**3GPP TSG-RAN WG4 Meeting # 98-bis-e R4-2104788**

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Title: TP for TS 38.176-1: Transmitted signal quality

Source: CATT

Agenda item: 5.3.2.3.1

Document for: Discussion

# 1 Introduction

This contribution provides the views on the TP for TS 38.176-1: Transmitted signal quality. TP is provided in Annex for review.

# 2 Discussion

Transmitted signal quality requirements include frequency error, modulation quality and time alignment error requirements. IAB-DU test spec can just reuse BS test spec because the requirements are same. For IAB-MT, frequency error requirements are defined as relative requirement. IAB-MT EVM measurement is still under discussion in core spec, the test spec needs to wait the conclusion. There’s no TAE requirement for IAB-MT. So there’re several issues to be discussed before the TP is prepared.

* How to separate IAB-DU part and IAB-MT part

There could be two approaches to separate IAB-DU and IAB-MT. First is that IAB-DU can refer the whole clause of TS 38.141-1, only IAB-MT part is written. Second is that the whole content is copied from TS 38.141-1 and the content is modified to include both IAB-DU and IAB-MT. This issue is common for every requirement. Second approach may be better because there could be some changes such as declarations, reference spec section number, etc compared with TS 38.141. Referring the whole spec for IAB-DU may also not always be correct. IAB-MT part needs more consideration.

In last meeting, there’s a guideline in WF that the test procedure can be separated as following if they’re different.

1. The procedure for IAB-DU and IAB-MT preferably use different paragraph starting with “For IAB-DU…” and “For IAB-MT”.

The draft TP in annex uses this approach when it’s needed.

* How to test frequency error for IAB-MT

According to the WF [2], the frequency error test can use two options,

* Option 1: Verification can be done together with EVM and allow the alternative to apply BS test equipment
* Option 2: Verify by UE approach including test set-up and test environment.

The first option makes IAB-MT test reuse BS approach which is the same as IAB-DU. The second option reuses UE approach that needs some work. TS 38.521-1 can be the reference but some modifications are needed such as test environment, RMC, etc. Direct referring 38.521-1 is not feasible. Draft TP provides the preliminary structure for this part to collect comments. The details need more work in future meetings.

* EVM test procedure for IAB-MT

EVM test spec can be discussed when core spec is fixed. In the contribution [3], we propose use the same EVM measurement procedure for IAB-DU and IAB-MT. The draft TP is prepared using that assumption. It can be revised if the agreement is different.

# 3 Conclusion

This contribution provides our proposal for the TP for TS 38.176-1: Transmitted signal quality. Draft TP is provided in annex for review. TS 38.141-1 is referred and the modifications are marked to make the review easier. The spec reference number, test model number can be revised when the corresponding TPs are approved.

# Reference

[1] R4-2103856, WF on IAB conformance specification work split and drafting guidelines, Nokia

[2] R4-2103977, WF on Testing aspect on IAB-MT dynamic range, power control and frequency error, Samsung

[3] R4-2104781, Discussion on open issues of IAB-MT EVM measurement, CATT

# TP for TS 38.176-1:

6.5 Transmitted signal quality

6.5.1 General

Unless otherwise stated, the requirements in clause 6.5 apply during the *transmitter ON period*.

6.5.2 Frequency error

6.5.2.1 Definition and applicability

For IAB-DU, frequency error is the measure of the difference between the actual IAB-DU transmit frequency and the assigned frequency. The same source shall be used for RF frequency and data clock generation.

It is not possible to verify by testing that the data clock is derived from the same frequency source as used for RF generation. This may be confirmed by the manufacturer's declaration.

For IAB-MT, frequency error is the measure of the difference between actual IAB-MT transmit frequency and the carrier frequency received from the parent node.

For *IAB-DU type 1-H and IAB-MT type 1-H* this requirement shall be applied at each *TAB connector* supporting transmission in the *operating band.*

6.5.2.2 Minimum Requirement

For IAB-DU, the minimum requirement is in TS 38.174 [2], clause 6.5.1.1.

For IAB-MT, the minimum requirement is in TS 38.174 [2], clause 6.5.1.2.

6.5.2.3 Test purpose

The test purpose is to verify that frequency error is within the limit specified by the minimum requirement.

6.5.2.4 Method of test

Requirement is tested together with modulation quality test, as described in clause 6.5.3.

6.5.2.5 Test Requirements

For IAB-DU, the modulated carrier frequency of each NR carrier configured by the IAB-DU shall be accurate to within the accuracy range given in table 6.5.2.5-1 observed over 1 ms.

**Table 6.5.2.5-1: Frequency error test requirement**

|  |  |
| --- | --- |
| **BS class** | **Accuracy** |
| Wide Area BS | ±(0.05 ppm + 12 Hz) |
| Medium Range BS | ±(0.1 ppm + 12 Hz) |
| Local Area BS | ±(0.1 ppm + 12 Hz) |

For IAB-MT, the mean value of basic measurements of IAB-MT modulated carrier frequency shall be accurate to within ± (0.1 PPM + 12 Hz) observed over a period of 1 ms of cumulated measurement intervals compared to the carrier frequency received from the parent node.

6.5.3 Modulation quality

6.5.3.1 Definition and applicability

Modulation quality is defined by the difference between the measured carrier signal and an ideal signal. Modulation quality can e.g. be expressed as Error Vector Magnitude (EVM). The Error Vector Magnitude is a measure of the difference between the ideal symbols and the measured symbols after the equalization. This difference is called the error vector.

For  *IAB type 1-H* this requirement shall be applied at each *TAB connector* supporting transmission in the *operating band.*

6.5.3.2 Minimum Requirement

For IAB-DU, the minimum requirement is in TS 38.174 [2], clause 6.5.2.1.

For IAB-MT, the minimum requirement is in TS 38.174 [2], clause 6.5.2.2.

6.5.3.3 Test purpose

The test purpose is to verify that modulation quality is within the limit specified by the minimum requirement.

6.5.3.4 Method of test

6.5.3.4.1 Initial conditions

Test environment: Normal; see annex B.2.

RF channels to be tested for single carrier: B, M and T; see clause 4.9.1.

RF bandwidth positions to be tested for multi-carrier and/or CA:

- BRFBW, MRFBW and TRFBW in single-band operation, see clause 4.9.1;

- BRFBW\_T'RFBW and B'RFBW\_TRFBW in multi-band operation, see clause 4.9.1.

6.5.3.4.2 Procedure for IAB-DU

For IAB-DU, the minimum requirement is applied to all *TAB connectors*, they may be tested one at a time or multiple *TAB connectors* may be tested in parallel as shown in annex D.3.1 for *IAB-DU type 1-H*. Whichever method is used the procedure is repeated until all *TAB connectors* necessary to demonstrate conformance have been tested.

1) For a or *TAB connector* declared to be capable of single carrier operation only (D.16), set the *TAB connector* under test to transmit a signal according to the applicable test configuration in clause 4.8 using the corresponding test models:

- NR-IAB-DU-FR1-TM 3.1a if 256QAM is supported by IAB-DU without power back off, or

- NR-IAB-DU-FR1-TM3.1a at manufacturer's declared rated output power if 256QAM is supported by IAB-DU with power back off, and NR-IAB-DU-FR1-TM3.1 at maximum power, or

- NR-IAB-DU-FR1-TM3.1 if highest modulation order supported by IAB-DU is 64QAM, or

- NR-IAB-DU-FR1-TM3.2 if highest modulation order supported by IAB-DU is 16QAM, or

- NR-IAB-DU-FR1-TM3.3 if highest modulation order supported by IAB-DU is QPSK.

For a *TAB connector* declared to be capable of multi-carrier and/or CA operation (D.15-D.16), set the *TAB connector* under test to transmit according to the applicable test configuration and corresponding power setting specified in clauses 4.7 and 4.8 using the corresponding test models on all carriers configured:

- NR-IAB-DU-FR1-TM 3.1a if 256QAM is supported by IAB-DU without power back off, or

- NR-IAB-DU-FR1-TM3.1a at manufacturer's declared rated output power if 256QAM is supported by IAB node with power back off, and NR-IAB-DU-FR1-TM3.1 at maximum power, or

- NR-IAB-DU-FR1-TM3.1 if highest modulation order supported by IAB-DU is 64QAM, or

- NR-IAB-DU-FR1-TM3.2 if highest modulation order supported by IAB-DU is 16QAM, or

- NR-IAB-DU-FR1-TM3.3 if highest modulation order supported by IAB-DU is QPSK.

For NR-IAB-DU-FR1-TM3.1a, power back-off shall be applied if it is declared.

2) Measure the EVM and frequency error as defined in annex H.

3) Repeat steps 1 and 2 for NR-IAB-DU-FR1-TM2 if 256QAM is not supported by IAB-DU or for NR-IAB-DU-FR1-TM2a if 256QAM is supported by IAB-DU. For NR-IAB-DU-FR1-TM2 and NR-IAB-DU-FR1-TM2a the OFDM symbol TX power (OSTP) shall be at the lower limit of the dynamic range according to the test procedure in clause 6.3.3.4 and test requirements in clause 6.3.3.5.

In addition, for *multi-band connector(s)*, the following steps shall apply:

4) For *multi-band connectors* and single band tests, repeat the steps above per involved band where single band test configurations and test models shall apply with no carrier activated in the other band.

6.5.3.4.3 Procedure for IAB-MT

For IAB-MT, the minimum requirement is applied to all *TAB connectors*, they may be tested one at a time or multiple *TAB connectors* may be tested in parallel as shown in annex D.3.1 for *IAB-MT type 1-H*. Whichever method is used the procedure is repeated until all *TAB connectors* necessary to demonstrate conformance have been tested.

1) For a or *TAB connector* declared to be capable of single carrier operation only (D.16), set the *TAB connector* under test to transmit a signal according to the applicable test configuration in clause 4.8 using the corresponding test models:

- NR-IAB-MT-FR1-TM 3.1a if 256QAM is supported by IAB-MT without power back off, or

- NR-IAB-MT-FR1-TM3.1a at manufacturer's declared rated output power if 256QAM is supported by IAB-MT with power back off, and NR-IAB-MT-FR1-TM3.1 at maximum power, or

- NR-IAB-MT-FR1-TM3.1 if highest modulation order supported by IAB-MT is 64QAM, or

- NR-IAB-MT-FR1-TM3.2 if highest modulation order supported by IAB-MT is 16QAM, or

- NR-IAB-MT-FR1-TM3.3 if highest modulation order supported by IAB-MT is QPSK.

For a *TAB connector* declared to be capable of multi-carrier and/or CA operation (D.15-D.16), set the *TAB connector* under test to transmit according to the applicable test configuration and corresponding power setting specified in clauses 4.7 and 4.8 using the corresponding test models on all carriers configured:

- NR-IAB-MT-FR1-TM 3.1a if 256QAM is supported by IAB-MT without power back off, or

- NR-IAB-MT-FR1-TM3.1a at manufacturer's declared rated output power if 256QAM is supported by IAB-MT with power back off, and NR-IAB-MT-FR1-TM3.1 at maximum power, or

- NR-IAB-MT-FR1-TM3.1 if highest modulation order supported by IAB-MT is 64QAM, or

- NR-IAB-MT-FR1-TM3.2 if highest modulation order supported by IAB-MT is 16QAM, or

- NR-IAB-MT-FR1-TM3.3 if highest modulation order supported by IAB-MT is QPSK.

For NR-IAB-MT-FR1-TM3.1a, power back-off shall be applied if it is declared.

2) Measure the EVM and frequency error as defined in annex H.

3) Repeat steps 1 and 2 for NR-IAB-MT-FR1-TM2 if 256QAM is not supported by IAB-MT or for NR-IAB-MT-FR1-TM2a if 256QAM is supported by IAB-MT. For NR-IAB-MT-FR1-TM2 and NR-IAB-MT-FR1-TM2a the OFDM symbol TX power (OSTP) shall be at the lower limit of the dynamic range according to the test procedure in clause 6.3.3.4 and test requirements in clause 6.3.3.5.

In addition, for *multi-band connector(s)*, the following steps shall apply:

4) For *multi-band connectors* and single band tests, repeat the steps above per involved band where single band test configurations and test models shall apply with no carrier activated in the other band.

6.5.3.5 Test requirements

The EVM of each NR carrier for different modulation schemes on PDSCH shall be less than the limits in table 6.5.3.5-1a.

**Table 6.5.3.5-1 EVM requirements for *IAB-DU type 1-H***

|  |  |
| --- | --- |
| **Modulation scheme for PUSCH** | **Required EVM (%)** |
| QPSK | 18.5 % |
| 16QAM | 13.5 % |
| 64QAM | 9 % |
| 256QAM | 4.5 % |

The EVM of each NR carrier for CP-OFDM waveform on PUSCH shall be less than the limits in table 6.5.3.5-2.

**Table 6.5.3.5-2 EVM requirements for *IAB-MT type 1-H***

|  |  |
| --- | --- |
| **Modulation scheme for PUSCH** | **Required EVM (%)** |
| QPSK | 18.5 % |
| 16QAM | 13.5 % |
| 64QAM | 9 % |
| 256QAM | 4.5 % |

For IAB-DU, EVM shall be evaluated for each NR carrier over all allocated resource blocks and downlink slots. Different modulation schemes listed in table 6.5.3.5-1a shall be considered for rank 1.

For IAB-MT, EVM shall be evaluated for each NR carrier over all allocated resource blocks and uplink slots. Different modulation schemes listed in table 6.5.3.5-1b shall be considered for rank 1.

For all bandwidths, the EVM measurement shall be performed for each NR carrier over all allocated resource blocks and downlink slots for IAB-DU or uplink slots for IAB-MT within 10 ms measurement periods. The boundaries of the EVM measurement periods need not be aligned with radio frame boundaries.

Table 6.5.3.5-2, 6.5.3.5-3, 6.5.3.5-4 below specify the EVM window length (*W*) for normal CP for  *IAB-DU type 1-H* and *IAB-MT type 1-H*.

**Table 6.5.3.5-2 EVM window length for normal CP for NR, FR1, 15 kHz SCS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Channelbandwidth (MHz)** | **FFT size** | **Cyclic prefix length for symbols 1‑6 and 8-13 in FFT samples** | **EVM window length *W*** | **Ratio of *W* to total CP length for symbols 1‑6 and 8-13 (%)****(Note)** |
| 5 | 512 | 36 | 14 | 40 |
| 10 | 1024 | 72 | 28 | 40 |
| 15 | 1536 | 108 | 44 | 40 |
| 20 | 2048 | 144 | 58 | 40 |
| 25 | 2048 | 144 | 72 | 50 |
| 30 | 3072 | 216 | 108 | 50 |
| 40 | 4096 | 288 | 144 | 50 |
| 50 | 4096 | 288 | 144 | 50 |
| Note: These percentages are informative and apply to a slot's symbols 1 to 6 and 8 to 13. Symbols 0 and 7 have a longer CP and therefore a lower percentage. |

**Table 6.5.3.5-3 EVM window length for normal CP for NR, FR1, 30 kHz SCS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Channelbandwidth (MHz)** | **FFT size** | **Cyclic prefix length for symbols 1‑13 in FFT samples** | **EVM window length *W*** | **Ratio of *W* to total CP length for symbols 1‑13 (%)****(Note)** |
| 5 | 256 | 18 | 8 | 40 |
| 10 | 512 | 36 | 14 | 40 |
| 15 | 768 | 54 | 22 | 40 |
| 20 | 1024 | 72 | 28 | 40 |
| 25 | 1024 | 72 | 36 | 50 |
| 30 | 1536 | 108 | 54 | 50 |
| 40 | 2048 | 144 | 72 | 50 |
| 50 | 2048 | 144 | 72 | 50 |
| 60 | 3072 | 216 | 130 | 60 |
| 70 | 3072 | 216 | 130 | 60 |
| 80 | 4096 | 288 | 172 | 60 |
| 90 | 4096 | 288 | 172 | 60 |
| 100 | 4096 | 288 | 172 | 60 |
| Note: These percentages are informative and apply to a slot's symbols 1 through 13. Symbol 0 has a longer CP and therefore a lower percentage. |

**Table 6.5.3.5-4 EVM window length for normal CP for NR, FR1, 60 kHz SCS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Channelbandwidth (MHz)** | **FFT size** | **Cyclic prefix length in FFT samples** | **EVM window length *W*** | **Ratio of *W* to total CP length (%)****(Note)** |
| 10 | 256 | 18 | 8 | 40 |
| 15 | 384 | 27 | 11 | 40 |
| 20 | 512 | 36 | 14 | 40 |
| 25 | 512 | 36 | 18 | 50 |
| 30 | 768 | 54 | 26 | 50 |
| 40 | 1024 | 72 | 36 | 50 |
| 50 | 1024 | 72 | 36 | 50 |
| 60 | 1536 | 108 | 64 | 60 |
| 70 | 1536 | 108 | 64 | 60 |
| 80 | 2048 | 144 | 86 | 60 |
| 90 | 2048 | 144 | 86 | 60 |
| 100 | 2048 | 144 | 86 | 60 |
| Note: These percentages are informative and apply to all OFDM symbols within subframe except for symbol 0 of slot 0 and slot 2. Symbol 0 of slot 0 and slot 2 has a longer CP and therefore a lower percentage. |

6.5.4 Time alignment error

6.5.4.1 Definition and applicability

For IAB-DU, this requirement applies to frame timing in MIMO transmission, carrier aggregation and their combinations.

Frames of the NR signals present at the IAB-DU transmitter *TAB connectors* are not perfectly aligned in time and may experience certain timing differences in relation to each other.

For *IAB-DU type 1-H*, the TAE is defined as the largest timing difference between any two signals belonging to *TAB connectors* belonging to different transmitter groups at the *transceiver array boundary*, where transmitter groups are associated with the *TAB connectors* in the transceiver unit array corresponding to MIMO transmission, *carrier aggregation* for a specific set of signals/transmitter configuration/transmission mode.

6.5.4.2 Minimum requirement

The minimum requirements for *IAB-DU type 1-H* are in TS 38.174 [x], clause 6.5.3.1.

6.5.4.3 Test purpose

To verify that the time alignment error is within the limit specified by the minimum requirement.

6.5.4.4 Method of test

6.5.4.4.1 Initial conditions

Test environment: Normal, see annex B.2.

RF channels to be tested for single carrier: M; see clause 4.9.1.

RF bandwidth positions to be tested for multi-carrier and/or CA:

- MRFBW in single-band operation, see clause 4.9.1.

- BRFBW\_T'RFBW and B'RFBW\_TRFBW in multi-band operation, see clause 4.9.1.

6.5.4.4.2 Procedure

For *IAB-DU type 1-H* *TAB connectors* to be tested are identified from the declared sets of *TAB connector beam forming groups* in the TAE groups declaration (D.31).

Compliance is to be demonstrated between all pairs of *single-band connectors and/or multi-band connectors*, however it is not required to exhaustively measure TAE between every combination of pairs of representative connectors. Compliance can be demonstrated by comparison of a reduced set of representative measurement results.

1) Conducted measurement setup:

- For *IAB-DU type 1-H*: Connect two representative *TAB connectors* one from separate TAE group (D.31) to the measurement equipment according to annex D.3.4. Terminate any unused *TAB connector(s).*

2) Set the connectors under test to transmit NR-IAB-DU-FR1-TM 1.1 or any DL signal using MIMO transmission or carrier aggregation.

NOTE: For MIMO transmission, different ports may be configured in NR-IAB-DU-FR1-TM 1.1 (using *PDSCH DMRS ports 1000 and 1001*).

3) For a connectors declared to be capable of single carrier operation only (D.16), set the representative connectors under test to transmit according to the applicable test configuration in clause 4.8 using the corresponding test models in clause 4.9.2 at *rated carrier output power* (Prated,c,AC, or Prated,c,TABC, D.21).

If the connector under test supports intra band contiguous or non-contiguous CA, set the representative connectors to transmit using the applicable test configuration and corresponding power setting specified in clauses 4.7 and 4.8.

If the IAB-DU supports inter band CA, set the representative connectors to transmit, for each band, a single carrier or all carriers, using the applicable test configuration and corresponding power setting specified in clauses 4.7 and 4.8.

For a connector declared to be capable of multi-carrier operation (D.15), set the IAB-DU to transmit according to the applicable test signal configuration and corresponding power setting specified in clauses 4.7 and 4.8 using the corresponding test model in clause 4.9.2 on all carriers configured.

4) Measure the time alignment error between the different PDSCH demodulation reference signals on different antenna ports belonging to different connectorson the carrier(s) from the representative connectors under test.

5) Repeat step 1 - 4 for any other configuration of connectors, which could be required to demonstrate compliance.

In addition, for *multi-band connectors*, the following steps shall apply:

6) For a *multi-band connectors* and single band tests, repeat the steps above per involved *operating band* where single band test configurations and test models shall apply with no carrier activated in the other *operating band*.

6.5.4.5 Test requirement

For MIMO transmission, at each carrier frequency, TAE shall not exceed 90 ns.

For intra-band contiguous CA, with or without MIMO, TAE shall not exceed 285 ns.

For intra-band non-contiguous CA, with or without MIMO, TAE shall not exceed 3.025 µs.

For inter-band CA, with or without MIMO, TAE shall not exceed 3.025 µs.