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5G

IBS Solutions

CenRF Communications

Mobile communication coverage solutions

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Contents

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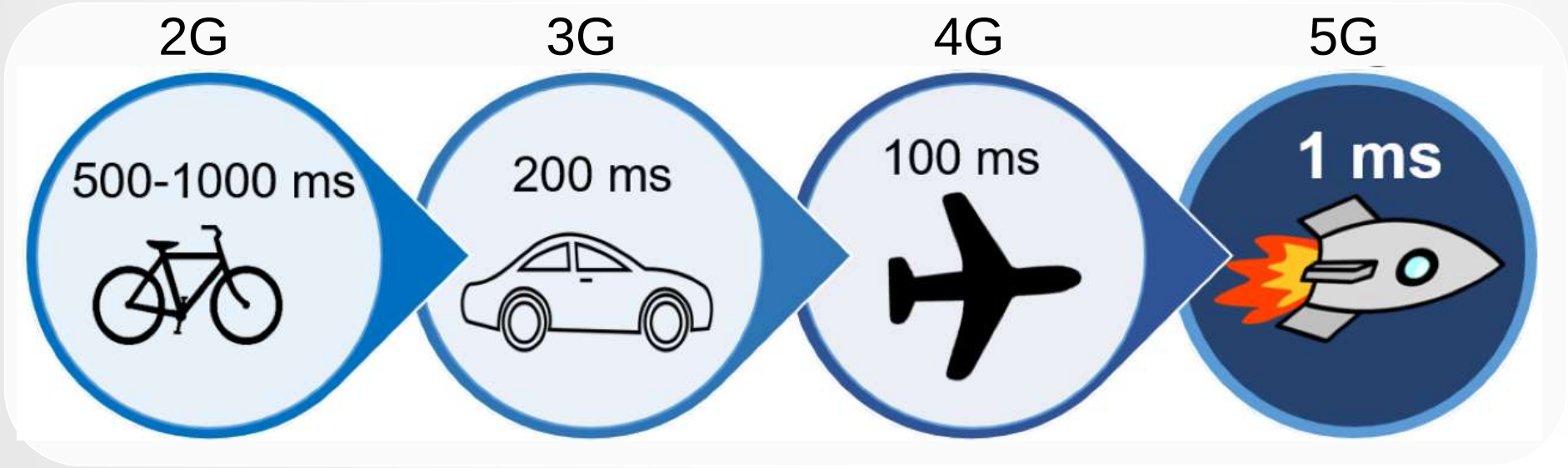
5G Application Scenarios



	2G	3G	4G	5G
Year	**1991**	**2002**	**2010**	**2022+**
Standards	GSM/GPRS EDGE/CDMA	UMTS CDMA2000	4G LTE	5G NR
Data rates	**100 kb/s**	**100 Mb/s**	**300 Mb/s**	**500 Mb/s -10G+bps**
Application	SMS / MMS	SMS / MMS, Internet access, Video calls, Mobile TV	SMS / MMS, Internet access, Video calls, Mobile TV, Gaming services, Cloud computing	Cloud AR/VR, 8K HD Video, Smart Industry, Wireless Medical

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5G Application Scenarios

eMBB-5G Application Scenario 1

8K HD Video

High definition video conferencing

VR

High definition online interactive games

Bandwidth requirement>4.2Gbps **Network latency<7ms**

VR/AR （Virtual/augmented reality technology） can provide people with real application experiences such as historical travel, Arctic exploration, and cross-border tourism, which require a 5G network to experience.

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5G Application Scenarios

eMTC-5G Application Scenario 2

Smart Home

Smart Watch

Intelligent transportation control

Intelligent measurement

Intelligent monitoring

Smart grid

5G real-time monitoring system

Apply property	Network requirements
HD H.265/HEVC	10 Mb/s
4K(2160/60/P)	30-40 Mb/s
8K(4320/60/P)	80-100 Mb/s
Time delay	100 ms
Equipment density	$10^3/km^2$
Reliability level	High
Cover	Underground, ground, and above ground (within 3km above sea level)
Movement speed	< 150km/h

- Real time monitoring system can transmit high-definition monitoring images.
- Wireless monitoring equipment can be easily deployed on various devices in urban and suburban areas.

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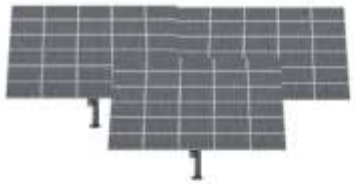
5G Application Scenarios

uRLLC-5G Application Scenario 3

Autonomous Driving



Intelligent Energy Management

Drone Control

Industrial Automation

Intelligent Robot

Remote Surgery

5G intelligent healthcare

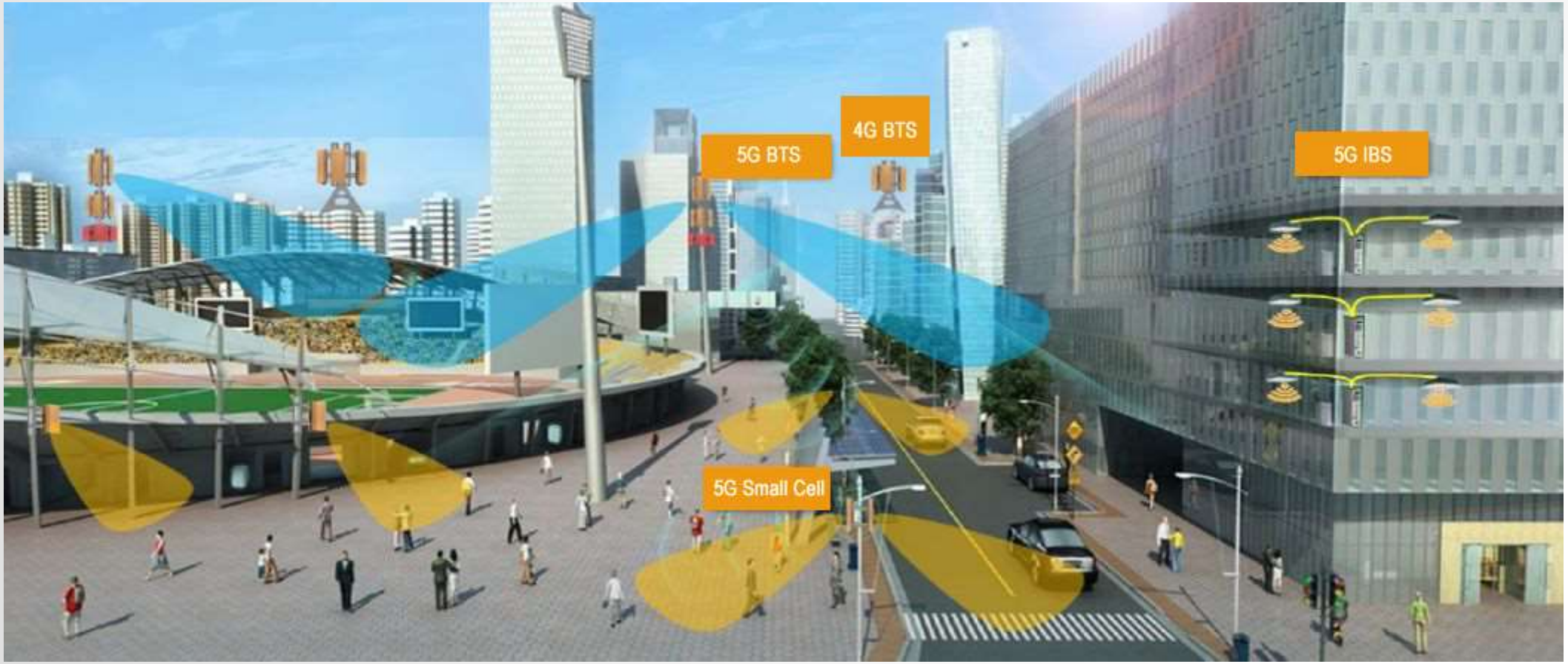
Apply property	Network requirements
Time delay	< 20 ms
Bandwidth	> 1Gbps
Cover	Medical area
Reliability	Guaranteed SLas& Traffic prioritization
Safety	Private network resources

URLLC is a part of 5G wireless emergency communication technology, mainly aimed at providing high reliability, feasibility, and real-time communication services in emergency situations, to ensure that 5G networks can respond to the needs and challenges brought about by emergency events.

5G Application Scenarios

Outdoor:
5G BTS antenna height is 10m lower than 4G antenna.
5G Small Cell covers densely crowded areas.

Indoor:
5G POI combines original DAS (passive).
New Small Cell (active).



5G IBS Construction Index Reference

According to the test, the access capacity is ≥ -128dBm, and after considering the margin and human body loss, it is ≥ -123dBm. Suggest indoor RSRP ≥ -110dBm.

For the newly built 5G distribution system, the following technical indicators need to be met for the sub station:

◆Standard floors and podiums: Over 90% of the target coverage area, RSRP ≥ -105dBm, SINR ≥ 3dB (public reference signal), ensuring that mobile stations can be connected normally without dropping calls.

◆Elevator: More than 90% of the target coverage area, RSRP ≥ -110dBm, SINR ≥ 3dB (public reference signal), ensuring that the mobile station can be connected normally without dropping calls.

◆Basement: 5G network coverage is temporarily not available.

◆In order to avoid pilot frequency pollution at the window edge of high-rise buildings, when indoor and outdoor networks are connected on the same frequency, the forward RSRP design index for indoor window edges above 10 floors is RSRP ≥-100dBm, SINR ≥ 3dB (public reference signal), reference standard floors and podium indicators below 10 floors.

◆The RSRP of indoor 5G signal leakage to a distance of 10m outside shall not exceed -105dBm.

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5G IBS construction index reference

5G IBS Construction Link Budget

The indoor propagation mode of a building is a restricted free space propagation mode, expressed as follows:

PL(d)=PL(d0)+20log(d/d0)+βd+FAF (dB)（1）； PL(d0)=32.4+20log(d0×0.001)+20logf (dB)

In equation (1), d0 is the reference close distance, in m; f is the working frequency, in MHz;

PL (d) - represents the total transmission loss value of path d (m);

PL (d0) - represents the free space attenuation value of the near ground reference distance (usually d0=1m);

β—— Indicates the path loss factor (0-1.6dB/m); FAF - represents the partition wall loss (5dB~20dB).

Classes	Material	Type	3.5GHz Penetration Loss
Exterior wall	concrete	35cm thick	26dB
Interior wall	gypsum board	12cm thick	12dB
Brick wall	brick	76x2mm，2-layers	24dB
Glass wall	glass	2-layers	12dB

5G coverage method 1 - outdoor BTS coverage indoor

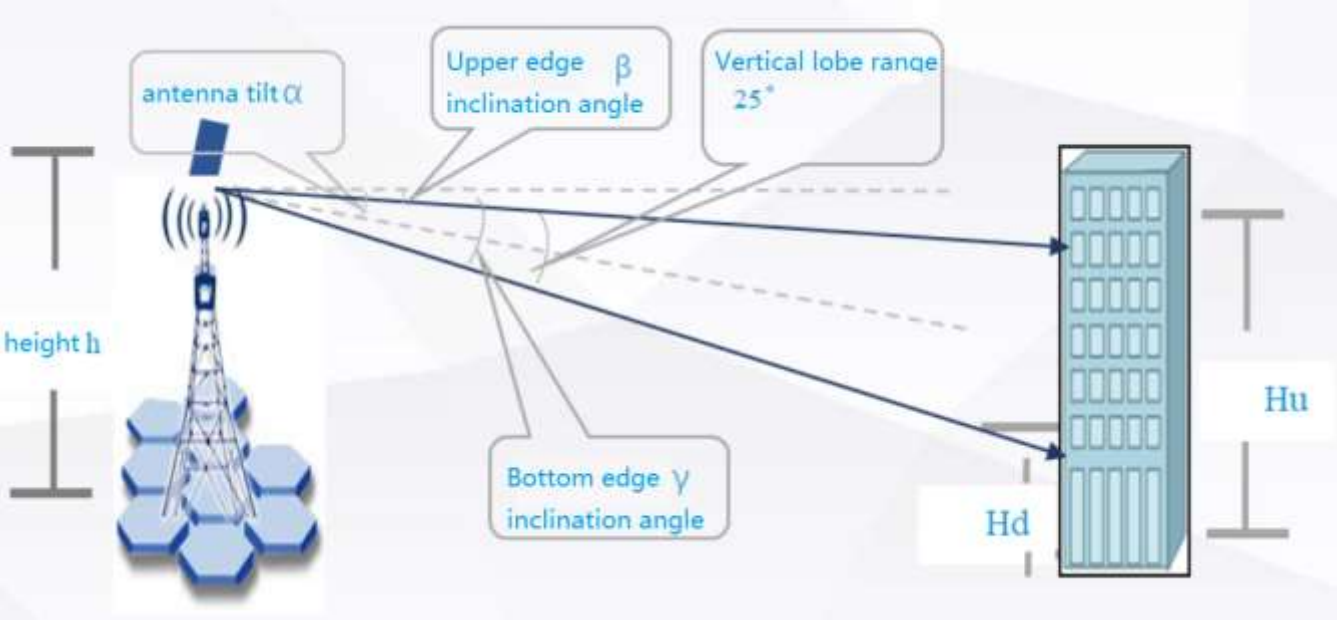
5G outdoor BTS covers both indoor areas

Distance requirements for covering buildings:

◆The building is located in the main coverage direction of BTS without obvious obstruction;

◆Buildings are typical buildings, which have non fully enclosed exterior walls, simple internal structures, and no deep coverage, such as small and medium-sized buildings, including residential buildings, small hotels, small office buildings, etc.

Combining theoretical analysis and field testing, using the outdoor 64T64R BTS, a shallow indoor coverage of about 3Mbps can be achieved for buildings about 100 meters away from the BTS. The theoretical vertical coverage of the building height is about 45 meters.



◆The coverage height of the upper edge of the service channel is Hu=h-L/tan（β），β=α- 25/2= α- 12.5 (1)

◆The coverage height of the lower edge of the service channel is Hd=h-L/tan（γ），γ=α+ 25/2= α+ 12.5 (2)

◆Where h is the height of the base station, L is the distance from the building to the base station, β The inclination angle of the upper edge of the business channel, γ The vertical coverage range of the service channel is 25°, which is the inclination angle of the lower edge of the service channel.

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5G coverage method 1 - outdoor BTS coverage indoor

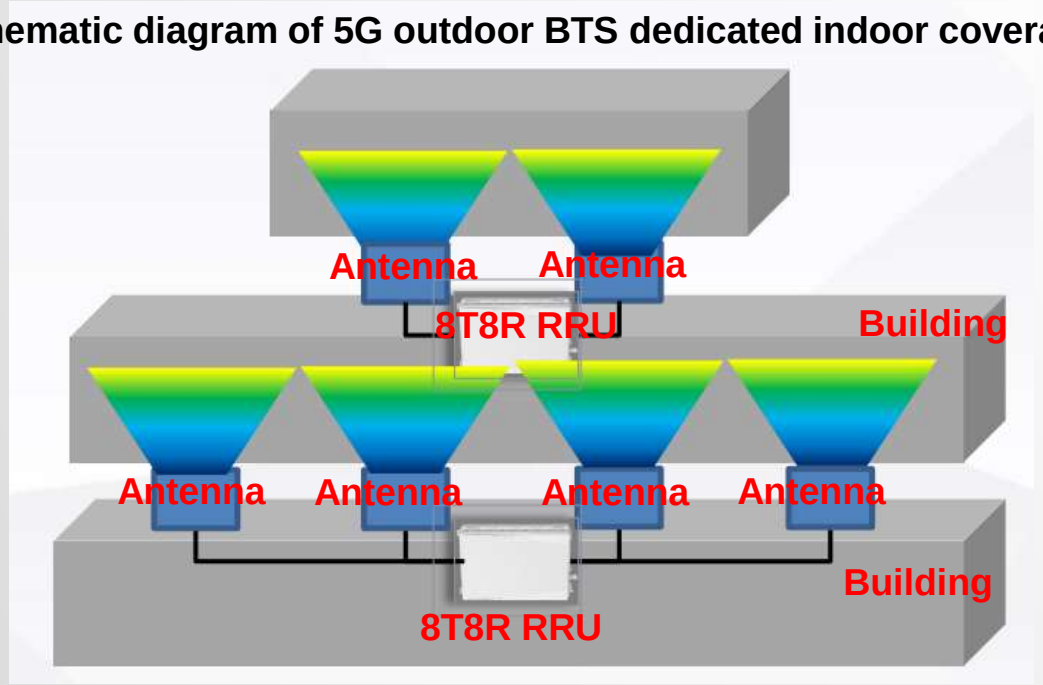
5G outdoor BTS dedicated coverage indoor

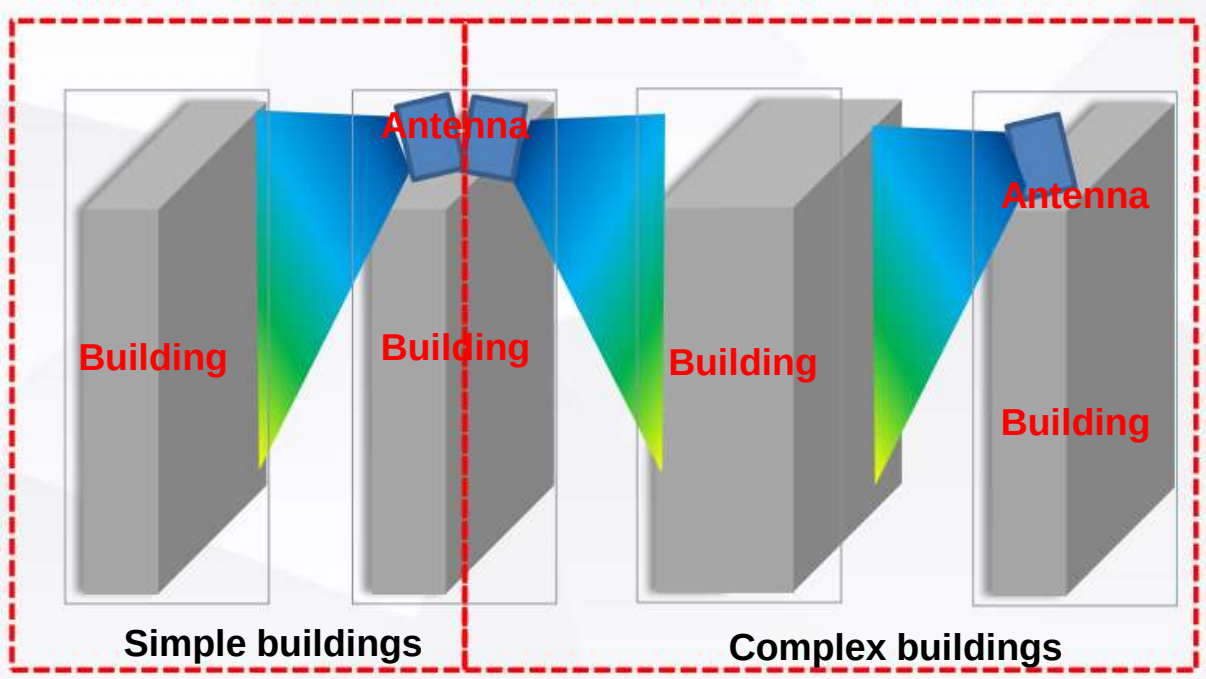
◆For buildings that cannot be covered by outdoor BTS and cannot be deployed with indoor systems, such as high-rise residential buildings, a dedicated outdoor station coverage indoor solution can be adopted.

◆Use 8T8R or 4T4R RRU, with multiple antennas connected externally through 1/2 "or 7/8" feeders for coverage.

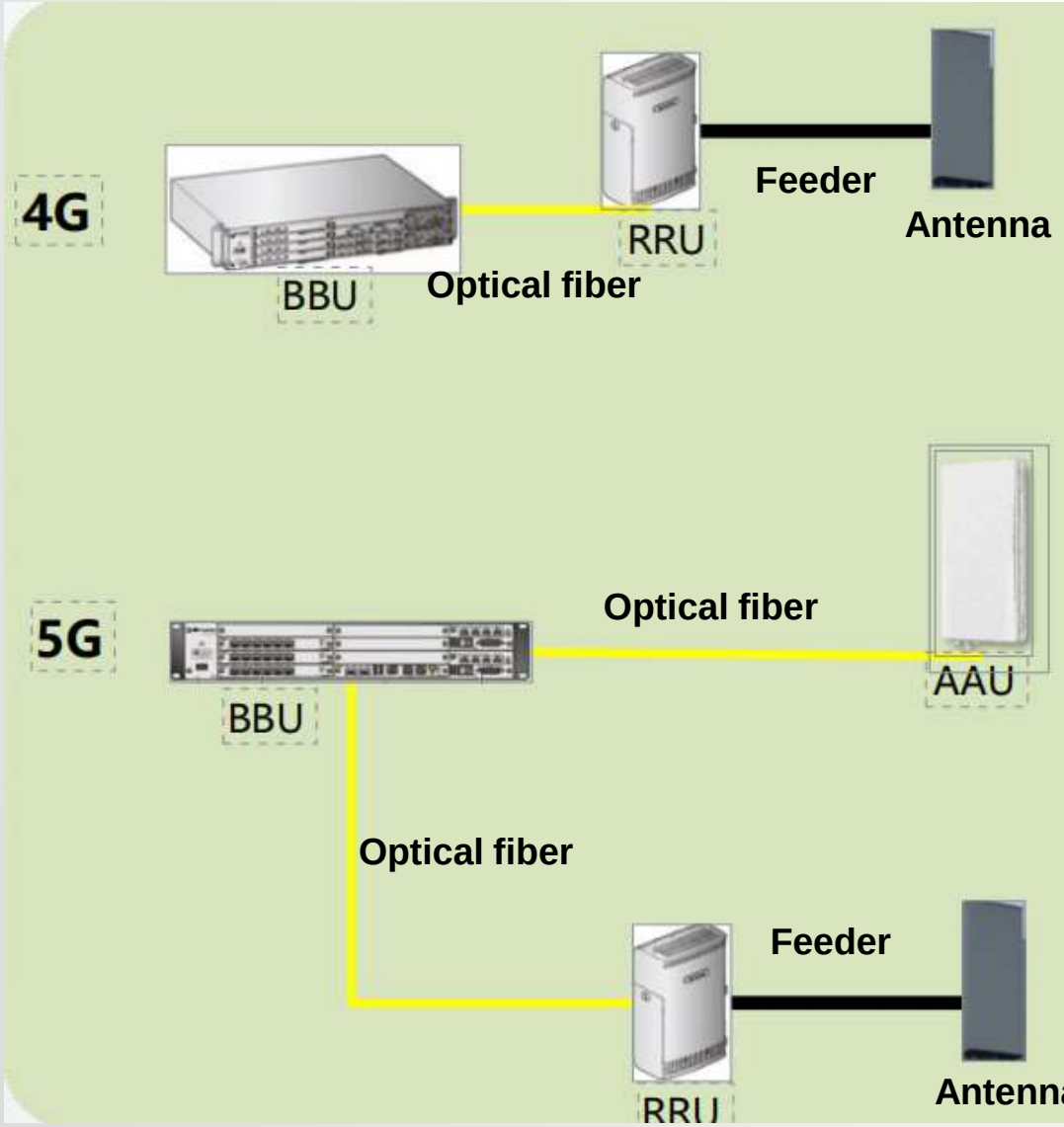
◆For buildings with larger depth, double-sided coverage can be achieved by illuminating both sides of the building.

Schematic diagram of 5G outdoor BTS dedicated indoor coverage





5G coverage method 1 - outdoor BTS coverage indoor



Device Type	Power (W)	Carrier frequency powerr (dBm)	Antenna gain (dBm)	Antenna Output Power (dBm)
2T4R RRU	2*60	17	15	32
64TR AAU	320	1.84	24.5	26.34
32TR AAU	320	4.85	24.5	29.35
64TR AAU	200	-0.2	24.5	24.3
16TR AAU	200	2.81	24.5	27.31
8TR RRU	8*40	10.87	17	27.87
4TR RRU	4*80	13.88	17	27.87
2TR RRU	2*100	14.85	17	31.85

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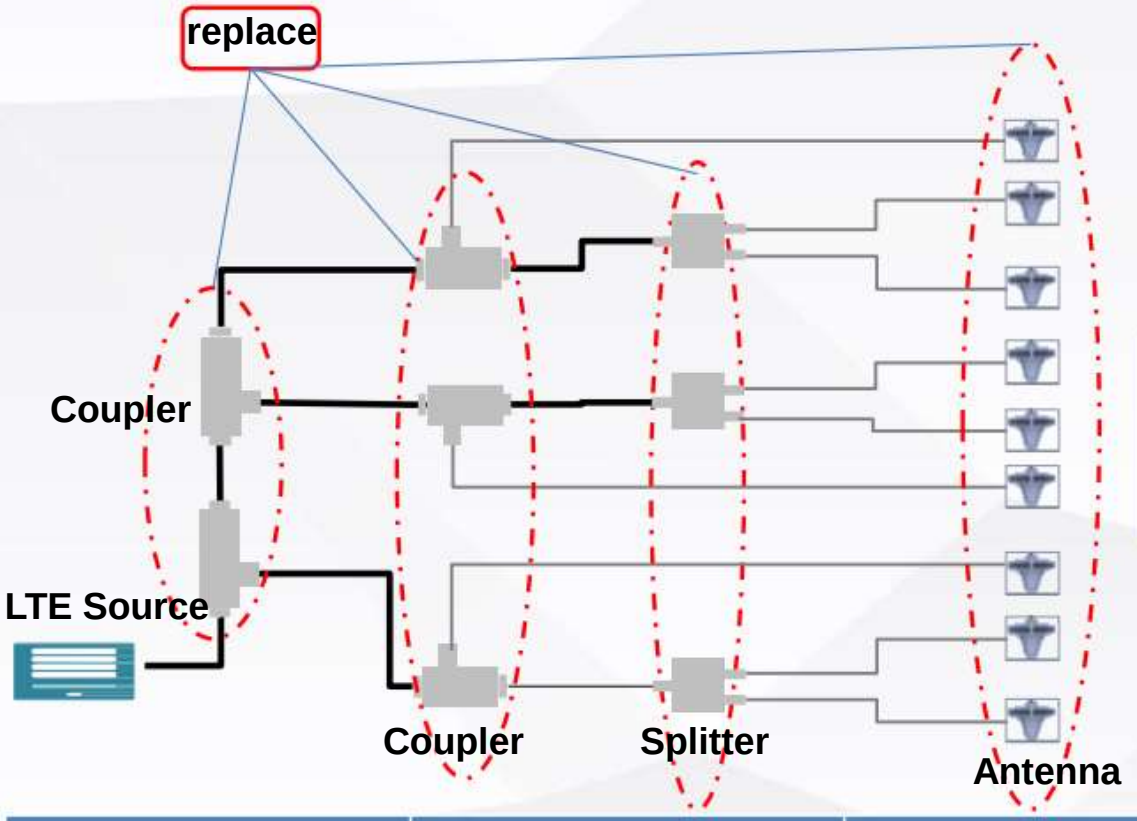
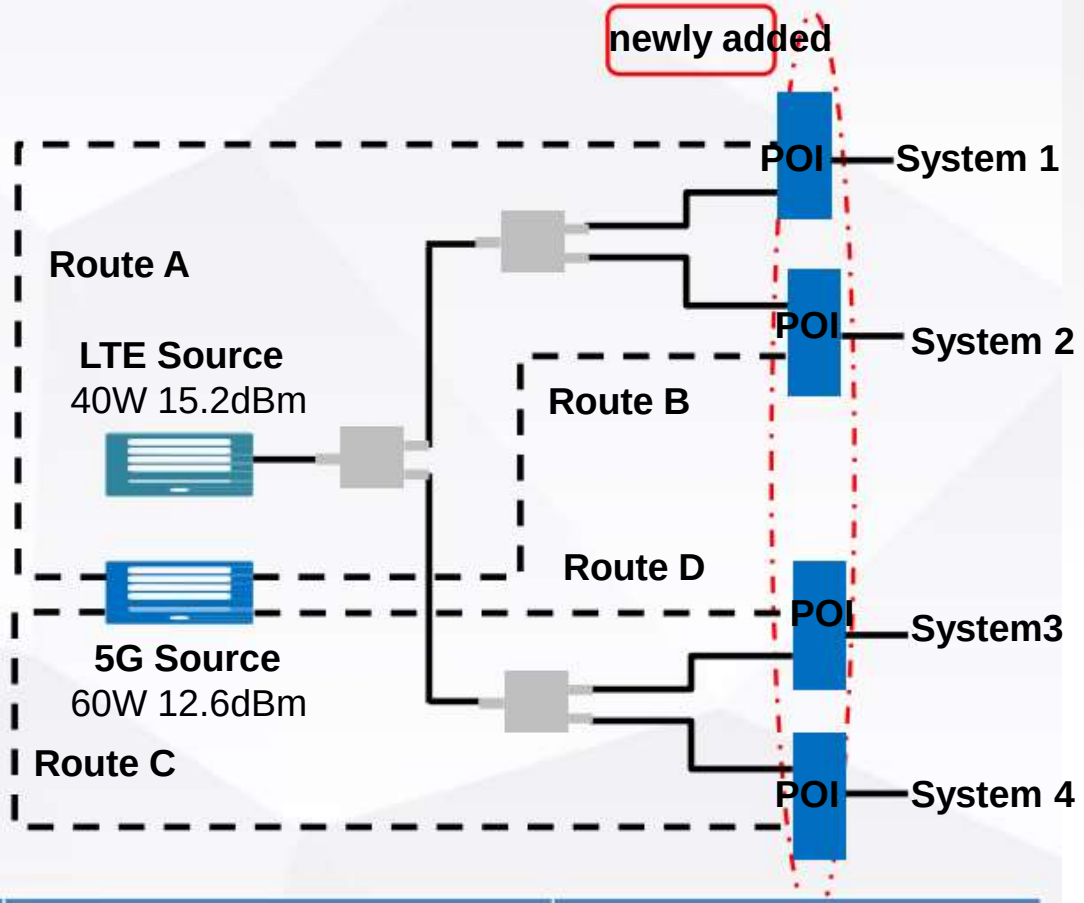
5G coverage method 2 - passive DAS modification

5G Passive DAS Modification





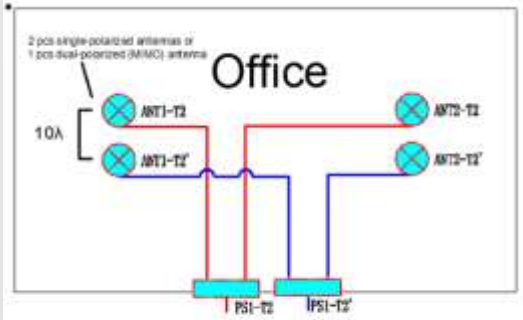
Frequency band	1/2 feeder loss per hundred meters (dB)	Source output power(W)	Source output RSRP(dBm)	RSRP after 100 meters (dBm)
2.1G	10.961	40	9.2	-1.761
3.5G	14.4	60	12.6	-1.8
difference (2.1G-3.5G)	-3.439		-3.4	0.039

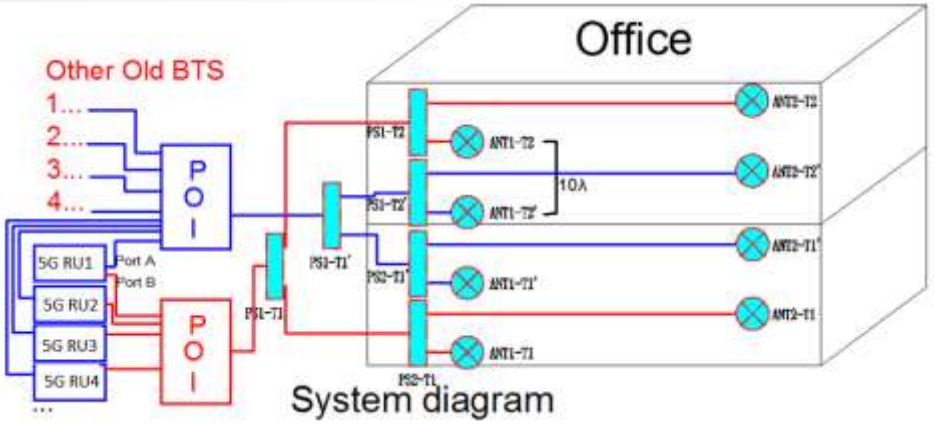
5G coverage method 2 - passive DAS modification

5G passive DAS construction proposal : (MIMO 2X2 upgrade)

A：Old DAS Support 2600MHz frequency band . (If the antenna spacing is too far, need to adjust)

Combine 1 old DAS (Replacement devices support 3800MHz) and Create 1 new DAS, the design of 2 DAS needs to be similar. New DAS frequency band needs to support 3800MHz, which is convenient for the 5G NR 3500MHz BTS to combine.





Old DAS Replace POI

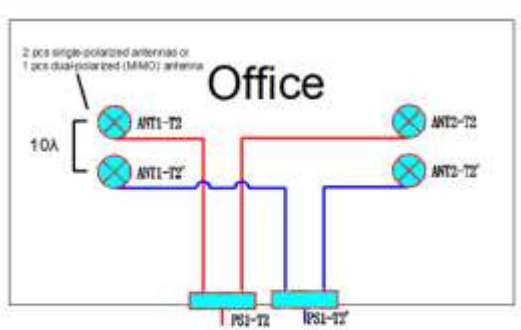
POI

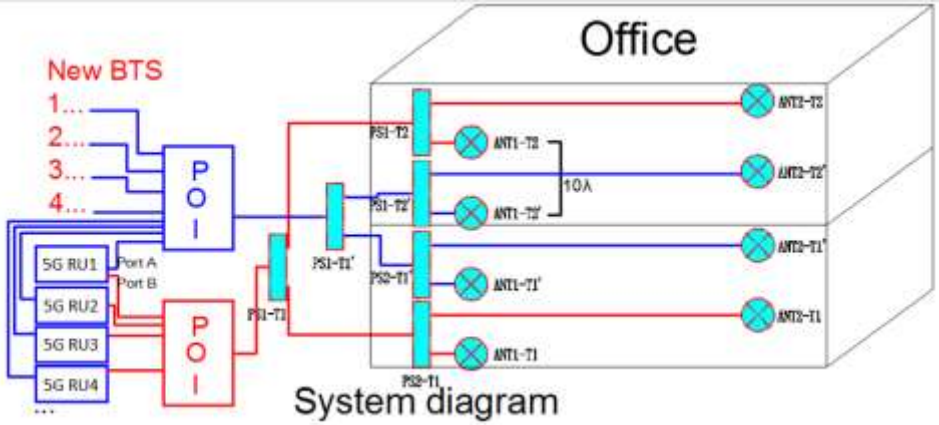
New DAS Need 700-3800MHz products

POI Splitter Antenna

B：New important large buildings need to cover 5G.

Create 2 new DAS, the design of 2 DAS needs to be similar. New DAS frequency band needs to support 3800MHz.





New DAS Need 700-3800MHz products

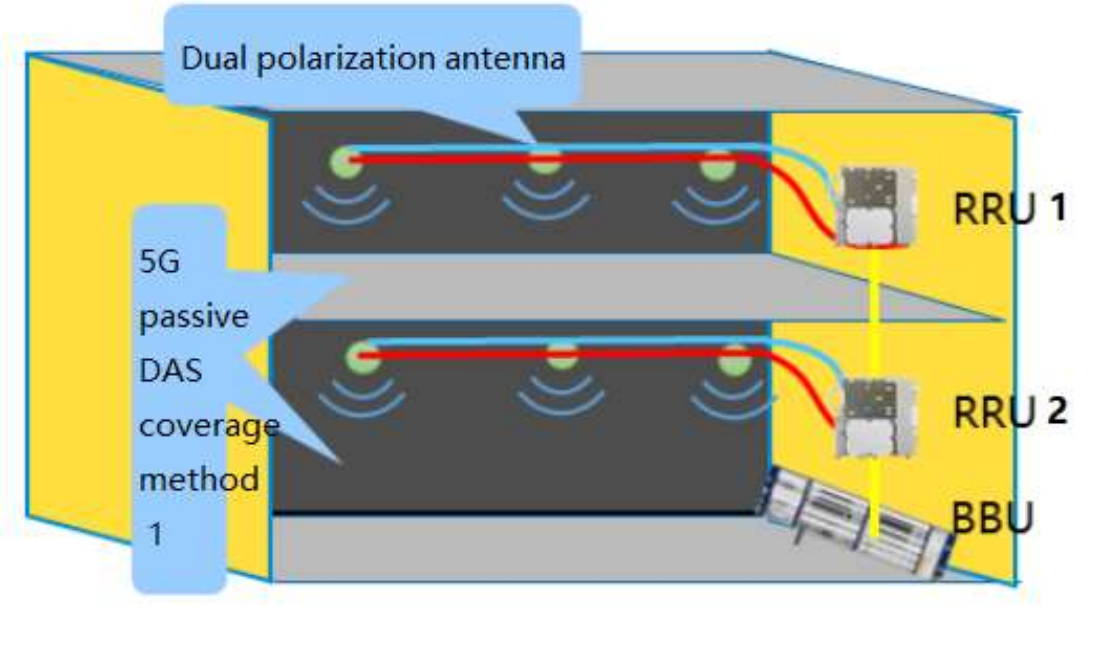
POI Splitter Antenna

5G coverage method 2 - passive DAS modification

5G DAS multi-channel joint technology brings significant capacity improvement

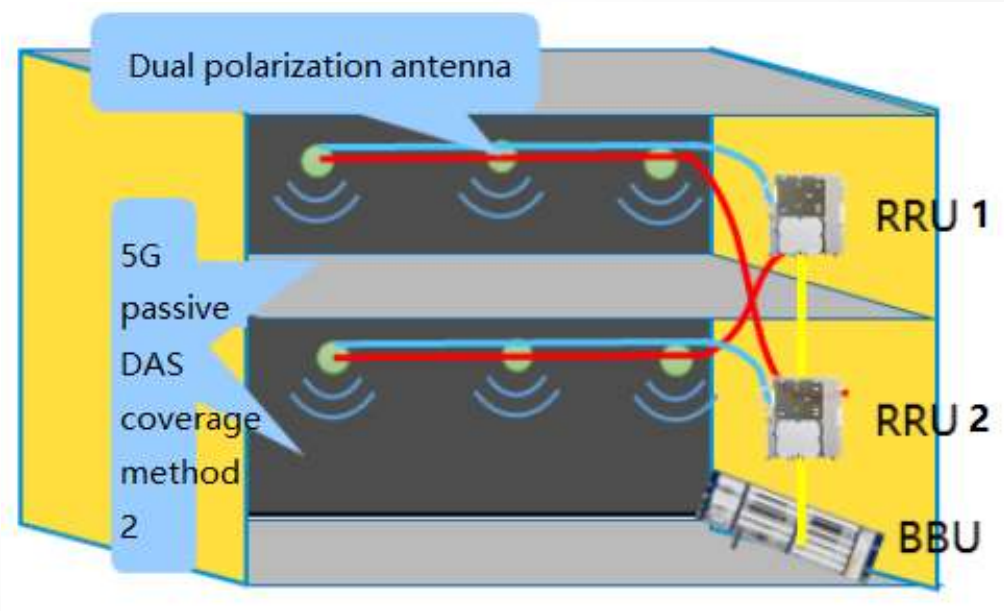
The 5G DAS multi-channel joint transmission and reception technology can achieve joint communication on the same floor and across floors. According to different networking scenarios, it can be divided into the following four sub schemes:

Option 1：Cross floor -2T2R to achieve 4T4R



Test Result 1: The overall downward pulling speed of the lower floors increased by 15.67%, and the downward speed of the near point fixed point test increased by 38.86%. The uplink has a good effect in the middle and far points, increasing by about 18%, and the overall SSB-RSRP has increased by about 1.5-3dB. The gain of the upper floor is relatively lower than that of the lower floor, but there is still a 22% improvement in the lower near point.

Option 2：Cross floor -Cross 2T2R to achieve 4T4R

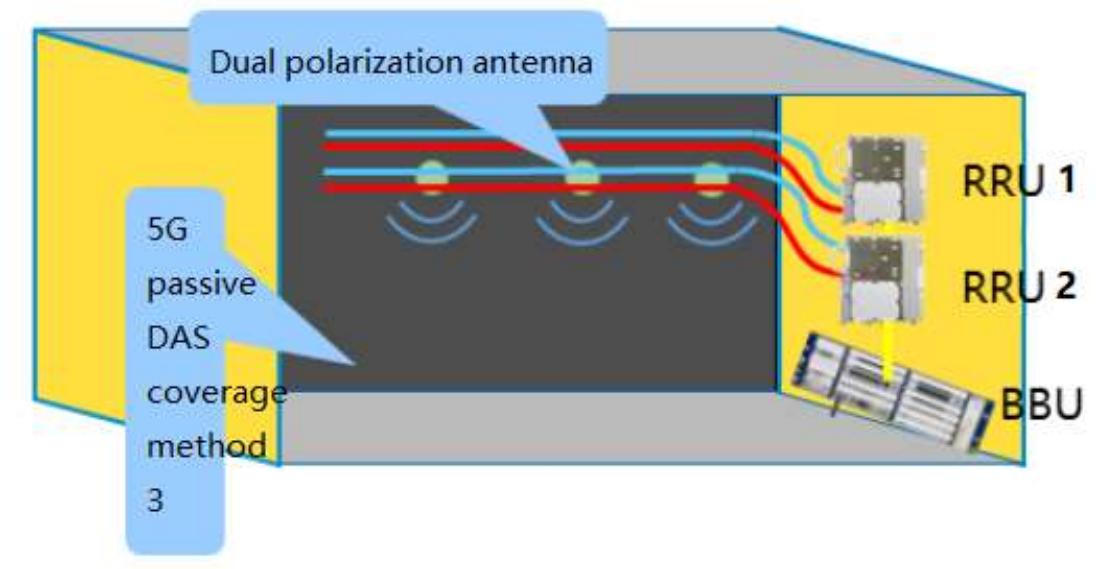


Test Result 2: The overall downward pulling speed of the lower floors has increased by 9.55%, and the downward speed of the near point fixed point test has increased by 42.66%. The uplink has a good effect in the middle and far points, increasing by more than 10%, and the overall SSB-RSRP has increased by about 1.5dB. The gain of the upper floor is relatively lower than that of the lower floor, but there is still a 32% improvement in the lower near point.

5G coverage method 2 - passive DAS modification

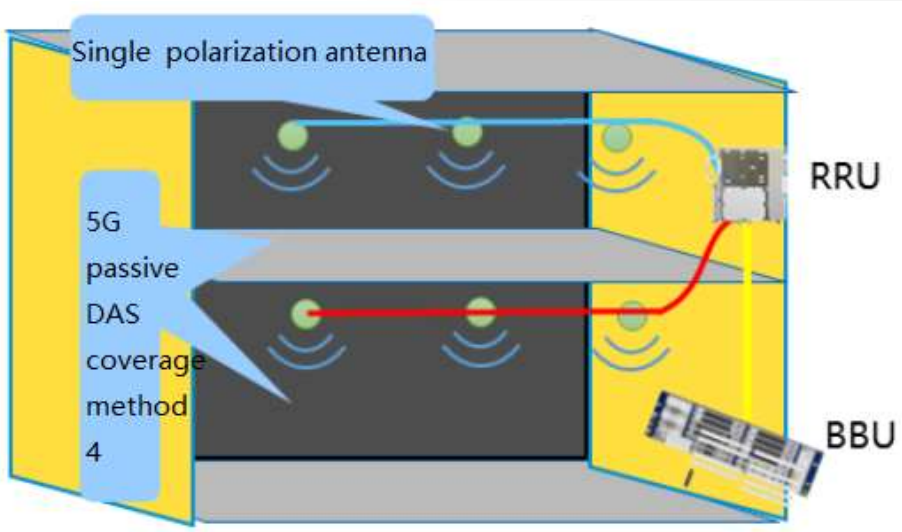
5G DAS multi-channel joint technology brings significant capacity improvement

Option 3：Same floor -2T2R to achieve 4T4R



Test Result 3: The overall downward pull rate has increased by about 35%, while the upward speed has increased by about 27%. The downlink rate of fixed point testing has increased by 65% at the near point, 56% at the midpoint, and 11% at the far point; Fixed point testing increases uplink speed by 37% at midpoint and 23% at far point.

Option 4：Cross floor -Cross SISO to achieve 2T2R



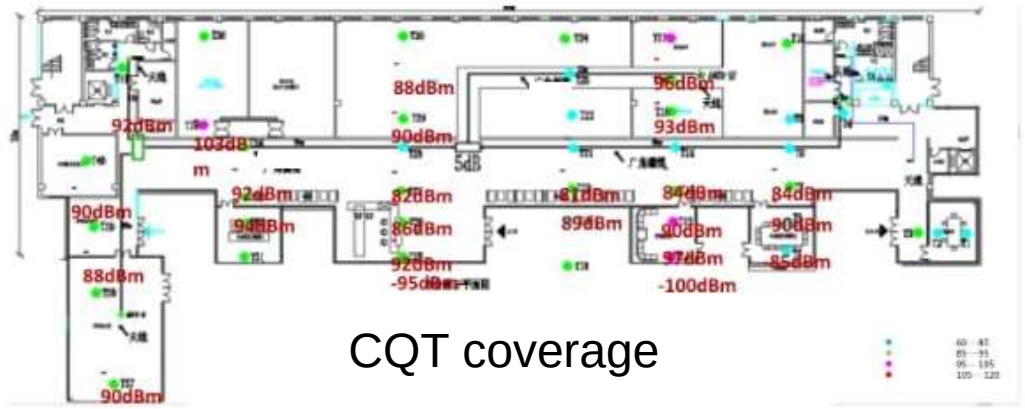
Test Result 4: The overall downward net pulling speed of the lower floors has increased by 72.03%, and the near point fixed point testing speed has increased by 84.33%. The uplink has a good effect at the far end, with an increase of over 40%, and an overall SSB-RSRP improvement of about 2dB. The gain of the upper floor is relatively low compared to the lower floor, but there is still a 59.87% increase in the near point of the lower floor.

Summary: The 5G DAS joint transmission and reception solution has taken a unique approach, perfectly avoiding the series of problems faced by the 5G transformation of the DAS system in traditional solutions. It has achieved significant gains without changing the network architecture, achieving the effect of "turning a stone into gold". I believe that with the in-depth application of this technology, it will provide 5G indoor coverage solution support for operators faster, better, and more economically, which will help improve user satisfaction and brand value.

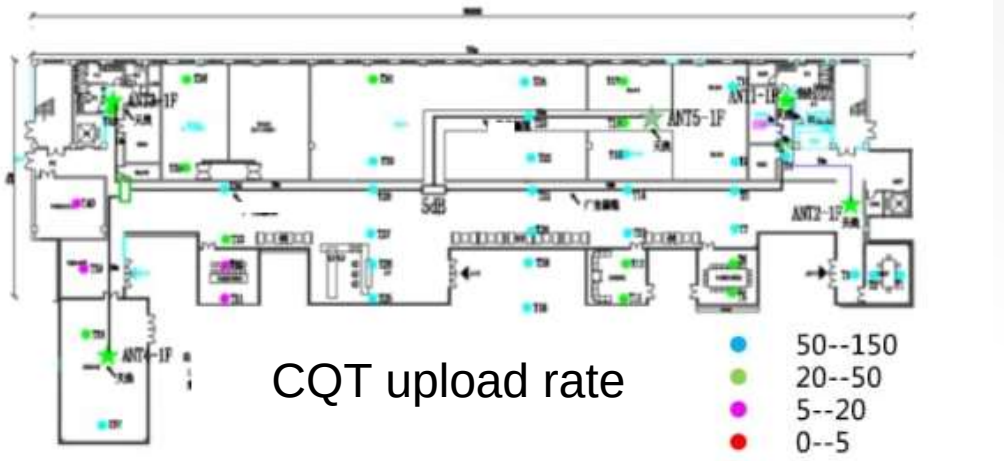
5G coverage method 2 - passive DAS modification

5G Passive DAS test

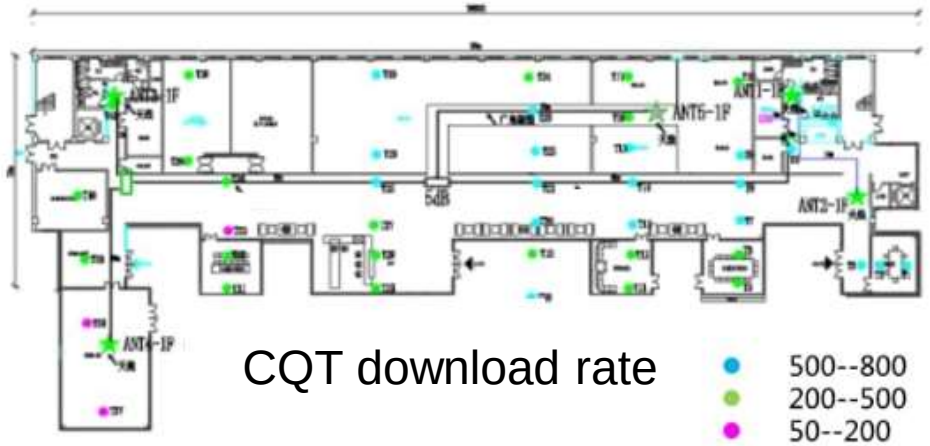
◆On the first floor of the office building, three original operators have built 4G DAS, and now POI combined 5G signal sources are used to upgrade passive room separation to 5G
Operator 1's 5G is 3.5G NR, while Operator 2's 5G is 2.6G NR.



CQT coverage



CQT upload rate



CQT download rate

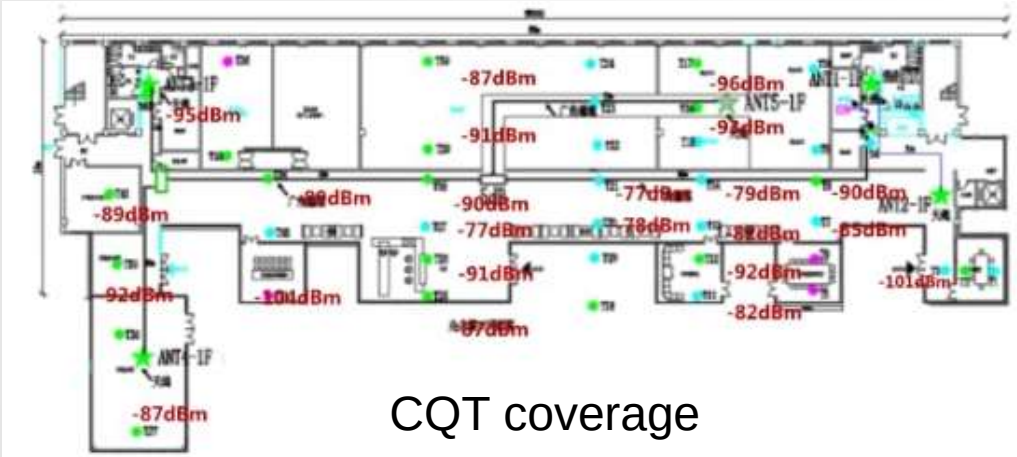
		4G LTE (1.8G)	5G NR (2.6G)
upload rate	peak value	56	79
	mean value	43	52
download rate	peak value	129	827
	mean value	115	479
coverage level		-70	-88

Comparison between Operator 1 4G and 5G

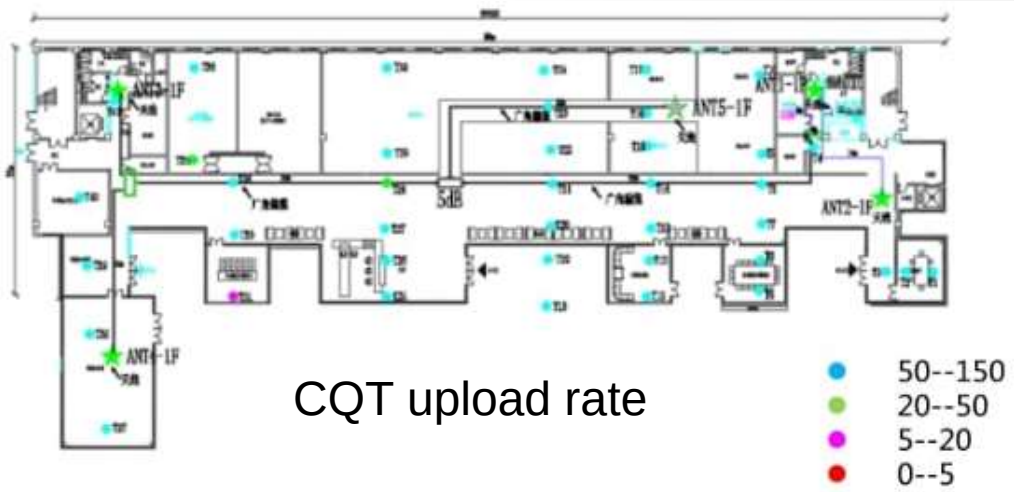
Test results: The average RSRP for Operator 1's 5G coverage is -88dBm, with a peak download rate of 827Mbps and a peak upload rate of less than 79Mbps.

5G coverage method 2 - passive DAS modification

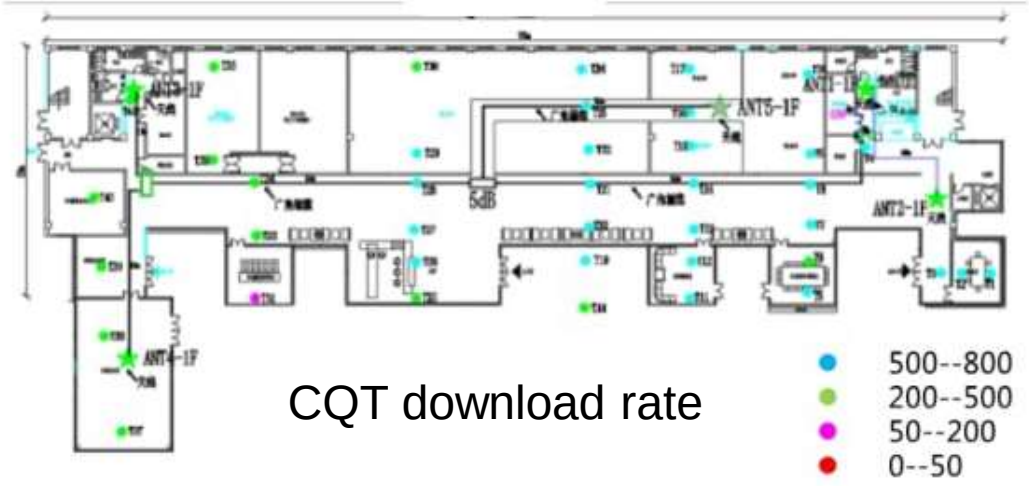
5G Passive DAS test



CQT coverage



CQT upload rate



CQT download rate

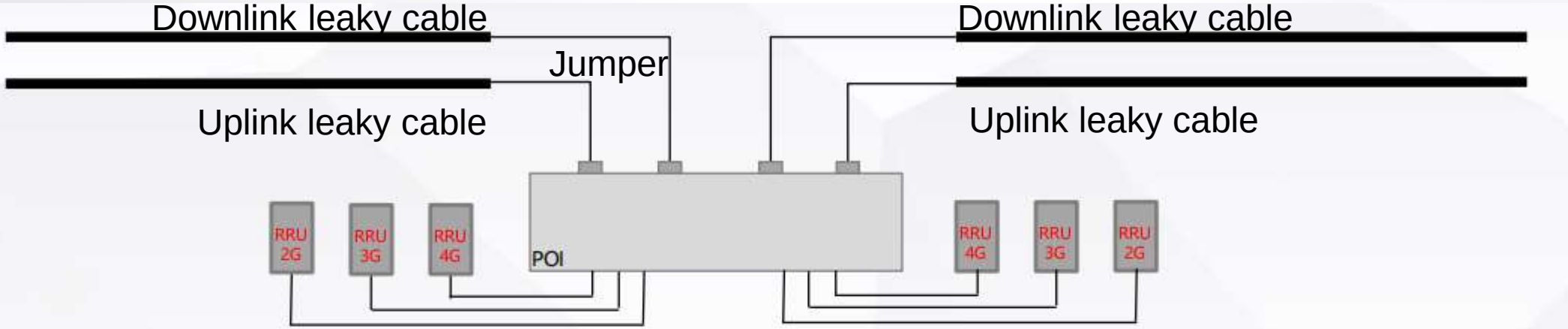
		4G LTE (2.1G)	5G NR (3.5G)
upload rate	peak value	66	101
	mean value	51	56
download rate	peak value	186	761
	mean value	165	488
coverage level		-71	-86

Comparison between Operator 2 4G and 5G

Test results: The average RSRP for Operator 2's 5G coverage is -86dBm, with a peak download rate of 761Mbps and a peak upload rate of less than 101Mbps.

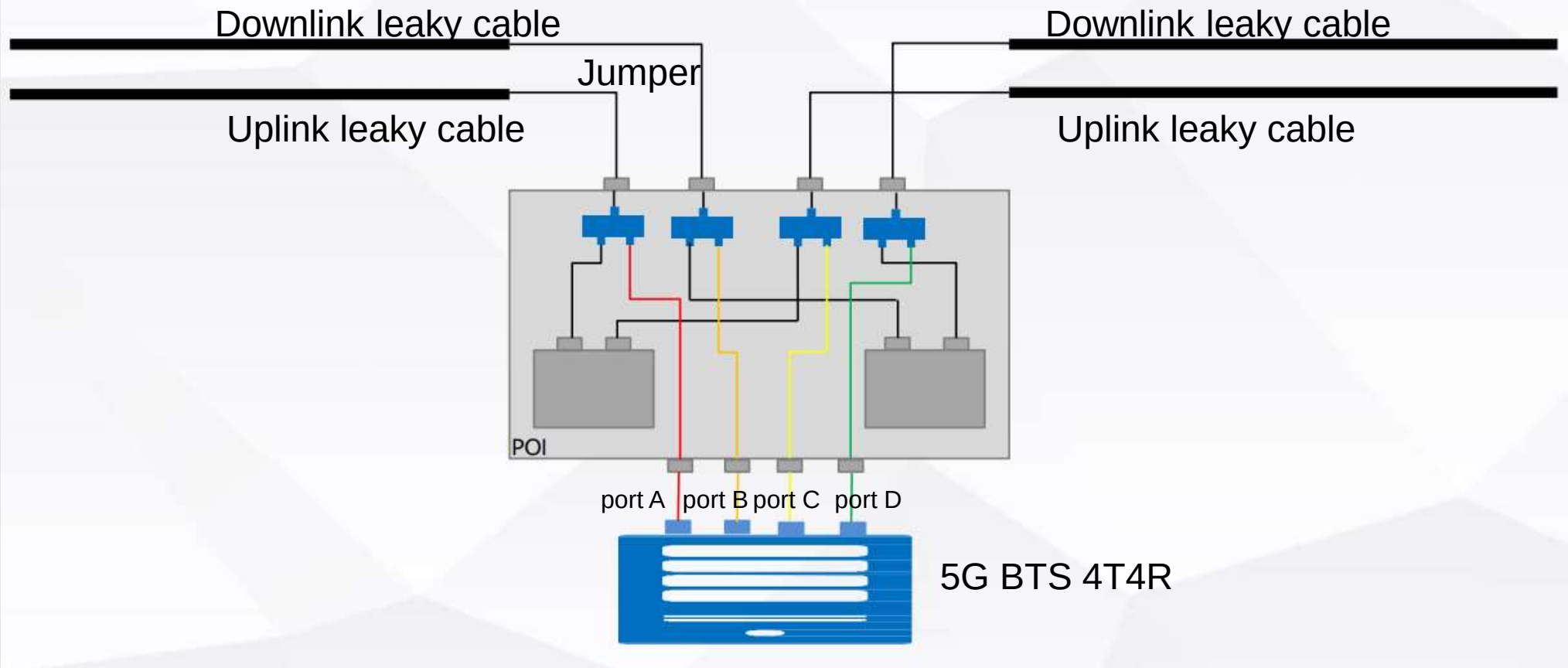
5G coverage method 2 - passive DAS modification

5G Passive Subway tunnel coverage



5G coverage method 2 - passive DAS modification

5G Passive Subway tunnel coverage

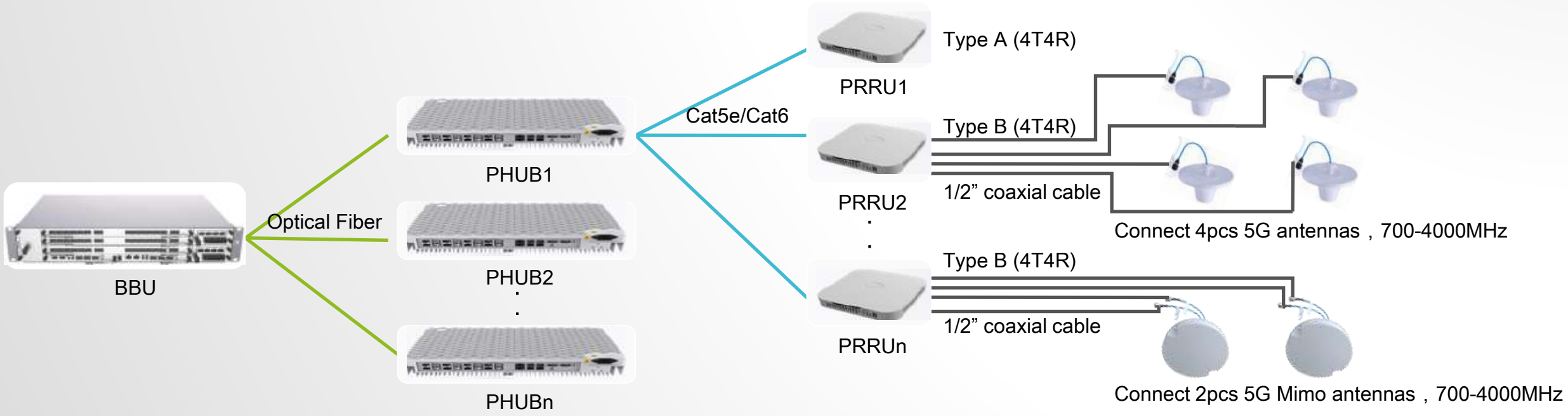


Frequency	Source output power	Source output RSRP(dBm)	POI loss（dB）	Combiner loss（dB）	Leakage cable input power RSRP(dBm)
LTE 2.1G	2*40W	15.2	7	1	7.2
5G 3.5G	4*60W	12.6	0	1	11.6

5G coverage method 3 - active DAS modification

5G active DAS construction proposal : (Small Cell MIMO 4X4)

C：Very important scenarios, high return on investment, need 3500MHz frequency band.
For example, airports, transportation hubs, 5G mobile phone experience areas, and super VIP customers.



- Note: The output power of PRRU is only 250mw, High power consumption and expensive equipment which is not suitable for 5G coverage of large buildings.

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5G coverage method 3 - active DAS modification

◆The active compartment, also known as the PRRU distribution system, mainly consists of a baseband control unit (BBU), a data aggregation unit, and a radio frequency pull remote unit (PRRU).
◆Supports 5G single mode or 4G/5G dual mode, with SA/NSA dual mode capability, and shares network management with 5G macro stations from the same manufacturer.
◆The BBU can directly connect to 6 remote aggregation units, and can be expanded to 12 through cascading; BBU can support 48 pRRUs;
◆Each data aggregation unit can support 8 pRRUs and can be split into 2 cells; PRRU can support 4T4R (4x250mW).
◆The pRRU can be divided into two types: one is the placement type, which includes the antenna integration, and the other is the room separation type, which requires an external room separation passive antenna to complete coverage.

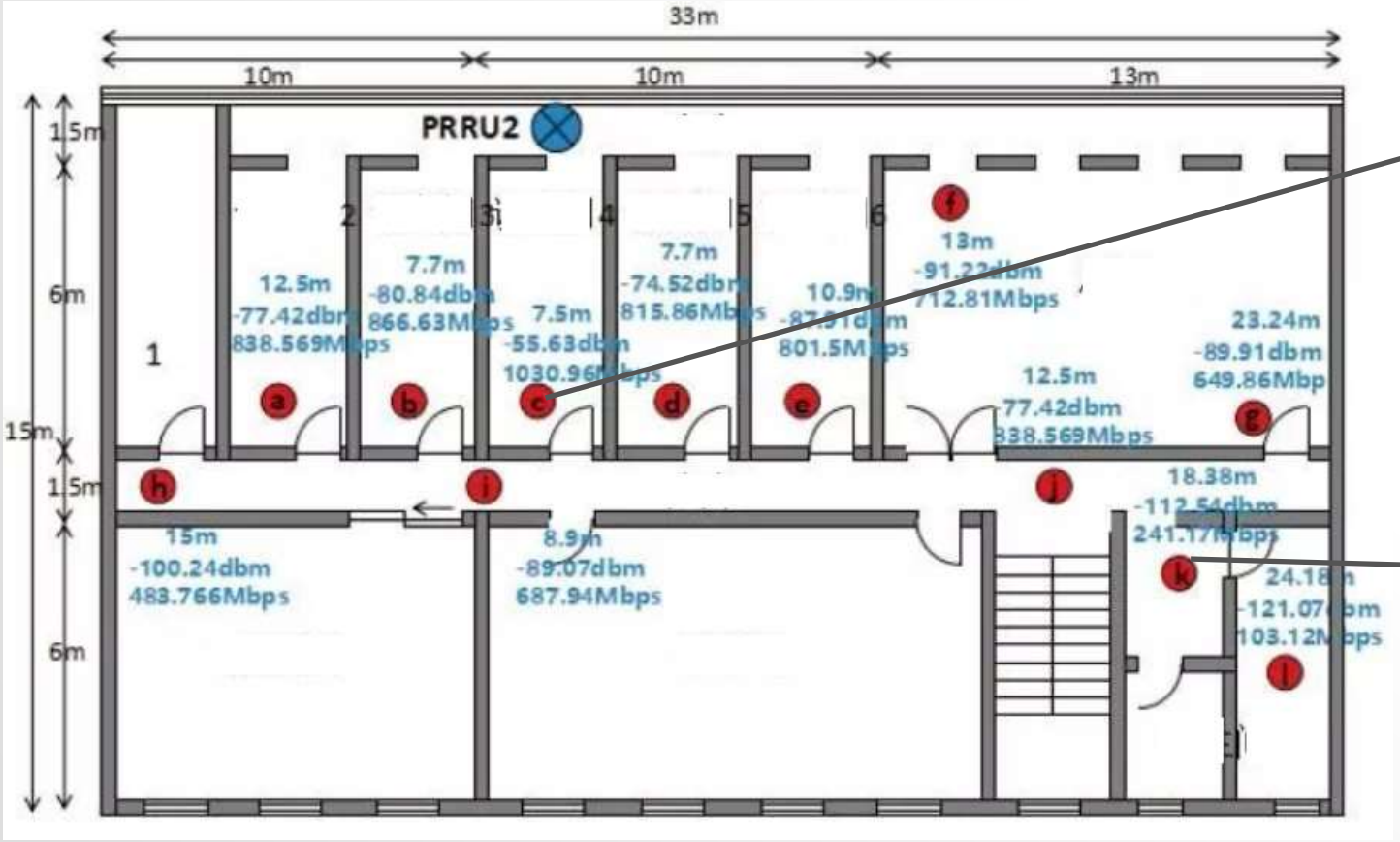
Scene Types covered by Small Cell (PRRU 4T4R)		Covered area (m^2)	Coverage radius/depth (m)	Distance between PRRU (m)
Very Open	Transportation hub, shopping mall	900-1200	20-30	30-50
Open	Large meeting room, office area	500-600	15-20	25-35
Less partition	Important office area	400-500	12-15	18-25
More partitions	Important restaurant, hotel	2-3 rooms on one side, 4-6 rooms on both sides	7-10	8-12

5G coverage method 3 - active DAS modification

5G active DAS test

A new 5G DAS was tested in an office building, using equipment including 5G pRRU. The device emits a power of 4 at 3.5 GHz x 250 mW, operating frequency from 3400 MHz to 3500 MHz.

Downlink coverage rate graph



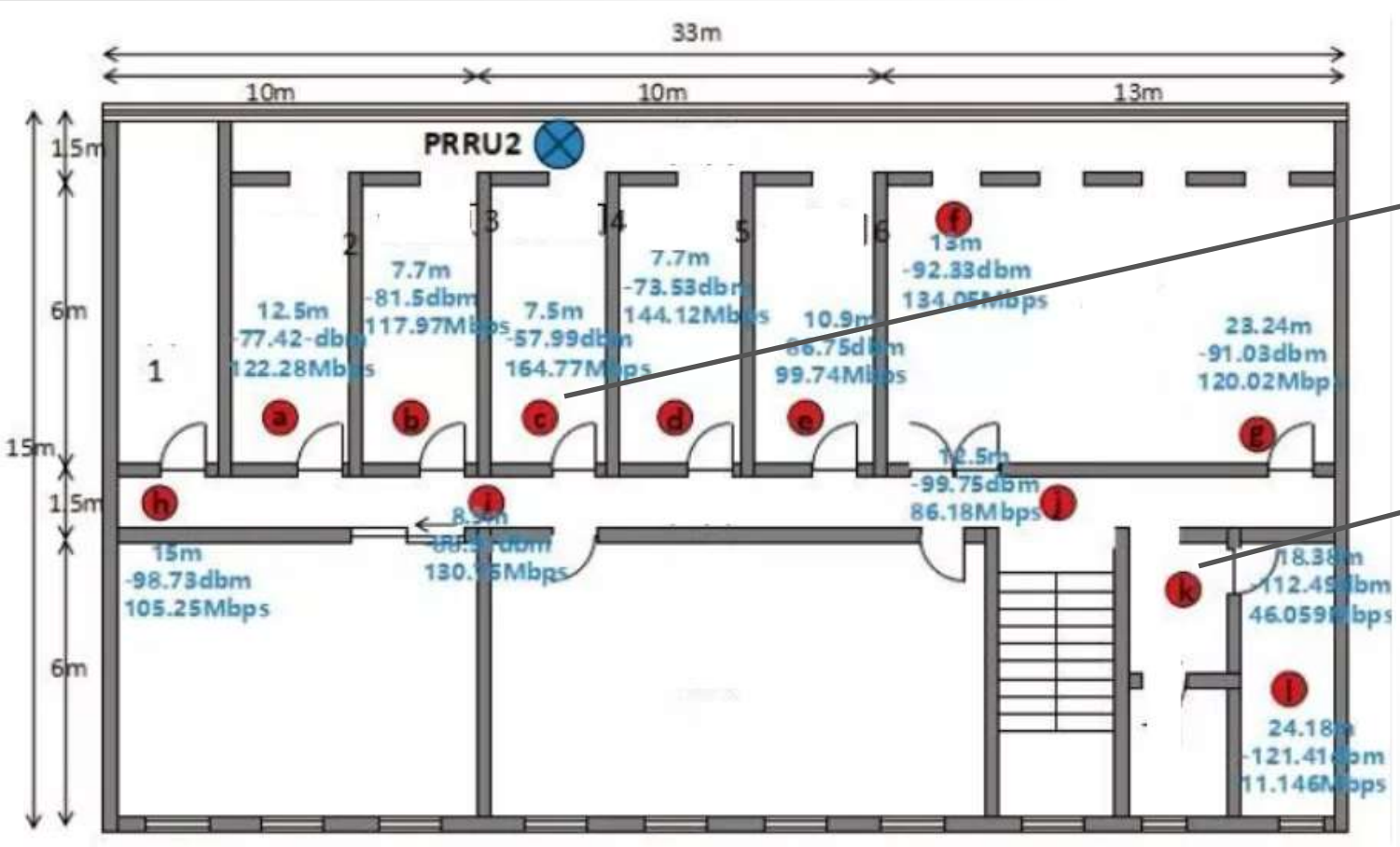
The RSRP of point c is -55 dBm, with a downlink rate of 1030.96 Mb/s. The straight-line distance from this point to pRRU is 7.5 m.

The RSRP of point k is -112 dBm, with a downlink rate of 241.17 Mb/s. The straight-line distance from this point to pRRU is 18.38 m, separated by 5 walls, with this point as the edge point. The coverage radius of a single pRRU is 18.38 m.

5G coverage method 3 - active DAS modification

5G active DAS test

Uplink coverage rate graph



The RSRP of point c is -58 dBm, with an uplink rate of 164.77 Mb/s. The linear distance from this point to pRRU is 7.5 m.

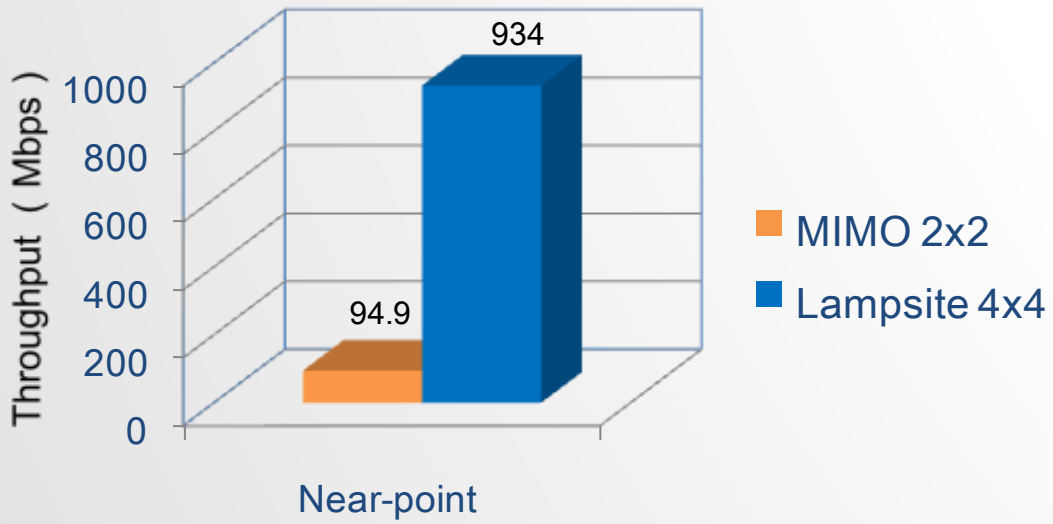
The RSRP of point k is -112 dBm, with an uplink rate of 46.06 Mb/s. The linear distance from this point to pRRU is 18.38 m, with an interval of 5 walls.

Test results: Point C is the peak rate of uplink and downlink, with a peak rate of 1030.96 Mb/s for downlink and 164.77 Mb/s for uplink.

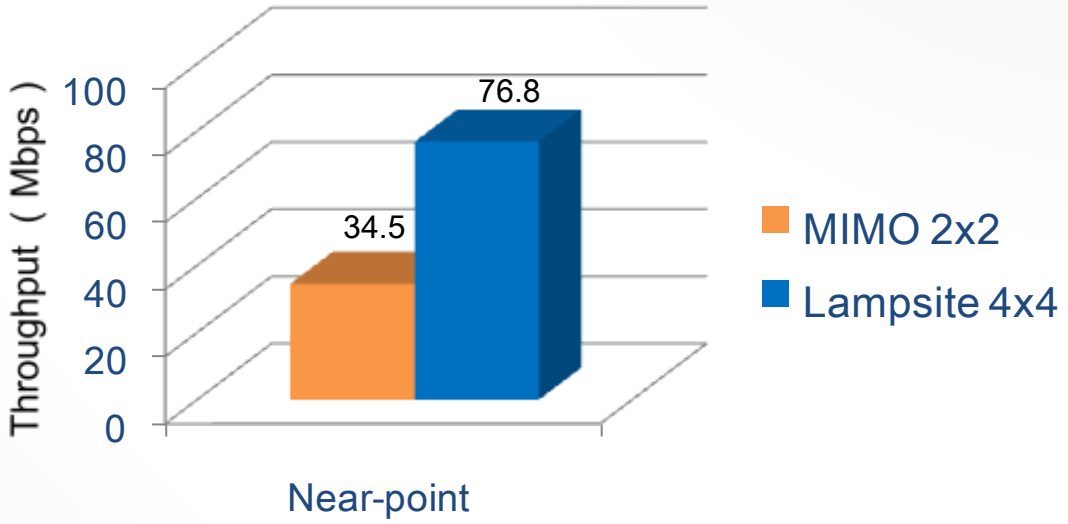
5G coverage method 3 - active DAS modification

TESTING RESULTS –
Between LTE MIMO 2T2R AND Small 5G NR 3500MHz 4T4R

1. DL throughput testing result



2. UL throughput testing result



- For DL throughout, 5G PRRU 4x4 is about 10 times faster than MIMO 2x2 in near-point.
- For UL throughout, 5G PRRU 4x4 is about 2 times faster than MIMO 2x2 in near-point.

Initial 5G IBS construction

According to the overall principle of "innovation, efficiency, and conservation", 5G indoor coverage should be planned in conjunction with outdoor coverage, and multiple methods should be used in different scenarios and stages to carry out 5G indoor coverage construction to meet the development needs of 5G indoor business.

Scenario for creating a new IBS

High value areas

Stadium

Transportation Hub

Operator brand promotion

Initial 5G IBS construction

Compare

NO.	Mode	Site situation	Construction method	Download Rate (Peak)	Construction Investment	Electricity Bill	Scenes
A	5G BTS 4T4R	1 Old DAS Support 5G NR 3500MHz band	Combine 1 old DAS and Create 1 new DAS, the design of 2 DAS needs to be similar.	761Mbps	Low	Medium	Most high buildings such as hotels, office buildings, shopping malls, etc.
B	5G BTS 4T4R	No DAS or old DAS support 5G NR 3500MHz band	Create 2 new DAS, the design of 2 DAS needs to be similar.	761Mbps	Medium, 2 times than A	Medium,	Most high buildings such as hotels, office buildings, shopping malls, etc.
C	Small Cell MIMO 4T4R	No DAS or old DAS support 5G NR 3500MHz band	Create 1 active DAS.	934Mbps	High, 3.18 times than A	High, 2 times than A	airports, transportation hubs, 5G mobile phone experience areas, and super VIP customers.

Test download rate

Small Cell 4T4R LTE MIMO 2T2R

Conclusion:

- In the early stage of 5G construction, high output power 3500MHz BTS 4T4R will be used first in outdoor.
- Most IBS sites give priority to the construction of 5G BTS 4T4R.
- New DAS needs to support 3800MHz, which is convenient for the future 3500MHz BTS to combine.

Key points of 5G DAS antenna design

Compared to the 2.1GHz frequency band, NR3.5GHz increases the comprehensive loss by 6-10dB, while the 4GDAS coverage under existing design habits usually has a margin of about 10dB. 5G testing results show that in most scenarios, the layout of 5G and 4G antenna points is feasible without changing the 4G design scheme, and there is no need to increase the number of antenna points, resulting in cost increases. The design value of antenna port power should be based on meeting the network coverage requirements. Except for the necessary margin that should be considered in engineering design, no additional margin should be reserved. The recommended value of 5G antenna port power is -15dBm~-18dBm.

1. Hall/Lobby/Outpatient Area Coverage Plan

（1）When the height of the hall is low, omnidirectional ceiling antennas can be selected for coverage.

（2）When the height of the hall exceeds 6 meters, directional wall mounted antennas should be used to cover it, placed in obstructed positions, or placed against the wall facing the interior of the hall to control signal leakage.

2. Mall/Shopping Center/Exhibition Hall Coverage Plan

The pedestrian flow is relatively dense, and a combination of traditional DAS and active room separation can be adopted. Active DAS schemes can be used in the catering, education and training areas of shopping malls and shopping centers, while passive DAS schemes can be used in other areas, achieving a balance of coverage and capacity at low cost.

5G Products and Application

Product

MIMO Omni Ceiling Antenna,
617-4000MHz, 3/5dBi

MIMO Directional Panel Antenna,
617-4000MHz, 6/8dBi

MIMO POI 12in 4out
GSM900,WCDMA2100, DCS-LTE1800,
LTE2600,5G NR3500 can be customized,
PIM(IM3) ≤ -155 dBc

5G Indoor Antenna, 617-4000MHz, PIM(IM3) ≤ -107 dBm @ 2 x 33 dBm

CenRF

5G Products and Application

Product

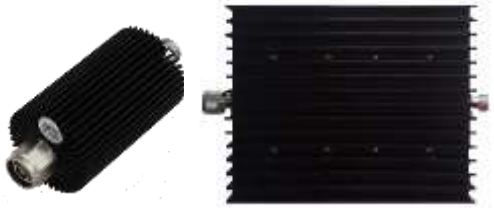
Combiner, 2-5 Input ports,
698-3800MHz can be customized
PIM(IM3) ≤ -155 dBc

Hybrid Coupler, 2in 2out, 4in 4out,
698-4000MHz, PIM(IM3) ≤ -155 dBc

Directional Coupler,
698-4000MHz, PIM(IM3) ≤ -155 dBc

Power Splitter, 698-4000MHz
PIM(IM3) ≤ -155 dBc

Termination Load,
2W-200W, DC-4GHz



Attenuator,
2W-200W, DC-4GHz

Connector, Adaptor, DC-6GHz,
Multiple types, PIM(IM3) ≤ -160 dBc

Market distribution

- Customers
- Headquarter

- sales cover over 60 countries
- service for over 10 operators

CenRF Communications

Mobile communication coverage solutions

THANK YOU

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