include cell-specific signals and channels, and * 0 < L≤ ~~[~~30~~]~~ | | Medium load | * Include cell-specific signals and channels, and * ~~[~~30~~]~~ < L≤ ~~[~~50~~]~~ | | For CA, the companies report whether the load is defined per CC or across all CCs. | |   **Proposal 3.3.1.1-1:**   * **For FR1, urban micro can be optionally considered.** * **For FR2, urban micro is prioritized, with ISD=200 m is assumed.**   **FL1 Proposal 3.2-1:**  **It is up to company report which traffic model is used among the agreed three traffic models in their evaluations.**   * **Other models may be used as well. Parameter (e.g. packet size and arrival rate) adjustment can be optionally considered and reported.**   **Proposal 2.3.1-1:**  **For set 3 FR2 reference configuration, the total DL power level and EIRP limit is set as 33 dBm and 63 dBm respectively. Note EIRP limit is also scaled with the number of TxRU.**  **Alternative Proposal 3.1.3-1:**  **For evaluation purpose, network energy saving gain is computed based on the energy consumptions for a technique and the baseline over the same duration.**  **Agreement**  **For initial evaluations, there is always a non-sleep mode assumed between adjacent sleep modes.**  **Agreement**  **Companies to report the assumption details for the reception of a low-power UL channel/signal, if used, including power states, additional transition energy, and transition times, receiver details (e.g. architecture and receiver sensitivity), and other impact/change on the power consumption model.**  **Agreement**  **Update the RAN1 agreements with the following changes**  In the evaluation,   * a load (L)% of a cell is a percentage of resources used for UE specific PDSCH/PUSCH. * The following load scenarios are considered.  |  |  | | --- | --- | | Load scenario | Characteristics | | Idle/empty load | * Include cell-specific signals and channels, and * L = 0 | | low load | * Include cell-specific signals and channels, and * 0 < L≤15 | | Light load | * Include cell-specific signals and channels, and * 15~~0~~ < L≤30 | | Medium load | * Include cell-specific signals and channels, and * 30 < L≤50 | | For CA, the companies report whether the load is defined per CC or across all CCs. | |   **Proposal 2.1.3.2-1-rev2:**   * **During the transition time period,** **relative power of sleep mode is assumed to be consumed. Additional transition energy and total transition time also include energy and time for both ramping down and ramping up ~~spent in two-way (ramping down and up) during the transition period is considered~~.** * ~~(Working Assumption) for set 1, the additional energy (unit in relative power\*(duration in~~ *~~ms~~*~~)) is~~  |  |  |  | | --- | --- | --- | | ~~Power state~~ | ~~Additional transition energy~~ | | | ~~Category 1~~ | ~~Category 2~~ | | ~~Deep sleep~~ | ~~1350~~ | ~~22500~~ | | ~~Light sleep~~ | ~~90~~ | ~~1088~~ |   **Proposal 2.1.4.2-1-rev1:**   * **The total transition time for set 2 and set 3 is the same as that for set 1.** * **Companies are encouraged to check the input and values provided in section 2.1.4.2 of R1-2208312 for further determination.**   **Conclusion**   * **Companies are encouraged to check discussion in section 2.2.2 of R1-2208312 for scaling discussion in the next meeting.**   **Proposal 3.1.2-1-rev2:**   * **FFS whether to set exact requirements/QoS target for UPT and/or latency impact** * **Other KPIs can be optionally reported, conditioned with clear definition/descriptions provided.** * **Note for potential new channel/signals, e.g. WUS from UE, the assumption for detection reliability at BS side is reported (performance and complexity impact would subject to results and further discussion).**   **Proposal 3.2.2-1-rev1:**  **It is up to company report the use of UE C-DRX.**   * **the baseline configuration (for alignment/calibration) for C-DRX, if reported, can be as below;** * **Other inactivity timer values can be optionally reported**  |  |  |  |  | | --- | --- | --- | --- | | **Traffic type** | **FTP** | **IM** | **VoIP** | | Model | FTP model 3 | FTP model 3 | As defined in R1-070674.  Assume max two packets bundled. | | Packet size | 0.5 Mbytes | 0.1 Mbytes | | Mean inter-arrival time | 200 ms | 2 sec | | DRX Period | 160 ms | 320 ms | 40 ms | | DRX Inactivity timer | 100 ms | 80 ms | 10 ms | | On duration | FR1: 8 ms  FR2: 4 ms | FR1: 10 ms  FR2: 5 ms | FR1: 4 ms  FR2: 2 ms |   **Proposal 3.3.2-1-rev2:**   * **For FR1, adopt the Reference SLS configurations in Annex-A in R1-2208312 as baseline SLS assumptions.**   + **Other carrier frequencies can be optionally considered.** * **FFS For FR2 adopt the Reference SLS configuration used in Dense Urban Config.B in Table2 of RP-180524 for IMT-2020 with the following clarification/update as initial SLS assumption.**   + **BS antenna configurations**     - **2 TxRU (M, N, P, Mg, Ng; Mp, Np) = (4,8,2,2,2;1,1)**     - **(dH, dV) = (0.5λ, 0.8λ) (dg,H, dg,V) = (4.0λ, 3.6λ)**   + **Traffic model & UE density**     - **Follow previous agreements with adjusted UE density**   + **Total transmit power per TRxP**     - **Value scaled from that in set 3 reference configuration considering BW** * **Further adjustment/clarification can be discussed in the next meeting.** |

## B. Agreed SLS configurations for FR1

**Table A The evaluation assumption for BS power consumption model**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Parameters | | |
| Basic parameters | Channel model | ~~3D/HF-Uma based on TR 38.901~~  (low-loss O2I penetration model) | ~~3D/HF-Uma based on TR 38.901~~  (low-loss O2I penetration model) |
| Device deployment | 80% indoor, 20% outdoor | 80% indoor, 20% outdoor |
| Inter-site distance | 500m | 500m |
| Network Topology | 7\*3 Sector | 7\*3 Sector |
| Carrier Frequency | 2.1GHz | 4.0GHz or 2.6GHz |
| Multiple access | OFDMA | OFDMA |
| Duplexing | FDD (for set 2 ref. config) | TDD (for set 1 ref. config.) |
| Numerology | 15KHz,  14 OFDM symbol slot | 30kHz,  14 OFDM symbol slot |
| Guard band ratio on simulation bandwidth | FDD: 6.4% (104RB for 15kHz SCS and 20 MHz BW) | TDD: 2.08% (272 RB for 30kHz SCS and 100 MHz bandwidth) |
| Simulation bandwidth | Follow reference configuration, (equal split of 10 MHz for UL and DL) | Follow reference configuration |
| Frame structure | ~~Full downlink~~ | DDDSU |
| UT attachment | Based on RSRP | Based on RSRP |
| Wrapping around method | Geographical distance based wrapping | Geographical distance based wrapping |
| Traffic model | Follow previous RAN1 agreements | Follow previous RAN1 agreements |
| BS parameters | BS antenna height | 25 m | 25 m |
| BS noise figure | 5 dB | 5 dB |
| BS antenna element gain | 8 dBi | 8 dBi |
| Antenna configuration at TRxP | For 32T: (M,N,P,Mg,Ng; Mp,Np) = (8,8,2,1,1;2,8) (dH, dV)=(0.5, 0.8)λ | For 64T:  ~~(M,N,P,Mg,Ng; Mp,Np) = (12,8,2,1,1;4,8) (dH, dV)=(0.5, 0.8)λ;~~  (M, N, P, Mg, Ng, MP, NP,) = (8, 8, 2, 1, 1, 4, 8).  based on 38.802 |
| UE parameters | UE power class | 23dBm | 23dBm |
| UE noise figure | 9 dB | ~~7~~ 9 dB |
| UE antenna element gain | 0 dBi | 0 dBi |
| UE antenna height | Outdoor UEs: 1.5 m; Indoor Uts: 1.5m or consider floor height | Outdoor UEs: 1.5 m; Indoor Uts: 1.5m or consider floor height |
| Antenna configuration at UE | For 4R: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2)  (dH, dV)=(0.5, N/A)λ | For 4R: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2)  (dH, dV)=(0.5, N/A)λ |
| Transmission parameters | Modulation | Up to 256 QAM | Up to 256 QAM |
| Transmission scheme | SU-MIMO | SU-MIMO |
| SU dimension | For 4Rx: Up to 4 layers | For 4Rx: Up to 4 layers |
| DL CSI measurement | Non-precoded CSI-RS based | Precoded CSI-RS based |
| DL codebook | Type I/II codebook | non-PMI transmission |
| SRS transmission | N/A | For UE 4 Tx ports: Non-precoded SRS |
| CSI feedback | Company to report the assumptions | Company to report the assumptions |
| Interference measurement | SU-CQI; CSI-IM for inter-cell interference measurement | SU-CQI; CSI-IM for inter-cell interference measurement |
| Scheduling | PF | PF |
| Receiver | MMSE-IRC | MMSE-IRC |
| Channel estimation | Non-ideal | Non-ideal |
| Common RS | SSB~~/SIB1~~ period | 20ms | 20ms |
| ~~SSB time resource~~ | ~~Slot#0~slot#3, Slot#0, slot#1, 2 SSB per slot~~  ~~4 symbols for each SSB~~ | ~~Slot#0, slot#1 Slot#0~slot#3, 2 SSB per slot~~  ~~4 symbols for each SSB~~ |
| ~~SSB frequency resource~~ | ~~20RB~~ | ~~20RB~~ |
| ~~SIB1 time resource~~ | ~~slot#10 ~ slot#17~~  ~~slot#10 ~ slot#13~~ | ~~slot#10 ~ slot#13~~  ~~slot#10 ~ slot#17~~ |
| ~~SIB1 frequency resource~~ | ~~40RB~~ | ~~40RB~~ |

(M, N, P, Mg, Ng; Mp, Np)

- M: Number of vertical antenna elements within a panel, on one polarization

- N: Number of horizontal antenna elements within a panel, on one polarization

- P: Number of polarizations

- Mg: Number of panels in a column;

- Ng: Number of panels in a row;

- Mp: Number of vertical TXRUs within a panel, on one polarization

- Np: Number of horizontal TXRUs within a panel, on one polarization

## C. SID abstraction

Study Item (SI) for network energy savings for NR is approved in [1]. For the study of performance evaluation for this SI, the relevant objectives include below

|  |
| --- |
| 1. Definition of a base station energy consumption model [RAN1]  * Adapt the framework of the power consumption modelling and evaluation methodology of TR38.840 to the base station side, including relative energy consumption for DL and UL (considering factors like PA efficiency, number of TxRU, base station load, etc), sleep states and the associated transition times, and one or more reference parameters/configurations.  1. Definition of an evaluation methodology and KPIs [RAN1]  * The evaluation methodology should target for evaluating system-level network energy consumption and energy savings gains, as well as assessing/balancing impact to network and user performance (e.g. spectral efficiency, capacity, UPT, latency, handover performance, call drop rate, initial access performance, SLA assurance related KPIs), energy efficiency, and UE power consumption, complexity. The evaluation methodology should not focus on a single KPI, and should reuse existing KPIs whenever applicable; where existing KPIs are found to be insufficient new KPIs may be developed as needed.   Note: WGs will decide KPIs to evaluate and how.  The study should prioritize idle/empty and low/medium load scenarios (the exact definition of such loads is left to the study), and different loads among carriers and neighbor cells are allowed.  The following example scenarios (mapping between scenarios and network loads is left to the study) including single-carrier and multi-carrier deployments are used as the starting point for discussion on prioritized scenarios for the study.  The following example scenarios are listed in no particular order.   * Urban micro in FR1, including TDD massive MIMO (note: this scenario can also model small cells) * FR2 beam-based scenarios (note: this scenario can also model small cells) * Urban/Rural macro in FR1 with/without DSS (no impact to LTE expected in case of DSS) * EN-DC/NR-DC macro with FDD PCell and TDD/Massive MIMO on higher FR1/FR2 frequency   Note 1: legacy UEs should be able to continue accessing a network implementing Rel-18 network energy savings techniques, with the possible exception of techniques developed specifically for greenfield deployments.  Note 2: the study of energy savings specifically for IAB is not part of the scope.  The study should coordinate with RAN4 as needed. |

## D. Contact list per RAN1#109-e

|  |  |  |
| --- | --- | --- |
| **Company** | **Contact** | **Email address** |
| Apple | Sigen Ye | sigen\_ye@apple.com |
| NOKIA/NSB | Naizheng Zheng | naizheng.zheng@nokia-sbell.com |
| Samsung | Junyung Yi | junyung.yi@samsung.com |
| ZTE,Sanechips | Mengzhu CHEN | chen.mengzhu@zte.com.cn |
| ZTE,Sanechips | Youjun HU | hu.youjun1@zte.com.cn |
| Panasonic | Hongchao LI | Hongchao.Li@eu.panasonic.com |
| Huawei, HiSilicon | Yi Wang | wangyi6@huawei.com |
| Huawei, HiSilicon | Xiaolei TIE | tiexiaolei@huawei.com |
| MediaTek | Weide Wu | weide.wu@mediatek.com |
| Xiaomi | Fu Ting | futing@xiaomi.com |
| CMCC | Yan Li | liyanwx@chinamobile.com |
| CMCC | Lijie Hu | hulijie@chinamobile.com |
| China Telecom | Hang Yin | [yinh6@chinatelecom.cn](mailto:yinh6@chinatelecom.cn) |
| vivo | Gen Li | [reagan.li@vivo.com](mailto:reagan.li@vivo.com) |
| DOCOMO | Yugen Takahashi | yugen.takahashi@docomo-lab.com |
| DOCOMO | JIANG Yu | jiangy@docomolabs-beijing.com.cn |
| QC | Konstantinos Dimou | kdimou@qti.qualcomm.com |
| InterDigital | Erdem Bala | erdem.bala@interdigital.com |
| Spreadtrum | Huayu Zhou | huayu.zhou@unisoc.com |
| OPPO | Hao Lin | lin.hao@oppo.com |
| OPPO | Zuomin Wu | wuzuomin@oppo.com |
| Fujitsu | Tsuyoshi Shimomura | tcsimomura@fujitsu.com |
| Intel | Toufiqul Islam | [toufiqul.islam@intel.com](mailto:toufiqul.islam@intel.com) |
| Ericsson | Ravikiran Nory | [Ravikiran.Nory@ericsson.com](mailto:Ravikiran.Nory@ericsson.com) |
| Ericsson | Ajit Nimbalker | Ajit.Nimbalker@ericsson.com |
| BT | Anvar Tukmanov | Anvar.tukmanov@bt.com |
| BT | Ryan Husbands | Ryan.husbands@bt.com |