3GPP TSG-RAN WG4 #100-e R4-21xxxxx

Electronic meeting, 16th – 27th August 2021

Source: Ericsson

Title: WF on FR2 OOB gain further studies

Agenda Item: x.x.x.x

Document for: Approval

# Introduction

OOB gain and ACRR for FR2 were briefly discussed at RAN4#100-e, but more study is needed. This WF presents a summary of some of the discussion and lists some issues for further consideration in relation to FR2. The considerations presented in this WF are not exhaustive; further issues may be brought to RAN4.

# Discussion

There are four potential sources of interference to other operators arising outside of the passband that a repeater could cause:

* Emissions due to non-linearities within the amplification circuitry in the repeater
* Amplification of thermal noise
* Amplification of unwanted emissions (outside the passband) from other nearby transmitters
* Amplification and distortion of the adjacent operator’s carrier outside of the passband.

Two requirements may be used to regulate the amplification effects, out of band gain and Adjacent Channel Rejection Ratio (ACRR). Further discussion is needed on the relationship between these two requirements and on how the requirements may be derived. During the discussion in the meeting, the following possibilities for understanding the difference were mentioned:

* OOB gain is used to regulate amplification of unwanted emissions from nearby transmitters and thermal noise, whereas ACRR is used to regulate amplification/distortion of other operators carriers
* The relationship between OOB gain and ACRR is similar to the relationship between OBUE and ACLR; one regulates amplification over the whole adjacent channel (ACRR) and the second amplification with a finer granularity (OOB gain)

Further discussion is needed on whether the above statements are correct. Other possibilities for the relationship between OOB gain and ACRR may be considered.

Regarding OOB gain, two companies presented some estimation of the pathlosses between an interferer that creates unwanted emissions and repeater (R4-2113366, R4-2113674). Analysis based on the following assumptions (R4-2113366):

* 24dBi antenna gain at both sides
* Free space pathloss
* 2m and 5m separation

suggested around 30-40dBm, implying a maximum 30-40dB OOB gain (considering DL, in the worst case) to avoid amplifying unwanted emissions, but also that 30-40dB is likely to be too much amplification of other operators carriers. Analysis in R4-2113674 resulted in OOB gain in roughly similar range, when 10 m separation distance was used. In R4-2113366, it was proposed to consider ACRR to regulate amplification of other operators’ carriers and OOB gain to regulate amplification of unwanted emissions from other sources. How much ACRR is needed depends on whether it is assumed that amplification of other carriers creates white noise like interference or something else. Further discussion and analysis is needed to check whether these conclusions are valid or not.

Another company suggested ACRR simulations (R4-2112202).

For radiated requirements in FR2, the following additional considerations are needed, which differ from conducted requirements in FR1:

* For FR2, there will be a main beam with a narrow lobe. Out of passband signals within the main RX lobe will be amplified to a much greater degree than those outside of the lobe. What impact does this have on the requirements ?
* How to deal with potentially different beam sizes / implementations of antenna array for FR2 ?
* Should the OTA requirement be defined as TRP or EIRP ?
  + TRP or EIRP for the output interference ?
  + TRP or EIRP for the input signal ?
  + If so, how to measure TRP at the output vs TRP at the input ? For example, does each direction at the output need to be measured considering the impact of all potential input directions for the output point in question ?
* Can the limits on re-amplified interference be the same as the limits for ACLR on BS/UE ?
* Filtering possibilities need to be taken into account according to R4-2113674, which may impact the frequency offset at which OOB gain can apply

# Conclusion

Companies are encouraged to contribute to RAN4#101-e taking into account these questions. The issues captured in this WF are not necessarily exhaustive.

The questions in section 2 are boiled down to some bullets here:

* Sources of interference outside of the passband:
  + Option 1: Non-linearities in repeater, Thermal noise, interference from other sources, amplification/distortion of other operator carriers
  + Option 2: Other sources

CMCC: I’m a little confused by this issue, do we only consider the interference outside passband or also include the interference inside passband. we think the non-linearities outside passband could also be suppressed by repeater’s outside-passband gain.

Ericsson: We are referring here to outside of passband. In our understanding, the repeater does two things; one is amplify other interference outside of the passband. The other is that the repeater can itself generate interference outside of the passband due to PA non-linearity; basically the same mechanism as a BS or UE. This WF is about requirements relating to re-amplified interference, but in the end we also need to take care of repeater generated interference.

* Relationship between ACRR and OOB gain
  + Option 1: ACRR is to regulate amplification of other operators’ carriers, OOB gain to regulate amplification of unwanted emissions from other sources
  + Option 2: ACRR is to regulate emissions over the whole bandwidth, OOB gain to regulate emissions on a finer granularity
  + Option 3: OOB gain and ACRR are both used to regulate the response to unwanted emission from other sources and to regulate the re-amplification &distortion of other carriers.
  + Option 4: Other…

CMCC: we suggest to add option 3. we share the same view as option 2. ACRR and ACLR requirements are different. However if we finally define outside passband ACLR, it seems analogy filter could both play a very important role in ACLR and ACRR requirements. From this point of view only 45dB outside band ACLR is enough and it could guarantee the out of band gain is enough to suppress amplification from other sources. Maybe we only need to define outside passband ACLR requirements instead of ACRR requirements.

About option1, if we refer to TS 25.956 it seems OOB gain and ACRR are both used to regulate the response to unwanted emission from other sources and to regulate the re-amplification &distortion of other carriers. Maybe option 1 is not a very precise understanding. I just add option 3 for GTW.

Ericsson: Yes fine to consider option 3 too.

QCOM: Option 3 makes sense as both are contributors.

* For regulating amplification of other sources of unwanted interference, the assumptions are:
  + Minimum distance of interference source to repeater (may differ for downlink and uplink, repeater class)
    - Option 1: 2m
    - Option 2: 5m
    - Option 3: Other
  + Is the interference source assumed to be in the repeater main beam ?
    - Option 1: Yes
    - Option 2: No
  + Gain of interference source and repeater:
    - Option 1: 24dBi for both
    - Option 2: Other assumptions
* OOB gain (may be different for UL and DL)
  + Option 1: maximum 30-40dB to mitigate amplification of unwanted emissions
  + Option 2: …

CMCC: from out point of view, the limit of amplification gain is more relax compared with ACRR requirements. therefore, 30-40 doesn’t seem to be a good starting point.

Nokia: Our initial analysis in R4-2113674 ended up in 35…50 dB range, but more analysis is clearly needed.

Ericsson: Yes more work needed. We could remove this altogether if preferred. Also this 30-40dB is only related to amplifying emissions and basically conditional on ACRR regulating amplification of other operator carriers.

* Interference arising from amplification of other operators’ carriers
  + Option 1: The interference after amplification of other operators’ carriers is noise like
  + Option 2: Other option

CMCC: we could take option 1 as a starting point. In previous repeater spec, the signal after repeater’s outside passband amplification is noise like.Ericsson: We assumed as a starting point. Still it may be worth to consider further whether it is possible that e.g. a repeater has some non-linear effects on the RS in other operators carriers, which breaks their channel estimation and has effects worse than noise. Or alternatively if the distortions are linear and can in fact be accounted for in the other operators channel estimation. Or something else…

* ACRR
  + Option 1: Same dB value as ACLR
  + Option 2: ACLR is enough and no ACRR requirement is necessary
  + Option 3: Other

CMCC: as stated previous, we could add another option that ACLR is enough and we don’t need ACRR

Nokia: We think ACRR needs to be discussed further as it regulates emissions originating outside of the repeater whereas ACLR considers only emissions originating from the repeater itself.

* Ericsson: We share the same understanding as Nokia. ACLR assumes an in passband input signal and output signal and is about repeater generated emissions. ACRR is about amplifying signals on the adjacent channel. Assumption on direction of input signal for OOB and/or ACRR requirement
  + Option 1: Directional
  + Option 2: Test from all directions
  + Option 3: other
* Assumption on definition of metric for measuring amplified signal/interference for OOB and/or ACRR
  + Option 1: TRP
  + Option 2: EIRP
* Filtering possibilities and offset at which out of passband gain requirement applies
* Can the limits on re-amplified interference be the same as the limits for ACLR on BS/UE ?
  + Option 1: Yes
  + Option 2: No
  + Option 3: More study needed
  + Option 4: Potentially yes, but it needs to be considered that as well as amplifying other carriers and noise, the repeater may produce it’s own unwanted emissions from IM and so the total interference form re-amplifications and ACLR needs to be considered.

CMCC: option 4 as a starting point and further check whether only ACLR is enough without any ACRR requirements.

Ericsson: If only ACRR then there is no requirement that captures interference generated by the repeater. We can discuss further though.