Institute of Information and Communication Technology

Introduction to Telecommunication
ICT-5104

Assignment on “5G Antenna Design Techniques for Mobile Terminal Communication Challenges & Solutions”

To Honorable:
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ABSTRACT

Objectives: This paper represents the challenge to smart design of 5G mobile terminal antenna designs and also given the solution plans with different type of motivations. In this content we have discussed and tried to focus on 3 pillar's of antenna design technique based on- 1)mmWave 2)Beam forming and massive MIMO 3)Special effect with DSP also with 4)Small cell for 5G backhaul 5)Effect of user's hand on 5G mobile terminal antenna 6)new radio interface and arrays instead of single antennas 7)even if the more effective problems and challenges, lacks with issues .By which 5G mobile terminal antenna with its advantages & medications to utilization consideration of user friendly technique.

Methods/statistical Analysis: Comprehensive study has been performed to build up substantial understanding about various designs, architectures and techniques described so far by enthusiastic research scholars regarding system model and practical implementation of the Massive-MIMO systems. The review is paying attention on the problems like, getting true channel state information, antenna correlation, channel estimation, signal detection schemes at receiver end, different kind of possible network architectures and their complexity and hardware impairments. Brief information is added about the projects running worldwide on Massive-MIMO and its application in future communication systems of next generation.

Findings: It is observed that multiple antenna systems with huge amount of antenna elements at base station are competent to increase data rate by many folds, without requirement of any extra bandwidth, as compared to other existing technologies. Massive-MIMO combined with multiple carrier systems (Massive-MIMO-OFDM) followed by suitable signal detection schemes, like beam forming, gives overwhelming results.

Application: With possibilities of further research and continuous improvements, Massive-MIMO system is one of the best suitable choices, among various technologies, for next generation wireless communication systems, like 5G.

ACKNOLEDGEMENT

I would like to thank Dr.Shahin Akter Madam, Assistant professor, IICT-BUET for her best class input, feedback & support activity to inspire as well as to do different work to research the latest technology phenomena & era. Her experience in telecommunication system design & support for the latest technology to learn & teaching technique which is fruitful & extensive when it came to that real challenge & solution to conquer.5G is the upcoming and latest technology to be implemented for IoT, Home Security, Nano Technology, AI, High-speed mobile network, Entertainment and multimedia, Smart home, Smart cities, Smart farming, Industrial Internet of Things (IoT),Healthcare and mission critical application, Autonomous Driving, Drone Operation, Security and surveillance, High Speed of Data Rate with special efficiency which will contribute to make the complementary new technology in the smart wireless telecommunication sector. Simulation Based Smart 5G Antenna Design is the prior fact as the challenge to consider with its right solution at here, eventually we can specify the combinations that 5G always with 4G.

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INTRODUCTION:

In modern age communication mobile phones are not only used as a calling or call-receiving devices instead uses of mobile devices are increasing exponentially every day. There must be some advanced technology to cater the need of vast amount of data required by these devices. The future communication systems for wireless communication known as Fifth Generation Communication (5G) networks ought to be able to address the capacity constraints of present networks and also must be able to address the challenges associated with existing communication systems such as range of coverage, link reliability and latency and energy efficiency. Massive-MIMO (Multiple Input Multiple Output) technology is capable to cater the needs of the fifth generation wireless communication systems. The term Massive-MIMO was firstly considered as a TDD (Time Division Duplexing) based cellular model consisting of numerous antenna units deployed at Base Transceiver Station (BTS) in a single-cell. But for multiple cell models, use of non-orthogonal pilot sequences is suggested as the orthogonally of pilot sequences in different cells is difficult to maintain due to the small channel coherence time1. For very high data rate and better link reliability, instead of few antenna units, large array of antenna elements is mounted at base station in Massive-MIMO. This is totally different configuration of BTS design as compared to the current standards in which maximum of 8 antennas are used in a sectored topology. Active antenna units in huge figures are used to focus the energy continuously towards the User Equipment (UE), in target, with the help of different pre coding schemes. As a result the requirement of radiated power and the interference among different users is reduced. However, big number of antennas mounted at a particular site creates several challenges for Massive-MIMO Systems which are completely different from the often arising problems of trivial networks. For example, in LTE or LTE-Advance, pilot overhead should be comparative to the numerical figure of antenna units. In Massive-MIMO this overhead will be very large due to the hefty amount of antenna elements but it is managed with the proper use of channel reciprocity between uplink and downlink in TDD. In channel reciprocity, the Channel State Information (CSI) acquired from pilots used in uplink transmission is utilized for downlink pre coder. The practical implementation of Massive-MIMO requires synchronization among large number of independent RF transceivers and scaling of data buses by an order of magnitude or more which are additional challenges to be encountered[2]. Massive-MIMO System constitutes cellular network with improved spectrum and energy efficiency. Benefits of a Massive-MIMO System can be enjoyed if and only if the accuracy of CSI is maintained at downlink and uplink both (that is at BTS and UE both). CSI is very important characteristic of a communication system. In Massive-MIMO, Quality of Service (QoS) depends on the accuracy of CSI. There are two main reasons of inaccuracy in CSI, in Massive-MIMO Systems, known as Channel Estimation Error and Channel Aging.

Challenges for 5G antenna designs-

- Avalanche of Traffic Volume
- Massive Growth in Connective Device
- Large Diversity of Use Cases & Requirements
- System Assembly Modeling
- Layout Modeling
- Coupling & Enveloping
- Passable CTIA Hand Model
- Effects of Hand Model
- Mobile Broadband Communication Base Station
- Targeted 6GHz Provocations.
- Reduce of Simulation Requirements For 4G or Old.
- Reduce Cost & Size
- Multipath Interference

Solutions: The 5G Antenna Technique

- MIMO-Multiple Input & Multiple Output
    - mmWave
    - SISO to mmWave massive MIMO
    - Massive MIMO
    - Beam forming
    - Polarization Diversity
    - Phase Array System
    - Adaptive Array System
    - Special Multiplexing For DSP [Digital Signal Processing]

- Small Cell Backhaul
- Different Type Of Antennas

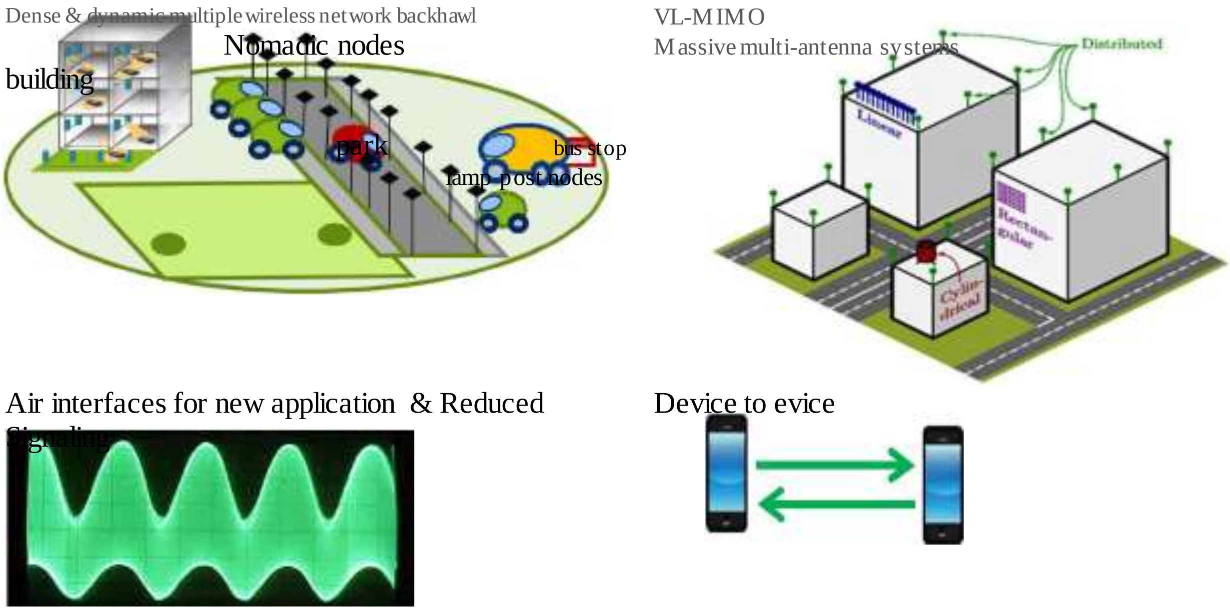
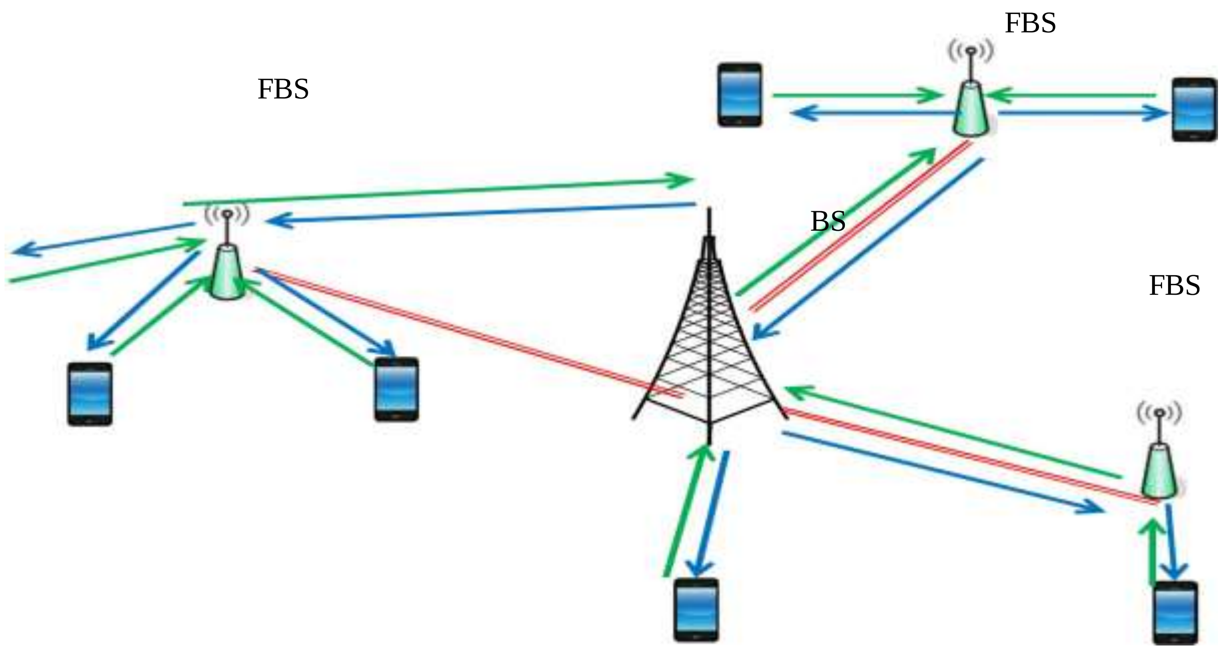


Fig: 5G components

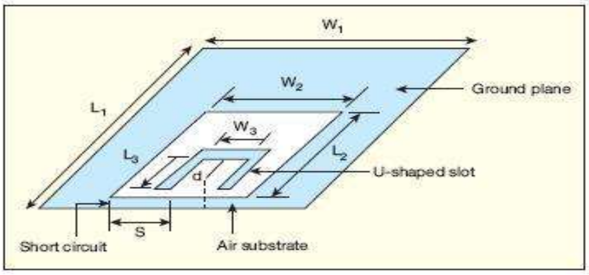
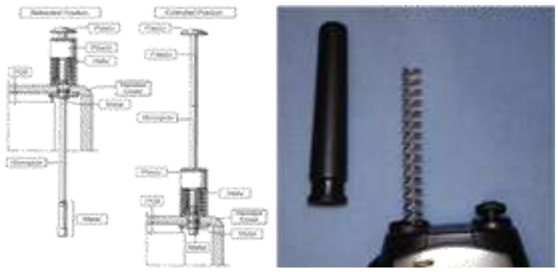
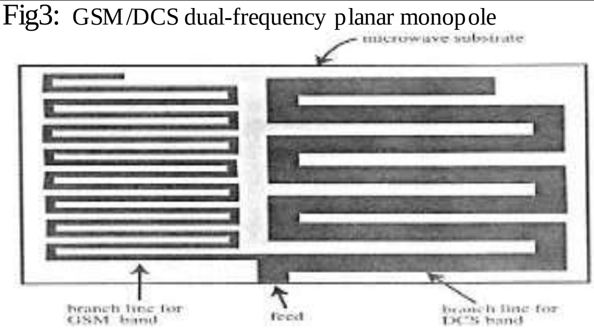
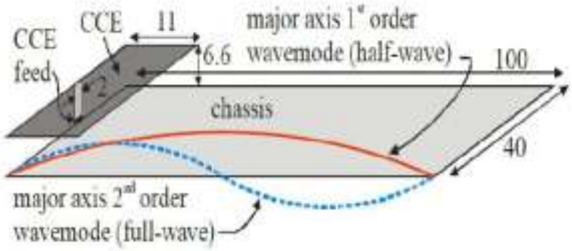
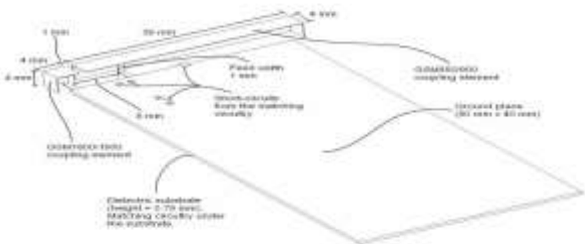
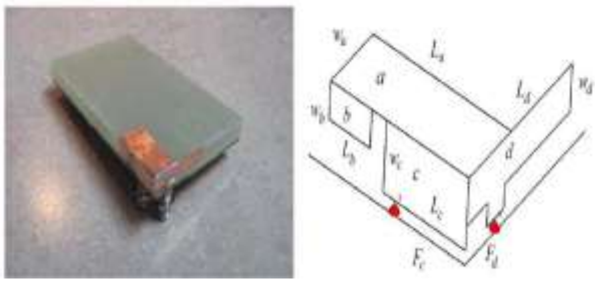


DIFFERENT TYPE OF 5G ANTENAS:

Different Type Of Antennas:

- Planar inverted-F antenna (PIFA):
- SISO Antenna in Mobile Terminals:
    - WIDE BAND AND DUAL BAND
    - MULTI BAND
- MIMO Antenna for Mobile Terminals:
    - WIDE BAND
    - DUAL BAND AND MULTI BAND
- Metal Rimmed Antenna for Mobile Terminals:
    - FULL ANTENNA

Planar inverted-F Antenna [PIFA]:

Fig1:Duel Band PIFA 	Fig2:Monopole Plus Helix Antenna 
Fig3: GSM/DCS dual-frequency planar monopole 	Fig4: Coupling Elements 
Fig5: quad-band prototype [coupling elements] 	Fig6:Two feed point Antenna 

1.1 At the first generation, the antennas were situated in the top portion of the mobile devices as a monopole. This monopole was designed to work as a quarter length of the operational frequency. Therefore, knowing the operational frequencies, miniaturization techniques were proposed to reduce the size of the monopole. One example of this miniaturization was to compress the antenna by making it helix type and, when working in multiband services a little whip was introduced into the helix so as to cover the two bands required. When the PCB was of the quarter length size these devices worked even better because PCB plus monopole worked as a dipole.Fig:2

1.2 The main disadvantage of this monopole-helix antenna was the external discomfort and even the good radiation pattern it had, this antenna also had a high Specific Absorption Rate (SAR). So, in the 1990's were developed internal antennas so as to avoid the trip of having discomfort. These internal antennas were called PIFA (planar inverted F antenna) and they had a ground plane connected to a physical point of the antenna and, for multiband behavior, they also had a slot in the main plate to disturb the current distribution. Fig: 1

1.3 Another kind of internal antenna used was a simple planar monopole which were not connected to the ground plane. This type of **antennas** may require a ground clearance region in the vicinity (generally on one edge of the PCB) for acceptable performance. Techniques like adding parasitic elements or adding parallel branches to the radiating element can be used for multiband operation. Currently this antenna is used for GSM coverage. In most cases the monopole requires miniaturization so as to be inside the antenna's housing. For instance, a 900 MHz operation frequency device must require an antenna with a straight planar monopole of a height of about 83 mm. The mainly designs techniques to reduce the antenna are the bending, the folding, or the wrapping two-dimensional planar monopoles into three-dimensional structures. Fig: 3

1.4 Low-volume antenna structures for mobile devices might require the reducing of the volume of the antenna elements –due either to the location into the PCB or the specifications-. A way to do that is to efficiently use the radiation of the currents in the ground plane or mobile PCB. As it is explained in, essentially non-resonant coupling elements (called CE) are used to optimally couple to the dominating characteristic wave modes of the chassis. The antenna structures are tuned to resonance with matching circuits. However, there are no systematic feasibility and performance studies of the coupling elements, and it is all reduced then to a practical-laboratory designs and tests. As it is stated in [12], the ground plane of the printed circuit board (PCB) in a mobile terminal plays the major role for radiation especially in the lower-frequency bands, where 90% of the total radiation comes from the PCB at 900MHz.

The coupling element based antenna structure consists of three main parts. The first part is the mobile terminal chassis, which is meant to work as the main radiator of the antenna structure. Coupling elements are used to excite the primary wave modes of the chassis as efficiently as possible. Impedance matching to the transceiver electronics is produced with a matching circuitry. In order to couple to the chassis wave mode efficiently, the location and shape of the coupling element have to be chosen correctly. The strongest coupling (and largest bandwidth) can be achieved by bending the coupling element over the shorter end of the chassis Fig: 4 & Fig 5

1.5 The solution to overcome this drawback is to implement a multi-feed point for the antenna. Each element of the antenna must be connected to one single point to cover each frequency band and to avoid the problem of 4G multi-sent data. However, this can derivate into another problem, the port-to-port isolation. The isolation is needed to dodge the port-to-port coupling and to evade the efficiency losses. Thus, obtaining a good isolation depends on the position of one antenna's element respect to the other one and -considering the small space reserved for the antenna-that is a parameter to be considered and analyzed in the design of the full antenna. Fig: 6

ANTENNA ANALYSIS & DESIGN

SISO Antenna:

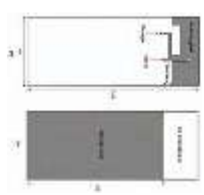
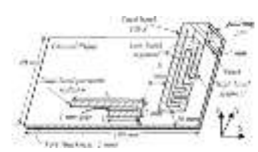
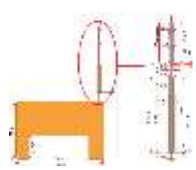
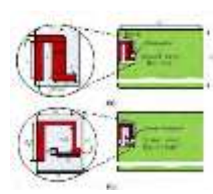
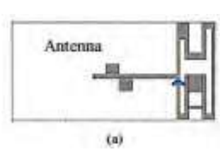
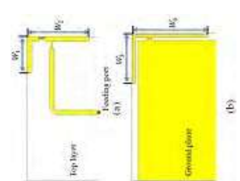
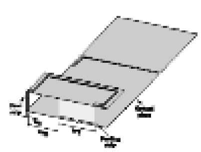
Ref	Antenna Design	Bandwidth [GHz]	Ref	Antenna Design	Bandwidth [GHz]
[14]		0.82 - 3	[18]		0.88 - 0.96 and 1.85 - 1.99
[15]		0.3 - 0.7	[19]		2.39 - 2.49 and 5.07 - 5.88
[16]		1.33 - 3.5	[20]		2.27 - 2.52 and 5.29 - 5.53
[17]		0.8 - 0.97 and 1.5 - 5.9	[21]		0.7 - 0.96

Fig: SISO Antenna Single Band

SISO Antenna: [Multi Band]

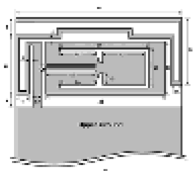
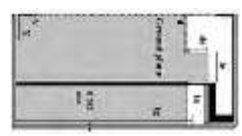
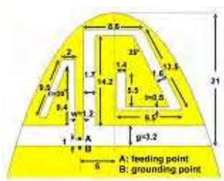
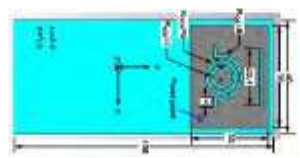
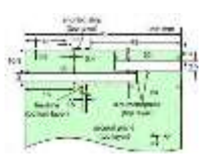
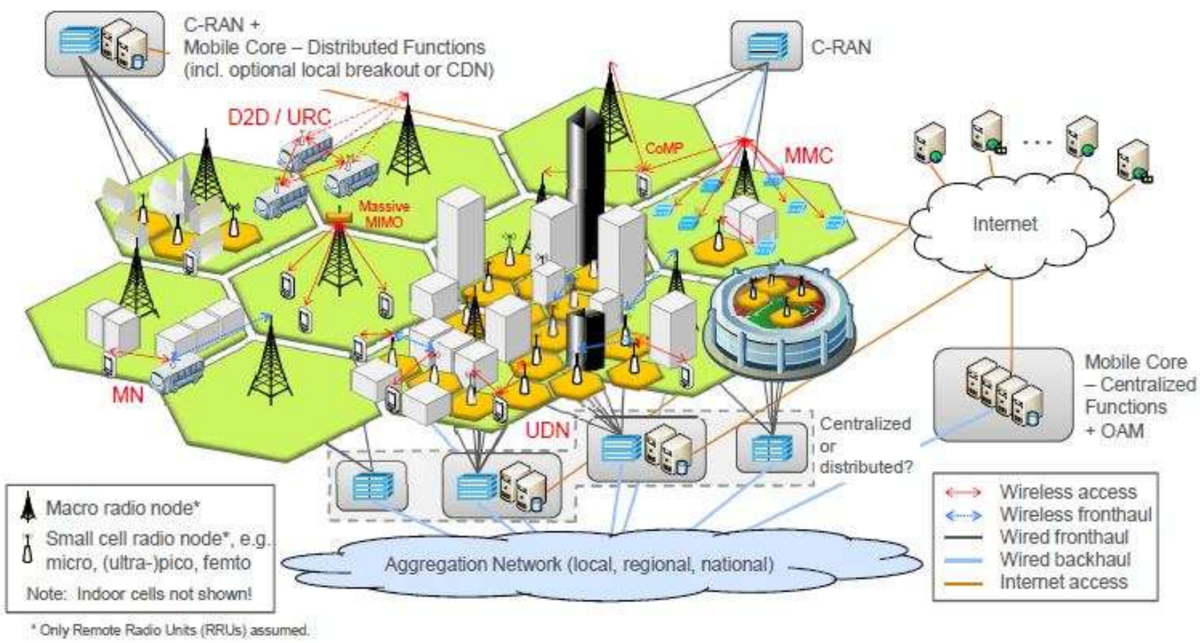
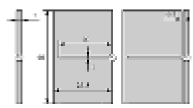
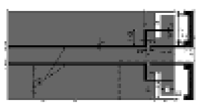
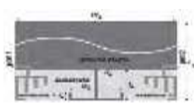
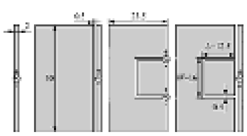
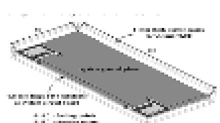
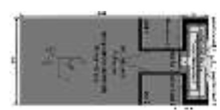
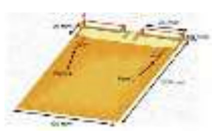
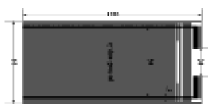
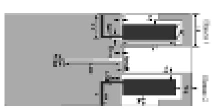
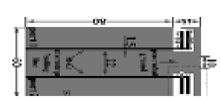
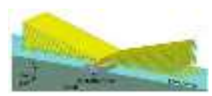
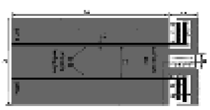
Ref	Antenna Design	Bandwidth [GHz]	Ref	Antenna Design	Bandwidth [GHz]
[22]		0.46 - 785, 880 - 980 and 1.45 - 1.49	[27]		0.834 - 0.907, 1.985 - 2.845 and 3.253 - 3.593
[23]		0.824 - 0.96 and 1.710 - 2170	[28]		0.70 - 0.96, 1.75 - 2.3 and 3.1 - 4.38
[24]		0.824 - 0. 96 and 1.71 - 1.99	[29]		2.08 - 2.17, 3.55 - 3.65, 4.88 - 4.94 and 5.68 - 5.76
[25]		0.704 - 1.04 and 1.56 - 2.46	[30]		0.45 - 0.474, 0.86 - 1.04, 1.7 - 2.43 and 2.5 - 2.71
[26]		0.89 - 0.96, and 1.4 - 2.7	[31]		0.87 - 0.96, 1.7 - 2.2 and 2.49 - 2.72

Fig: SISO Antenna Multi Band



C-RAN +
Mobile Core – Distributed Functions
(incl. optional local breakout or CDN)
C-RAN
D2D / URC
CoMP
MMC
Massive MIMO
Internet
MN
UDN
Centralized
or
distributed?
Mobile Core
– Centralized
Functions
+ OAM
Macro radio node*
Small cell radio node*, e.g. micro, (ultra-)pico, femto
Note: Indoor cells not shown!
Aggregation Network (local, regional, national)
Wireless access
Wireless fronthaul
Wired fronthaul
Wired backhaul
Internet access
* Only Remote Radio Units (RRUs) assumed.

MIMO Antenna: [Wide Band]

Ref	Antenna Design	Bandwidth [GHz]	Ref	Antenna Design	Bandwidth [GHz]
[32]		1.8 - 4.6	[40]		1.7 - 2.87
[33]		1.85 - 2.31	[41]		1.79 - 3.77
[34]		2.0 - 5.6	[42]		1.7 - 3.5
[35]		1.7 - 2.75	[43]		1.62 - 2.92
[36]		0.74 - 0.96	[44]		1.71 - 2.72
[37]		0.87 - 2.82	[45]		1.68 - 2.74
[38]		3.4 - 3.6	[46]		4.55 - 4.75
[39]		1.67 - 2.76	[47]		2.2 - 2.6

MIMO Antenna: [Duel & Multi Band]

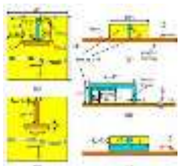
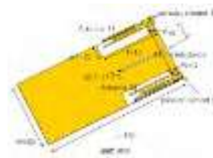
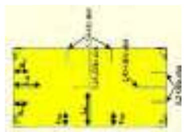
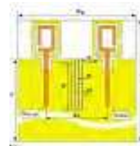
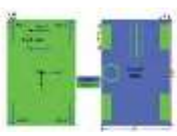
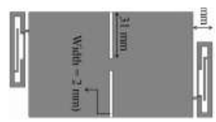
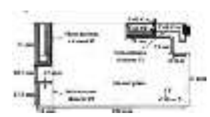
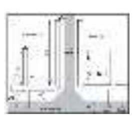
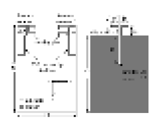
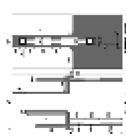
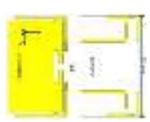
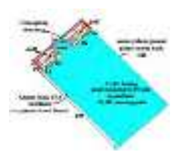
Ref	Antenna Design	Bandwidth [GHz]	Ref	Antenna Design	Bandwidth [GHz]
[48]		2.4 - 2.48, and 3.4 - 3.6	[56]		0.746 - 0.798, and 1.71 - 2.7
[49]		2.35 - 2.6 and 5.1 - 5.3	[57]		1.924 - 2.2, 2.836 - 3.235 and 5.629 - 5.743
[50]		1.93 - 2.05 and 3.99 - 4.23	[58]		0.68 - 0.912, 1.92 - 2.203 and 2.38 - 3.603
[51]		2.6 - 2.8 and 3.4 - 3.6	[59]		0.88 - 0.96, 1.75 - 1.87, 2.3 - 2.4 and 2.4 - 2.5
[52]		0.58 - 0.92 and 2.955 - 3.13	[60]		0.826 - 1.005, 1.527 - 2.480, 3.436 - 3.690 and 5.34 - 5.725
[53]		0.803 - 0.823 and 2.44 - 2.90	[61]		0.824 - 0.960 and 1.71 - 2.690
[54]		2.34 - 2.5 and 5.18 - 5.5	[62]		0.704 - 0.787, 0.88 - 0.96 and 1.8 - 2.69
[55]		2.4 and 5.0			

Fig: MIMO Antenna Multi Band

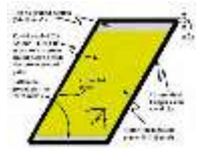
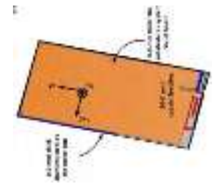
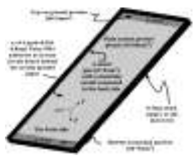
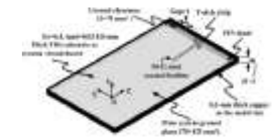
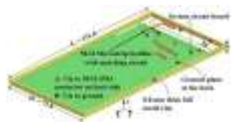
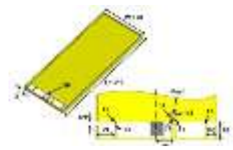
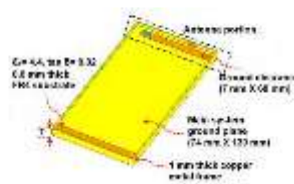
3 pillars of Antenna Design Technique for MIMO are: [5G frequency Bands]

- Millimeter Wave
  - Greater Propagation Loss
  - Shallow Building Penetration
  - Smaller Cell Size
  - Can contain hundreds of elements of small arrays
- Beam Forming & Massive MIMO
  - Adaptive beam forming antenna & massive MIMO antenna combine increase the capacity and performance and improve SINR
  - Can follow multiple users
  - Dynamically adapts to the environment
- Special Efficiency with DSP
  - DSP with antenna improvement of massive MIMO increase the capacity and speed and data rate also.

ANTENNA ANALYSIS & DESIGN

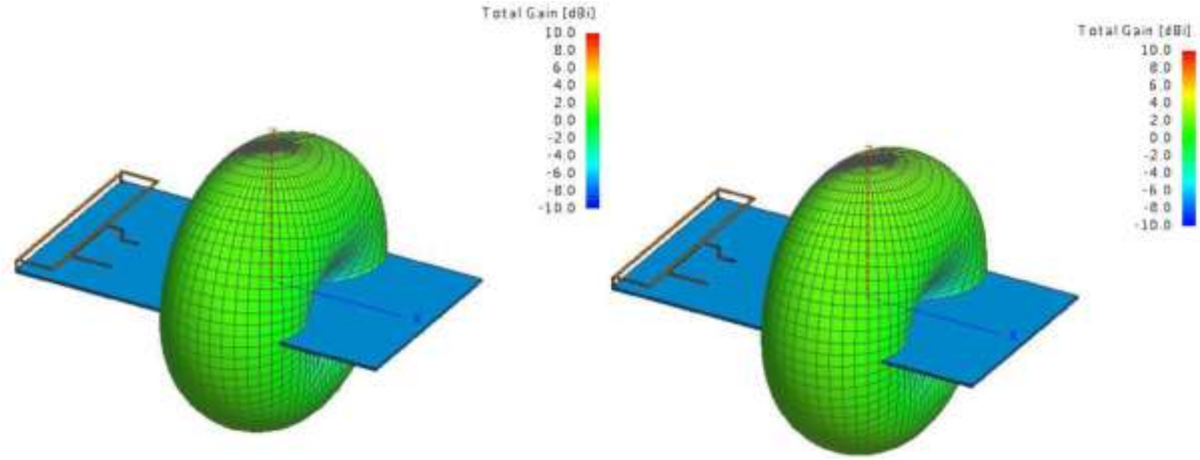
Metal Rimmed Antenna:

Ref	Antenna Design	Bandwidth [GHz]	Ref	Antenna Design	Bandwidth [GHz]

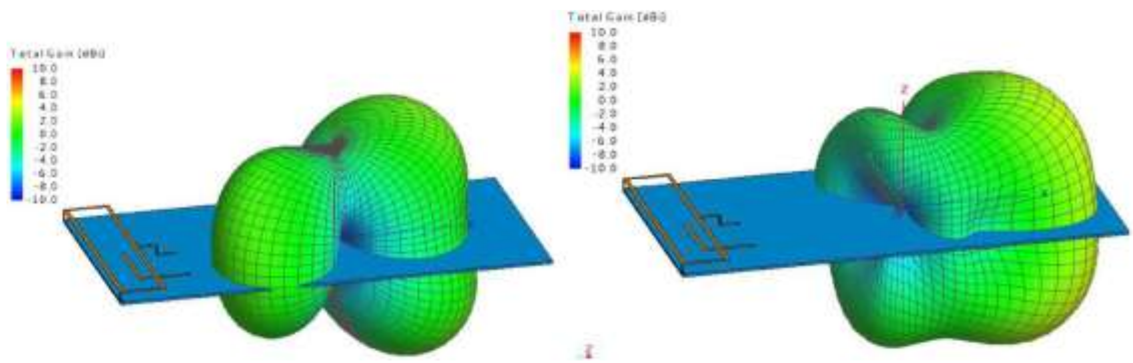
[64]		0.824 - 0.96 and 1.71 - 2.69	[68]		0.824 - 0.96 and 1.71 - 2.69
[65]		0.798 - 0.968 and 1.44 - 2.95	[69]		0.824 - 0.96 and 1.71 - 2.69
[66]		0.824 - 0.96 and 1.71 - 2.69	[70]		0.698 - 0.96 and 1.71 - 2.69
[67]		0.822 - 0.965 and 1.59 - 2.91	[71]		0.698 - 0.96 and 1.71 - 2.69

Full Antenna Radiation Pattern: [4G] Simulation

Radiation pattern at a) 754 MHz and b) 958 MHz



Radiation Pattern a)1.77GHz and b)2.63GHz



5G MOBILE TERMINAL ANTENNA DESIGN

5G antenna:

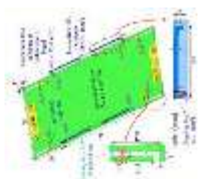
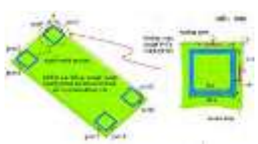
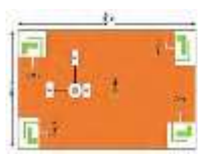
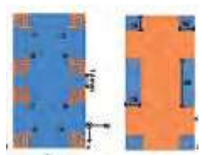
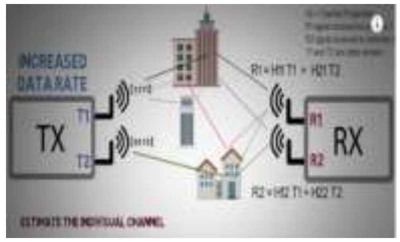
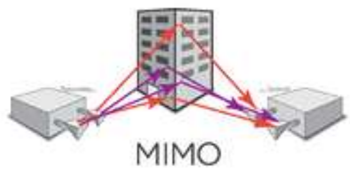
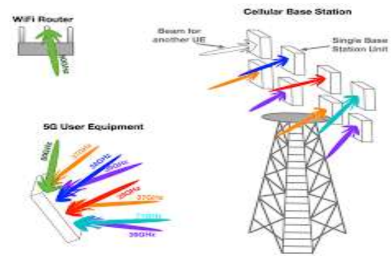
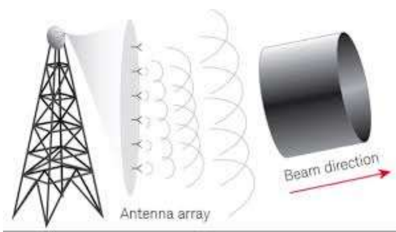
Ref	Antenna Design	Bandwidth [GHz]	Ref	Antenna Design	Bandwidth [GHz]
[78]		2.55 - 2.65	[81]		0.824 - 0.96 1.71 - 2.69 and 3.4 - 3.6
[79]		2.55 - 2.65	[82]		3.4 - 3.6
[80]		1.8 - 1.92, 2.3 - 2.4 and 2.54 - 2.62	[83]		3.4 - 3.6

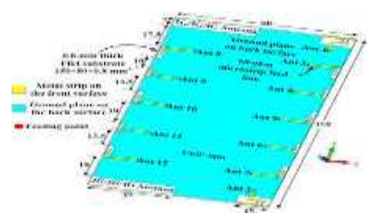
Fig: Multiplexing, Beam Forming, LTE, massive MIMO,Phase array System& 5G features

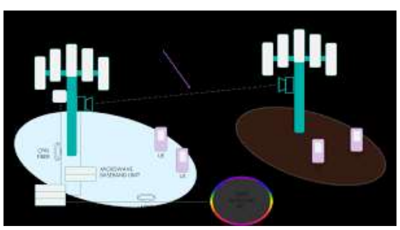


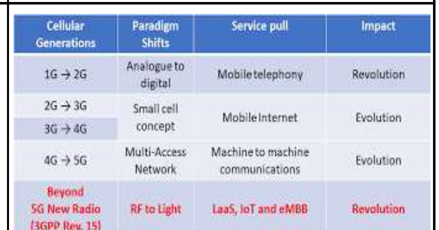








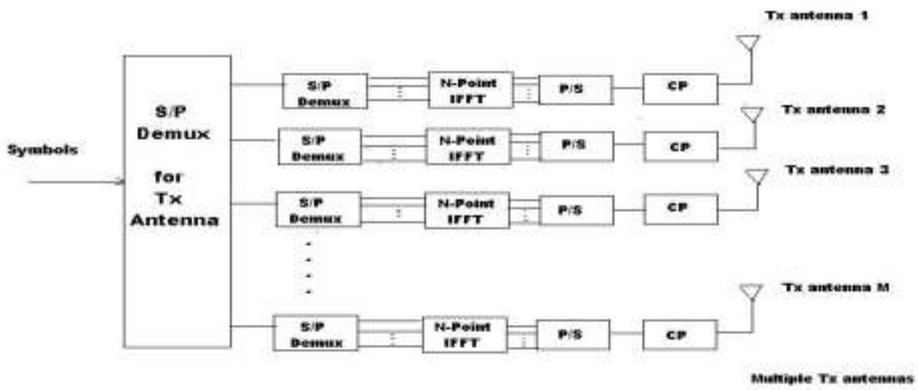




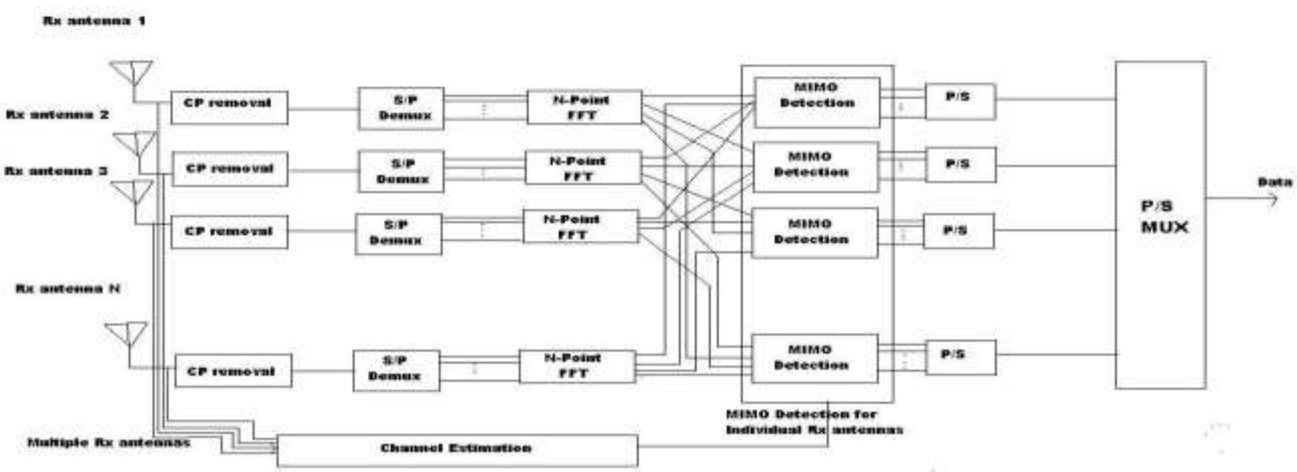
Cellular Generations	Paradigm Shifts	Service pull	Impact
1G → 2G	Analogue to digital	Mobile telephony	Revolution
2G → 3G 3G → 4G	Small cell concept	Mobile Internet	Evolution
4G → 5G	Multi-Access Network	Machine to machine communications	Evolution
Beyond 5G New Radio (3GPP Rev. 15)	RF to Light	LaaS, IoT and eMBB	Revolution

MIMO TRANSMITTION & RECEIVE BY ANTENNA

MIMO OFDM Transmitter:



M



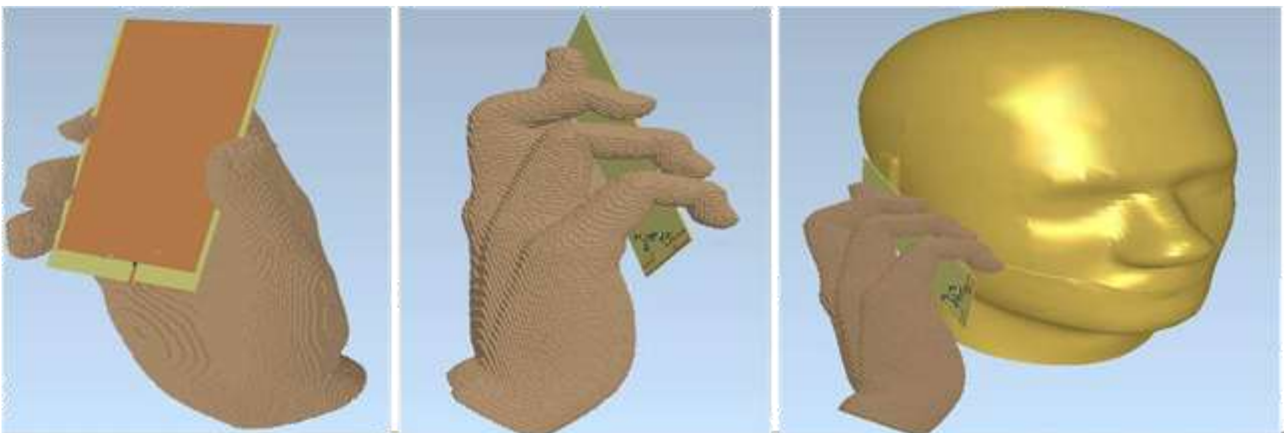
SMALL CELL BACKHAUL WITH 5G

Small cell antenna infrastructure which contains higher order of e and cost to effective solutions to avoid interference.

- MACRO, MICRO & PICO
- Lower cost for both CAPEX & OPEX
- Be Easy to manage
- Outdoor furniture appearance
- High Weather reliability
- Safe to touch design
- IoT ,smart city,5G optimize
- Easy to diagnose potentials
- Cost effective across net hauled
- Quickly Activated, AT & T Predicts low fold
- Physical Small, increase capacity
- Excellent frequency reuse

EFFECTS OF 5G HAND ON:

Fig: Simulation Models of the Antenna Considering the User



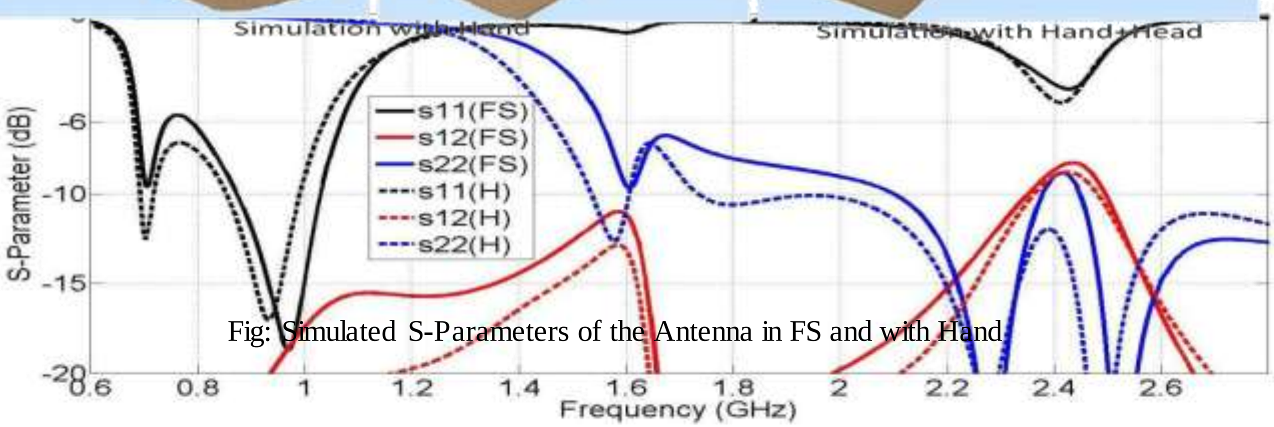
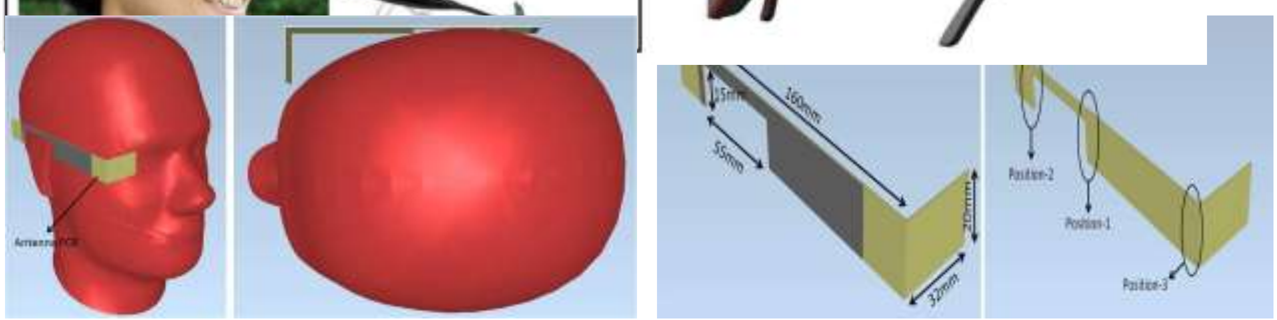


Fig: Simulated S-Parameters of the Antenna in FS and with Hand

FEASIBILITY STUDY FOR EYEWEAR 4G ANTENNAS

Fig: Different Eyewear Devices under Development



CONCLUSION:

In this papers we have submitted the total conceptual & abstractions with figure & desctiptions.5G is the most upgraded technology for mobile terminal antenna design for user friendly and that has the goal of 2020.We have tried to find out with revolution-evaluation-complementary as follow of 1G-2G-3G to 4G to 5G road way antenna design
& we will improve and modify for research purpose to know & share basics for the purpose of antenna design simulations though next.
5G basically based on the dynamic data flow way and always with 4G.This feature design will complete the lack and issues of old antennas like signal simulation roundness, propagation models & technique so.
This technology designs antenna to serve with Small cell for 5G backhaul ,new radio interface and arrays instead of single antennas ,even if the more effective problems and challenges, lacks with issues .By which 5G mobile terminal antenna with its advantages & medications to utilization & consideration of user friendly technique

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