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RECOMMENDATION FOR RF CLUSTER CONNECTOR FOR USE IN 5G NR 8T8R TDD DEPLOYMENT

Recommendation for RF Cluster Connector for use in 5G NR 8T8R TDD deployment

by NGMN Alliance

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Abstract

The mobile communication industry has an increasing demand for highly integrated antennas with a large number of RF ports. At the same time, antenna size is a critical factor in network deployment which limits the amount of connectors in antennas. Cluster connectors solve this problem through integrating several RF ports into single connectors.

With several options for cluster connector types, there is a need to harmonise the industry towards a common standard solution. This is most urgent for early 5G deployment, where e.g. antennas supporting both several FDD 4T4R bands and TDD/5G NR 8T8R require cluster connectors to meet the antenna size requirments.

In order to provide a cluster connector standard in time for the operator antenna roll-outs, an NGMN cluster connector taskforce project was established. Due to the fact that some operators already started to deploy 8T8R solution, there was a strong demand to standardize a corresponding cluster as soon as possible. Consequently the objectives were split in two phases:

- Phase 1: targeting the early 5G 8T8R deployment with time to market as key driver, and
- Phase 2: targeting a long term solution capable of handling all foreseen relevant port combination cases.

As this white paper is focused on Phase 1 of the project, technical key parameters and criteria for selecting the most suitable connector type were analysed and defined. A list of candidate cluster connector types were presented and compared by specified values. Mock-ups with mechanical functionality were delivered. Appropriate weights for the key parameters were given, reflecting the criticality of each technical parameter in deciding which connector candidate best fits the market needs.

With the Phase 1 objective of selecting one cluster connector as the recommended industry standard for early 5G deployment, the project participants contributed to the decision making through voting procedures, defining the weights for each key parameter as well as rating each connector candidate on all key parameters.

Eventually, the most suitable connector type to standardise as the industry harmonised solution for early 5G deployment, Type C, was identified as the result of the combined weighted scoring of all voting participants.

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1 Introduction and Purpose of Document

Antenna design is facing challenges, e.g. operators need highly integrated antennas to support multi-band FDD 4T4R and LTE TDD/5G NR 8T8R, resulting in more than 20 ports. Antenna size is a critical factor in network deployment which limits the amount of single connectors in antennas.

Cluster connectors (connector including several RF ports) enables compact solutions overcoming this challenge. With cluster connectors, >20 ports supporting multi-band 4T4R and 8T8R can be realised within the size constraints of a typical antenna end cap.

With several different cluster connector solutions under discussion, the standard of cluster connectors needs to be aligned to avoid unmanageable mixed connector combinations in networks on-site. A project team of industry players was organised by NGMN, with the objective of introducing a common cluster connector harmonised across the industry.

This document describes the objective of the NGMN cluster connector taskforce project, outlines the process for reaching an industry wide decision meeting the objective, and summarizes the outcome of the decision.

The focus of this document is on Phase 1 of the NGMN cluster connector project; early 5G deployment of e.g. TDD/5G NR 8T8R antennas.

For the scope of this document, certain words are used to indicate requirements, while others indicate directive enforcement. Key words used numerous time in the paper are:

- ***Shall:*** indicates requirements or directives strictly to be followed in order to conform to this paper and from which no deviation is permitted.
- ***Shall, if supported:*** indicates requirements or directives strictly to be followed in order to conform to this whitepaper, if this requirement or directives are supported and from which no deviation is permitted.
- ***Should:*** indicates that among several possibilities, one is recommended as particularly suitable without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended*).
- ***May:*** is used to indicate a course of action permissible within the limits of this whitepaper
- ***Can:*** is used for statements of capability.
- ***Mandatory:*** indicates compulsory or required information, parameter or element.
- ***Optional:*** indicates elective or possible information, parameter or element.

1.1 References

This white paper incorporates provisions from other publications. These are cited in the text and the referenced publications are listed below. Where references are listed with a specific version or release, subsequent amendments or revisions of these publications apply only when specifically incorporated by amendment or revision of this whitepaper. For references listed without a version or release, the latest edition of the publication referred to applies.

1. IEEE Std. 145-1993 or following versions Standard definitions of Terms for Antennas.
2. 3GPP TS 37.104, v14.1.0, 2016-09 Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) radio transmission and reception.
3. IEC 60529 Degrees of Protection Provided By Enclosures (IP CODE).

4. IEC 62037-6 Passive RF and microwave devices, intermodulation level measurement - Part 6: Measurement of passive intermodulation in antennas

2 Abbreviations and Antenna Terms Definitions

2.1 Abbreviations

The abbreviations used in this whitepaper are explained in the following table:

Abbreviation	Definition
3GPP	3rd Generation Partnership Project
ETSI	European Telecommunication Standards Institute
FDD	Frequency Division Duplex
IEC	International Electrotechnical Commission
IEEE	Institute Electricals and Electronics Engineers
MIMO	Multiple Input/Multiple Output
N/A or n/a	Not Available or Not Applicable
NGMN	Next Generation Mobile Network Alliance
PIM	Passive Inter Modulation
RL	Return Loss
TDD	Time Division Duplex

Table 2.1-1—Acronyms and abbreviations table.

3 Parameter and Specifications

3.1 Format

In this paper the selection criterias will be classified as required or optional.

The following format will be used for specifications:

Criteria Name

Criteria Definition

- A description of the criteria parameter in terms of the evaluation using standard antenna and cellular communications terminology.

Specification Definition

- A definition for each element of the specification and associated unit of measure.
- A description of the specification's area of validity.
- The specification's measurement unit.

Note 3.1.0.1: *For the purpose of this document, the numeric values associated to each parameter shall be always positive when not otherwise specified.*

Relevance

- A short description of the impact of the Criteria definition to the RF Cluster performance and/or communication network performance. **WHY IS THIS CRITIERIA IMPORTANT**
- If needed, an elaboration on issues surrounding the parameter and its specification will be addressed here or in the additional topics section of the whitepaper.

3.2 Selection criteria Parameters

The below listed parameters are all key criteria, i.e. considered as important technical characteristics of the most suitable cluster connector. However, during the technical analysis phase of the project, it was discovered that for certain key parameters, such as RF performance, the differences between solutions were very small or in some cases generally meeting the technical requirements. At the same time, other parameters, such as maturity, had a wide spread among the solutions.

In order to identify the cluster connector that best meets the objective of the project, the weighting scores reflect the criticality of the technical parameter in the decision making. E.g. with minor differences in RF performance, but major differences in maturity, maturity could be considered as more critical when selecting between the connector candidates for phase 1 of the project, with time to market as key driver.

3.2.1 Maturity

Parameter Definition
Maturity refers to at what stage of a product lifecycle the connector is at currently. E.g. concept phase, development phase, final verification phase or commercially available in mass production. In the case of mass production, connectors might have been used in real networks with feedback on reliability available.

Specification Definition
The score values range from 1 = in concept phase to 9 = commercially available.

Relevance
As some operators have started to deploy products using cluster connectors for 8T8R in 2018, maturity is important for phase one, as the key driver is to enable a connector solution harmonized across the industry in time for the early 5G deployment of e.g. 8T8R. Selecting a mature solution ensures that a recommended connector can be supplied in a timely manner to antenna suppliers, and ultimately enable operators to achieve early 5G deployment schedule targets. Selecting an immature solution could potentially have led to a late time to market for the standardized connector, which either could have led to fragmentation on the market due to operators being forced to select from whatever is available, or delaying 5G roll-out waiting for a new connector solution to become available.

3.2.2 Standardization Ready

Parameter Definition
Standardization ready refers to at what stage of standardization the connector is at currently.

Specification Definition
The score values range from 1 = not started, 5 = ongoing to 9 = finalized.

Relevance

This parameter is important as it has an impact on the time to market for a cluster connector standard, which is one the key objective of phase one in this project.

3.2.3 Electrical Performance

Parameter Definition
Electrical performance includes parameters such as PIM performance and power handling capability,

Specification Definition
The score values range from 1 = major gaps or weaknesses to 9 = sufficient for all sub 6GHz FDD & TDD applications.

Relevance
Electrical performance is very important for actual network performance, for example PIM which could negatively affect the network capacity if compromised. However, the differences between connector solutions turned out to be very small, making the parameter not critical when actually selecting among the solutions which best fits the objective of phase I.

3.2.4 Mechanical Performance

Parameter Definition
Mechanical performance includes parameters such as connector size, connector assembly weight including jumpers, IP protection and robustness as well as mounting in antenna and on-site.

Specification Definition
The score values are relative rankings of the connector solution candidates, ranging from 1 = worst to 9 = best.

Relevance
Mechanical performance is important as the connector size impacts the product size, which is of key importance for operators. Other mechanical parameters such as IP protection and robustness impacts the reliability of the products in-field over time, which is always important to ensure. Finally, weight and on-site mounting impacts the installation convenience.

3.2.5 Cable

Parameter Definition
Cable refers to which cable types are supported by the connector, both inside antenna as well as jumper cables.

Specification Definition
The score values range from 1 = significant limitations in using suitable standard cables, to 9 = supports all suitable standard cables. The key point is that the connector type should enable use of the relevant cables for the intended application.

Relevance
This parameter is important, as the connector needs to enable use of suitable standard cables for the intended applications.

3.2.6 Installation Cost

Parameter Definition
Installation cost refers to installation time, additional material- (IP68) and tools necessary (torque wrench).

Specification Definition
The score values are relative rankings of the connector solution candidates, ranging from 1 = worst to 9 = best.

Relevance.
Cost of a connector is in general important, including all aspects from BOM- and manufacturing cost, license fee costs to installation costs. However, since it is not possible within that project to in a fair way compare actual prices between suppliers for the different connector types, what is possible to measure at this stage are license fees and installation costs.

3.3 Selection Process and Methods

The cluster connector project was split into two phases:

- Phase 1 has the target to enable early 5G deployment of TDD/5G NR 8T8R. 8T8R roll-out in networks has already started, driving the need for mature cluster connector solutions available for deployment.
- Phase 2 has the target to achieve a universal cluster connector solution, able to cover all the foreseen relevant port and cable combinations in one connector. For Phase 2 all the requirements need to be discussed and defined first, which still needs some analysis and time.

In general, the approach was to use voting to decide which connector best fits the project objectives, in order to enable all participating organizations to contribute to achieving an industry wide common decision.

3.3.1 Phase 1 process

The method for selecting the most suitable cluster connector for Phase 1 of the taskforce project consisted of a process with several steps, ensuring involvement of the project participants in analyzing and deciding.

First, the key parameters for a suitable cluster connector solution were identified. Those parameters reflected what the market (operators) considered as most important for them. Once identified, more detailed descriptions and scoring criteria were created.

Second, the importance of the different key parameters was taken into account through allocating weights in percentage, for scoring the connector solution candidates. The weight factors were decided through a voting process, where all participating organizations could vote with a proposal for weights for each key parameter. The final weights for each key parameter was the result of the combined votes from the participants.

Third, the scoring of connector solutions was done similarly, where each participating party could vote. In order to reflect the focus on what is important for the users of the connector (operators and network equipment suppliers), higher voting weight was allocated to the customer group, compared to the connector supplier group. Basically, giving higher importance to what the buyer/user rate as important, than what the connector seller does. This was implemented through splitting the decision-making matrix into two parts; one for customers (operators and equipment suppliers), and one for connector suppliers.

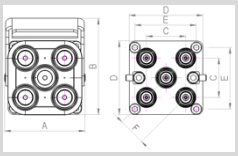
The final result was calculated through combining the weighted scoring from all participating organizations.

3.3.2 Phase 2 process

Will be defined in Phase 2 of the NGMN cluster connector project

4 RF cluster connector candidate solutions

The table below summarizes the key parameters of the cluster connector candidates included in this project.

	Type A 4-port	**Type A 5-port**	**Type B** Allows all kinds of inserts (coax, DC, AISG, fiber, etc.). Bellow mentioned technical values refer to coax insert 2.2-5 (IEC 61169-66).	**Type C (MQ4) 4-port**	**Type C (MQ5) 5-port**	**Type D 4-port**	**Type D 5-port**
							
Availability status (mass production date)	Q1/2019		Q3 / 2019	Available in mass production .		Q2/2019	
Standardization process status	In process (Nex10) In process (NGMN)		Coax insert 2.2-5: IEC 61169-66 CD	IEC 63138-2 CDV	IEC 63138-X (not started)	Possible start with NEX10 standardization in April 2019	
PIM (2x20W, static & dynamic)	166dBc		≤- 160dBc; -166dBc typ.	≤-166dBc	≤-166dBc	≤-166dBc	≤-166dBc
Max power handling (3,5GHz @ 85°C)	4x100W	5x100W	9 x 120W	4x80W	4x80W	4x100W	5x100W
Return loss (3,5GHz)	≥36dB	≥36dB	≥ 36dB (interface)	≥38dB (interface only)	≥38dB (interface only)	≥ 28 dB	≥ 28 dB
Cluster connector size (outer dimensions)	36x36mm	36x36mm	80x45mm	35x35mm	35x35mm	32x32mm	32x32mm
Interface ingress protection (IP class)	IP68 (1m, 24H)	IP68 (1m, 24H)	IP68 (1m, 24h)	IP68 (1m, 24H)	IP68 (1m, 24H)	IP68(1m, 24H)	IP68(1m, 24H)
Temperature range	-40°C – +85 °C	-40°C – +85 °C	-40 to +85°C	-55 ~ 125℃	-55 ~ 125℃	-55°C - 125°C	-55℃ - 125°C
Mating force (engagement)	50N MAX	62N MAX	200N typ.	<50N	<60N	< 100 N	< 125 N
Cable size (panel mount & jumper diameter)	Panel Mount 0.141"" or 1/4"" Jumper 1/4" or 3/8"		Up to SF 3/8”	Panel mount 0.141" or 1/4" Jumper 1/4	Panel mount 0.141" or 1/4" Jumper 1/4	Panel mount 0.141" or 1/4" Jumper 1/4	Panel mount 0.141" or 1/4" Jumper 1/4

5 Conclusions

The outcome of the decision-making process for Phase 1 is presented in the table below.

As indicated in the table, both Type C connectors (4 port and 5 port) were ranked as the type(s) with the highest votes for Phase 1, i.e. early 5G deployment.

The results show a relatively big spread in maturity and standardization readiness, while technical parameters such as RF- and mechanical performance were more equally ranked.

	Operators, RAN & Antenna suppliers (customer)						Connector suppliers (supplier)					Score customer	Score supplier	Total score	Ranking
	Maturity	Standardisation ready	Electrical performance	Mech performance	Cable	Instalation Costs	Maturity	Standardisation ready	Electrical performance	Mech performance	Cable				
Weight	**20%**	**15%**	**16%**	**15%**	**13%**	**11%**	**10%**	**4%**	**23%**	**24%**	**19%**	**80%**	**20%**		
Type A	3.5	2.5	6.5	6.9	7.5	6.1	5.0	2.3	7.8	4.5	6.8	4.8	4.7	**4.8**	3
Type B	3.2	2.6	6.8	5.4	6.8	6.1	3.3	5.7	7.3	5.7	7.0	4.4	4.9	**4.5**	4
Type C (MQ4/MQ5)	7.7	6.4	6.8	7.3	6.9	5.2	9.0	6.3	6.8	5.8	5.0	6.1	5.0	**5.9**	1
Type D	5.0	2.0	6.9	8.1	7.1	5.8	6.5	3.0	7.5	6.3	5.0	5.1	4.9	**5.1**	2

The project team concluded to recommend selecting Type C (MQ4/MQ5) as cluster connector as industry standard for early 5G deployment.

6 Pin numbering

AISG will add cluster connector pin numbering specification to its APCC (Antenna Port Colour Coding) standard.