Standard RF Cluster Connector for FDD 4T4R to 8T8R Applications

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Standard RF Cluster Connector for FDD 4T4R to 8T8R Applications

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: the introduction of higher MIMO orders (8x8 configurations) and beamforming for FDD is an efficient way of sending signals in specific directions to improve throughput and reliability. The expected benefits from FDD 8T8R are an increase in capacity, as well as a wider coverage with respect to 4T4R, which will permit a better cell edge user experience.

Nonetheless, antenna size is a critical factor in network deployment, which limits the number of connectors in antennas. Cluster connectors aim to 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. In phase I of the Cluster Connector project NGMN identified the most suitable connector type as the industry harmonised solution for early 5G deployment for TDD 8T8R uses. In phase II, the project focused on port naming conventions for MQ4/MQ5 connectors, addressing TDD 8T8R passive antennas and radios (4G and 5G NR). In the current phase (phase III) the project focused on the identification of the best candidate cluster connectors for FDD 4T4R to 8T8R applications.

At this stage, the goal of the project is quite ambitious: FDD 8T8R may be the preferred option for mid-band future evolution in Sub3G NR and the number of connectors in antenna plates can quickly become a tight constraint. On the other side FDD higher power needs (several bands at once) and, above all, PIM sensitivity constitutes a considerable stake.
The objective of Phase III is to provide guidance to Mobile Network Operators for selecting a RF Cluster Connector for FDD 4T4R to 8T8R applications, that fulfils requirements agreed within NGMN.

The project consisted of several phases including identification of candidate connectors, definition of standard protocol of measurements and completion of a test campaign. Full progress of the project is described in this document.

Contents

1 INTRODUCTION AND PURPOSE OF DOCUMENT

1.1 Introduction

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 number of single connectors in antennas.

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

With several different cluster connector solutions, the standard of cluster connectors needs to be aligned to avoid unmanageable mixed connector combinations in the networks. A project team of industry players was organized by NGMN, with the objective of introducing common rules for cluster connectors to reach harmonization across the industry.

The NGMN Cluster Connector Task Force was created to achieve alignment on cluster connector solutions and related accessories. So far this is the progression of the activities:

1.1.1 Phase I

In phase one the project was targeting the early 5G 8T8R deployment with time to market as the key driver. Phase I focused on immediate cluster connector requirements for 5G TDD @ 3.5GHz, leading to recommendation of Type C, generally known in the telecoms industry as MQ4 and MQ5. The published deliverable (version 1.13, Standard RF Cluster Connector Proposal for Early 5G Deployment) is available since June 2019 [1].

1.1.2 Phase II

Phase 2 of the project focused on port naming conventions for MQ4/MQ5 connectors, addressing TDD 8T8R passive antennas and radios (4G and 5G NR).
The published deliverable (version 1.5, Recommendation on RF Cluster Connector PHASE 2 – Antenna to Radio Module Pinout Alignment) is available since June 2020 [2].

1.1.3 Phase III

The third phase of the project was launched in 2020. Its target was to achieve alignment on cluster connectors for legacy 4T4R or alternatively 4T2R FDD antennas, easily extensible to 8T8R antennas, operating in frequency bands below 3GHz: their distinctive mark is to be multi-band multi-port devices with higher power capabilities, as requested by the market (evolution of RRU to multi-band).

Connector choice having to be a long-lasting solution, OEMs have been requested to provide their RRU power capabilities (from existing roadmaps), that was translated into specific connector requirements, respecting the required low-PIM constraints, for FDD systems.

Three Cluster Connector candidates applied to be evaluated in Phase III.

1.1.4 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 White Paper. 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 EVALUATION CRITERIA AND TESTS

2.1 The Survey

At launch of the project, an open discussion was initiated in order to determine the basic mechanical and electrical characteristics required for Cluster Connectors for FDD applications. Recommendation reports were presented and jointly discussed. In a second step, the basic technical requirements, which a Cluster Connector must comply with for these applications, were determined and agreed as can be seen in Table 1

Parameter	**Parameter condition**	**Must Have**	***Nice to have***
Max Frequency	DC-3GHz	DC-2,7GHz	
Min. environmental temperature *[°C]*	@ 614-960 MHz	- 45°C	*- 55°C*
	@ 1427-2690 MHz		
Max. environmental/system temperature *[°C]*	@ 614-960 MHz	+ 90°C	*+ 120°C*
	@ 1427-2690 MHz		
Power Rating (i.e. max. power handling capability) *(@ max. environmental/system temperature and @ each port)*	@ 614-960 MHz	4x200W@50°C	
	@ 1427-2690 MHz	4x200W@50°C	

Max. Distance Radio – Antenna (i.e. max. jumper length)	@ 614-960 MHz	3m	*5m*
	@ 1427-2690 MHz	3m	*5m*
Insertion Loss budget (Radio - Antenna)	@ 614-960 MHz	< 1 dB	*< 0.65dB @ 614 MHz~960 MHz*
	@ 1427-2690 MHz	< 1 dB	*< 0.75 dB @ 2.2~2.7GHz*
Cable diameter	Internal (Panel Mount)	up to SR 1/4" (internal)	
	external (Jumper)	up to 1/2" super flexible (external)	
PIM	(2x20W, static & dynamic)	≤ -163 dBc	
Isolation between adjacent ports		> 90 dB	
Return loss	@ 614-960 MHz	< -32 dB	*< -36 dB*
	@ 1427-2690 MHz		
Cluster connector size (max)	(outer dimensions)	max. 50 x 50 mm	
Interface ingress protection	(IP class)	IP 68	
Mating force *[N]*	engagement disengagement	< 80	
Number of ports		4 pin / 5 pin	

Table 1– NGMN Cluster requirements Phase III

2.2 Test Plan, Measurements, and Analysis

Based on the above defined requirements, a first round of testing was performed with three candidate connector types provided by NGMN partners. Results were shared, after finalization, in the third quarter of 2021.

2.3 Outcomes

The shared test report reveals an overall compliance of the three applicants with only minor mechanical differences (size, easiness to manipulate, weight, mating force).

3 FURTHER EVALUATIONS

3.1 Additional Test Plan

Taking into account the limits of this phase of the project, such as higher power needs (several bands at once) and PIM sensitivity for a FDD Cluster Connector, intended to facilitate the mid-band future evolution in Sub3G NR, the project team concluded for the convenience of an additional test plan to be defined, complementing the already existing test plan with a new, deeper test protocol.

The Test Plan is designed to check the performance of Cluster Connectors for external cell-site applications against a commonly agreed NGMN framework.

TEST PLAN FOR CLUSTER CONNECTOR ASSEMBLIES			
Step	**Test Type**	**Test Reference**	**Severity/Details**
1	**VISUAL INSPECTION**		Unpackaged
1,1	Workmanship	IEC 61169-1 section 9.1.1	No damage to cables & connectors. Samples prepared carefully & professionally?
1,2	Visual inspection of labelling and identification	IEC 61169-1 section 11.1	Look for manufacturer's identity code and connector identification code
1,3	Check for damage to cables, connectors & labels. Report issues.	IEC 61169-1 section 9.1.1	
1,4	Check for corrosion, water ingress, damage etc. before the test process. Report issues.	IEC 61169-1 section 9.1.1	
2	**VOLTAGE PROOF**		
2,1	Voltage proof	IEC 61169-1 section 9.2.6	AC voltage 1500 VAC ± 50 V RMS, duration 60 +/- 5 secs
3	**RETURN LOSS**		

3,1	Return Loss, 600-4000MHz		Record VNA sweep results. Record measurements as per Appendix A.
4	**PIM**		
4,1	PIM	IEC62037-1	Perform PIM test with a PIM tester in the supplied frequency range for lowband and midband
5	**RANDOM VIBRATION**		
5,1	Random Vibration	IEC 60068-2-30	Vibration frequency range shall be 10-500 Hz in 3 axes with a maximum acceleration of 0.5g, duration = 90minutes.
6	**BUMP/SHOCK TEST**		
6,1	Bump/Shock Test	EIA-364-27C (R2017)	Test condition letter：H, Acceleration ：294m/s^2, Duration：11 ms, Waveform: half sine wave, velocity variation：2.07 m/s. 50 positive, 50 negative pulses along 3 axes (a total of 300 shocks).
7	**SINUSOIDAL VIBRATION**		
7,1	Sinusoidal Vibration	IEC 60068-2-6	Repetitively sweeping for 10 cycles at frequency range 5 - 200 Hz in both X, Y and Z axes with acceleration of 1g. Duration 1h30mins per axis, total duration 4h30mins (1x octave per min)
8	**VERTICAL LOADING**		
8,1	Vertical Loading	None available	3 kg per port. Room temperature. Duration: 24 hours

9	**IMPACT OF THE INJECTION PART AT LOW TEMP**		
9,1	Impact of the Injection Part at Low Temp	IEC 60811-506 / IEC60811-100	1.The impact device and the sample of the cable assembly with injection connector are put into the incubator at a low temperature of -40 ℃ and the storage time is 4h. 2. The load drops to impact the injection connector of the cable assembly sample at a height of 100mm. The weight of the load is 300g (assuming OD in range 10-15mm) as per Table 2 of IEC 60811-506. 3. The injection part of the connector must not be cracked. 4. After returning to room temperature, the injection part of the connector must not be cracked.
10	**TEMPERATURE/THERMAL CYCLE**		
10,1	Temperature/Thermal Cycle	IEC60068-2-14	1. High temperature 70 ℃, Low temperature -40 ℃, one cycle 16h, repeat 9 cycles, 144h（6 days) 2. Keep the temperature at the high and low temperature extremes for at least 4 hours. 3. After the normal temperature recovers for 2 hours, check the sample.
11	**WATERPROOF TEST**		
11,1	Waterproof Test	IEC529	Sample Height ≤850mm: sample lowest point shall be 1000mm lower than the water surface. Sample Height ≥850mm: sample highest point shall be 150mm lower than the water surface. Duration: 24h
12	**UV/SUNLIGHT AGING TEST**		
12,1	UV/Sunlight Aging Test	IEC 60068-2-9	Total duration is considered as 1344hrs, with cyclic 22hrs light and 2hrs dark time as more aggressive condition, UVA 340nm
13	**SALT FOG TEST**		
13,1	Salt Fog Test	IEC 60068-2-11	With 5% weight high quality NaCl-distilled water solution, pH 6.5-7.2 at temperature of 35°C. Continuous monitoring 720hrs with mock-up product.

14	**LIGHTNING SURGE**		
14,1	Lightning Surge	IEC 61000-4-5	1.5kV (0.75kA) via the 1.2/50us (8/20us) waveform, between center pin to shielding
15	**DAMP HEAT STEADY STATE**		
15,1	Damp Heat Steady State	IEC 60068-2-78	Testing duration 21days, at +40°C±2, w/ (95±3)% RH.
16	**4 PORTS POWER TEST**		
16,1	4 Ports Power Test		Test frequency：2.7 GHz Power: 200 W applied on each port simultaneously (total of 4 ports) Duration：test is performed for 48 hours Environmental temperature: 83.5°C Rampup profile: TBA

Table 2 - Test Plan - NGMN Cluster requirements Phase III

3.2 New Discussions and Further Steps

In case a candidate Cluster Connector passes the agreed tests, it can be considered as fulfilling the NGMN requirements. The test protocol needs to be carried out by the applicant, who will have to provide a statement of compliance.

3.3 Conclusions

From NGMN perspective, all connectors fulfilling the requirements (i.e. compliant with the NGMN test plan) will be considered as valid cluster connectors for FDD 4T4R to 8T8R applications. Examples of candidate cluster connectors for FDD 4T4R to 8T8R applications include MQ, SPINNER SMMC 5G (2.2-5), CommScope MLOC. Other cluster connectors may be available on the market. Parties are strongly encouraged to use the test plan to assess compliance of product to these industry requirements. NGMN is not responsible or liable for any use of or assessment made by parties from use of the test plan.

The test plan can be found in the appendix of this white paper.

LIST OF ABBREVIATIONS

The abbreviations used in this White Paper are explained in the following table:

Abbreviation	Definition
3GPP	3rd Generation Partnership Project
C/C	Cluster Connector
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 Networks Alliance
NR	New Radio
PIM	Passive Inter Modulation
RF	Radio Frequency
RL	Return Loss
RRU	Remote Radio Unit
SR	Semi Rigid
TDD	Time Division Duplex

Table 3 - Acronyms and abbreviations table

REFERENCES

[1] Recommendation for RF Cluster Connector for use in 5G NR 8T8R TDD deployment V1.13 by NGMN Alliance
[2] Recommendation On RF Cluster Connector Phase 2 (Antenna To Radio Module PinOut Alignment): "NGMN-RF-Cluster-Connector-White-Paper-Phase-2-v1-5.pdf"

APPENDIX

Please download the test plan from here:
https://www.ngmn.org/wp-content/uploads/221012-Test-Plan-in-NGMN-RF-Cluster-Connector-FDD-4T4R-to-8T8R-v1.0.xlsx