

A Survey on Millimeter-Wave a Permissive Technology for 5G Cellular Communications

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ABSTRACT- Every year the number of wireless enabled devices and the amount of data consumed continues to grow at an exponential rate (53%)CAGR.The mobile data traffic is extended at very rapid rate and causes superlative attention of researchers towards underutilized spectrum in the millimetre-wave frequency bands as a potentially viable solution for achieving tens to hundreds of times more capacity compared to current 4G cellular networks. This paper discuss the overview of mm wave bands as well as new efficient protocols and algorithms which makes mm.Wave bands more sophisticated for the next generation 5G cellular networks..

KEYWORDS: nechoic chamber, millimeter-wave beam forming, hybrid beam forming, 5G cellular communications, 4G cellular networks, next generation cellular systems, mobile communications, mobile traffic, channel measurement.

I. INTRODUCTION

The millimetres-wave region of the electromagnetic spectrum is usually considered to be the range of wavelengths from 10 millimetres (0.4 inches) to 1 millimetre (0.04 inches). This means millimetres waves are longer than infrared waves or x-rays, for example, but shorter than radio waves or microwaves. The millimetre-wave region of the electromagnetic spectrum corresponds to radio band frequencies of 30 GHz to 300 GHz and is sometimes called the Extremely High Frequency (EHF) range. The high frequency of millimetres waves as well as their propagation characteristics (that is, the ways they change or interact with the atmosphere as they travel make them useful for a variety of applications including transmitting large amounts of computer data, cellular communications, and radar. In this article we have reviewed the solutions provided in by minimizing the common misunderstanding about the Friis equation. It uses the two actual patch antennas at 3 GHz and an array antenna at 30 GHz of the same physical size to determine the propagation losses at higher frequencies. The solution we have reviewed is the concept of beam formation for mm.Wave by using novel hybrid beam forming scheme which is adaptable in analog and digital domain both based on link and system level simulation. At the last, we have also described the prototype for beam forming model.

II. MM WAVE: THE STORY OF 3 FREQUENCIES

An Opening up new spectrum could enable service operators to accommodate more users while also delivering a higher performance mobile broadband data experience. Compared to spectrum below 6GHz, mmWave is plentiful and lightly licensed, meaning it could be made accessible to service operators around the world. Service operators have begun investigating in mmWave technology to evaluate the best candidate frequencies for use in mobile applications. The International Telecommunication Union (ITU) and 3GPP have aligned on a plan for 2 phases of research for 5G standards. The first phase defines a period of research for frequencies under 40 GHz to address the more urgent subset of the commercial needs completing September 2018. The second phase is slated to begin in 2018 and completing December 2019 to address the KPIs outlined by IMT 2020. This second phase focuses on frequencies up to 100 GHz.In an effort to globally align the standardization of mmWave frequencies, ITU released a list of proposed globally viable frequencies between 24 GHz and 86 GHz after the most recent World Radio communications Conference (WRC)[5].

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24.25–27.5GHz	31.8–33.4GHz
37–40.5GHz	40.5–42.5GHz
45.5–50.2GHz	50.4–52.6GHz
66–76GHz	81–86GHz

Shortly after ITU proposal, the Federal Communications Commission (FCC) in the United States issued a Notice of Proposed Rule Making (NPRM) on October 21st 2015 that proposed new flexible service rules among the 28 GHz, 37 GHz, 39 GHz, and 64-71 GHz bands [6].

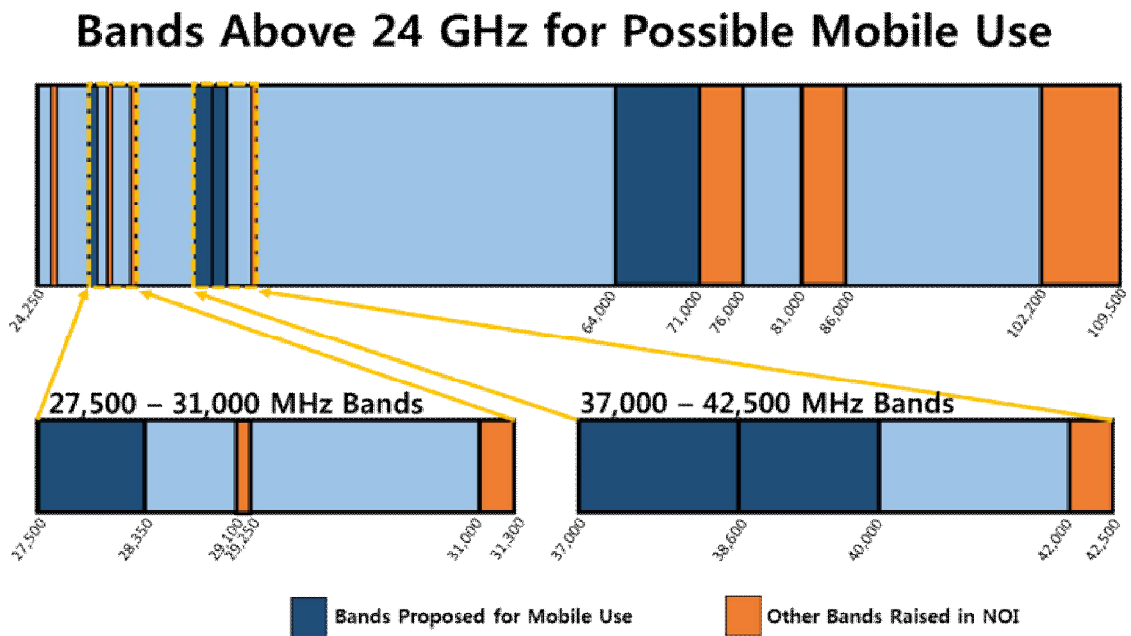


Figure 1: FCC Bands Proposed for Mobile Use

These 3 frequency bands have emerged for a number of reasons. These frequencies also function well in multipath environments and can be used for non-line-of-sight communications. Using highly directional antennas in combination with beam forming and beam tracking, mmWave can provide a reliable and very secure link.

III. MM WAVE CHANNEL PROPAGATION: THEORY AND MEASUREMENTS

The several advance research have been done to minimize to sustain the traffic surge which needed high data rates. The different investigation on fourth generation (4G) Long Term Evolution (LTE) to provide high data rates by improving the spectral efficiency. The various enhancement has been done on multiple-input multiple-output (MIMO), coordinated multipoint (CoMP), heterogeneous networks (HetNets), and carrier aggregation (CA), to increase the channel capacity of to deliver the high data rates. Since 2013, projects like METIS, investigation to provide a viable solution for the improvement of 5G era. To reform underutilized spectra for future outdoor cellular applications, two key hurdles must be overcome: sufficiently large geographical coverage and support for mobility even in non-line-of sight (NLoS) environments where the direct communications path between the transmitter and the receiver is blocked by obstacles. There always been concerns about utilizing the mmWave spectrum for high frequency and long distance

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communications because of several losses especially higher penetration, precipitation, and foliage losses etc. The biggest misunderstanding about losses in free space propagation can be cleared by using Friis transmission equation, given by.

$$P_r = P_t + G_t + G_r + 20 \log \left(\frac{c}{4\pi Rf} \right) [dBm] \quad (1)$$

where P_r is the receive power in unobstructed free space, P_t is the transmit power, G_t and G_r are the transmit and receive antenna gains, respectively, R is the distance between the transmitter and receiver in meters, f is the carrier frequency, and c is the speed of light. The received power can easily be seen as inversely proportional to the frequency squared when an ideal isotropic radiator ($G_t = 1$) and an ideal isotropic receiver ($G_r = 1$) are used at each end. In reality, same aperture transmit and receive antennas at higher frequencies, in fact, send and receive more energy through narrower directed beams, which is not commonly recognized [9]. It can be verified at anechoic chamber by using patch antenna at 3GHz and array antenna at 30 GHz. It is found that when array antennas are used at both transmitting and receiving ends at 30 GHz, the measured receive power is 20 dB higher than that of the 3 GHz patch antenna case. The several other studies also considered that utilizing higher frequency bands for cellular communications. In for outdoor channel measurements. These study results reveal that the key parameters characterizing the propagation properties of the mm Wave bands, such as the path loss exponent, are comparable to those of typical cellular frequency bands when transmit and receive antennas are used to produce beam forming gains.

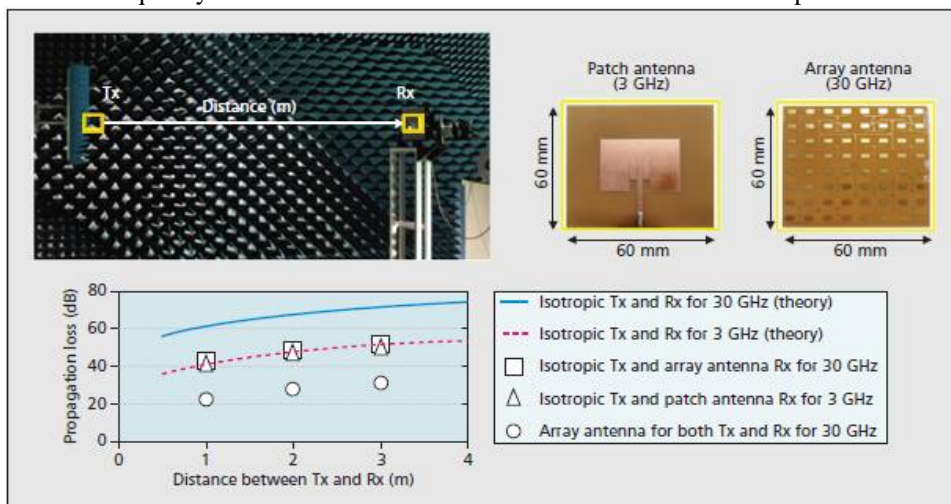


Figure 2. Results of verification measurements of propagation loss predicted by the Friis equation.

From the experimental study we have concluded that the small wavelengths of mm Wave frequencies facilitate the use of a large number of antenna elements in a compact form factor to synthesize highly directional beams corresponding to large array gains.

IV. MM WAVE BEAM FORMING ALGORITHM

The beam forming scheme employed to reduce unfavourable path loss for cellular communications at mmWave frequency bands. The small wavelengths of mm Wave frequencies facilitate the use of a large number of antenna elements in a compact form factor to synthesize highly directional beams corresponding to large array gains. [7]. For digital beam forming the particular coefficients are multiplied with modulated signal per Rf chain whereas in analog, the complex coefficients applied to manipulate the RF signals by means of controlling phase shifters and/or

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variable gain amplifiers (VGAs). By and large, advanced beam forming gives a higher level of flexibility and offers better execution to the detriment of expanded multifaceted nature furthermore, cost because of the way that different FFT/IFFT hinders (for OFDM frameworks), computerized-to-simple converters (DACs), and simple-to-computerized converters (ADCs) are required per every RF chain. Simple beam forming, then again, is a straightforward and viable strategy for producing high beam forming picks up from an extensive number of radio wires yet less adaptable than advanced beam forming. It is this exchange off between adaptability/execution what's more, straightforwardness that drives the requirement for half and half beam forming designs, particularly at the point when a large number of reception apparatuses is required as in the mmWave groups. Fig. 3 below shows the architecture for hybrid beam forming applied at both the transmitter and receiver end. In this architecture, the sharp beams formed with analog beam forming (phase shifters) compensate for the large path loss at mmWave bands, and digital beam forming provides the necessary flexibility to perform advanced multi-antenna techniques such as multi-beam MIMO.

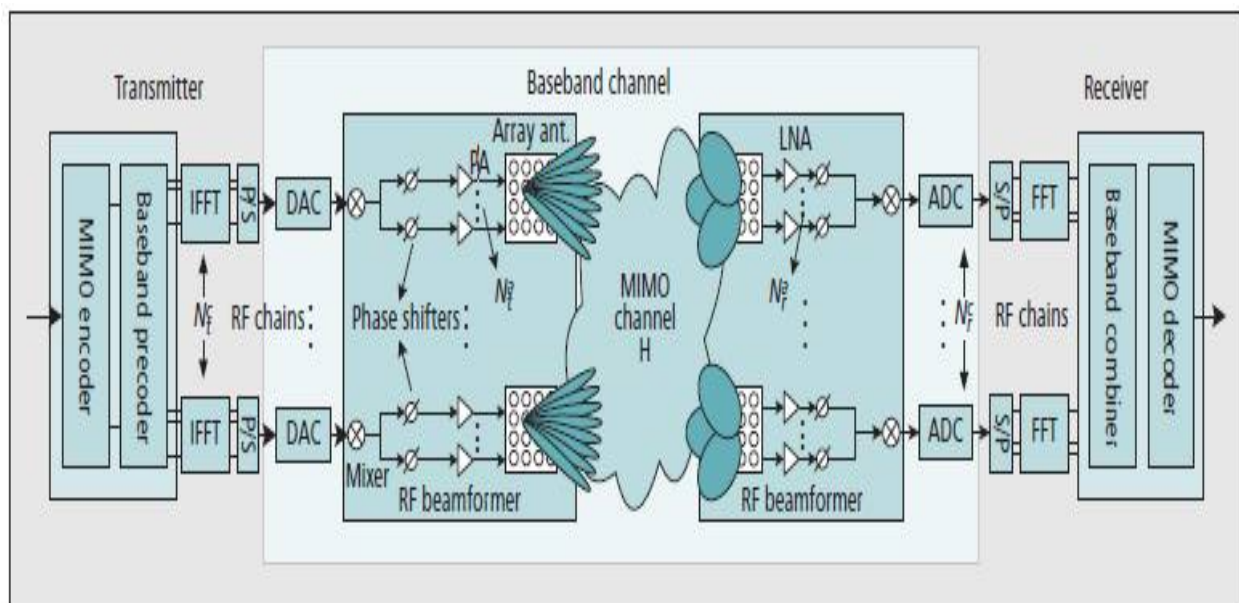


Figure 3. Block diagram of a hybrid beam forming architecture.

The system level simulation [5] for hybrid beam forming analysed by using different antenna's at both the transmitter and receiver end in mm Wave bands. Using a 500 MHz bandwidth at 28 GHz, [5] presents some notable results for the hybrid beam forming system including an 8 dB gain over the conventional spatial multiplexing scheme and 8 Gb/s average sector throughput with 16 antennas with 4 RF chains at the base station and 8 antennas with a single RF chain at the mobile station.

V. MM WAVE BEAM FORMING PROTOTYPE

In this section we have described the mmWave beamforming prototype developed and tested at the DMC R&D Centre, Samsung Electronics, Korea, including system configuration, key parameters, and capabilities. The main purposes of the mmWave prototype are to check the feasibility of mmWave bands for sufficiently large geographical coverage for cellular services and support for mobility even in NLoS environments. The parameters which are considered for the prototype are listed in table below 1 below. As shown in fig 4, the transmit and receiving antennas have two channels and each comprises 32 antenna elements arranged in the form of a uniform planar array (UPA) with 8 horizontal and 4 vertical elements, confined within an area of 60 mm × 30 mm. By setting the phase shifter values to a particular set,

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transmit and receive array antennas are capable of forming a sharp beam pattern in the intended horizontal (azimuth) and vertical (elevation) angles. The sub array architecture is employed to reduce the hardware complexity which groups the subgroup of 8 antenna, therefore needs only 4 RF units per channel instead of 32.

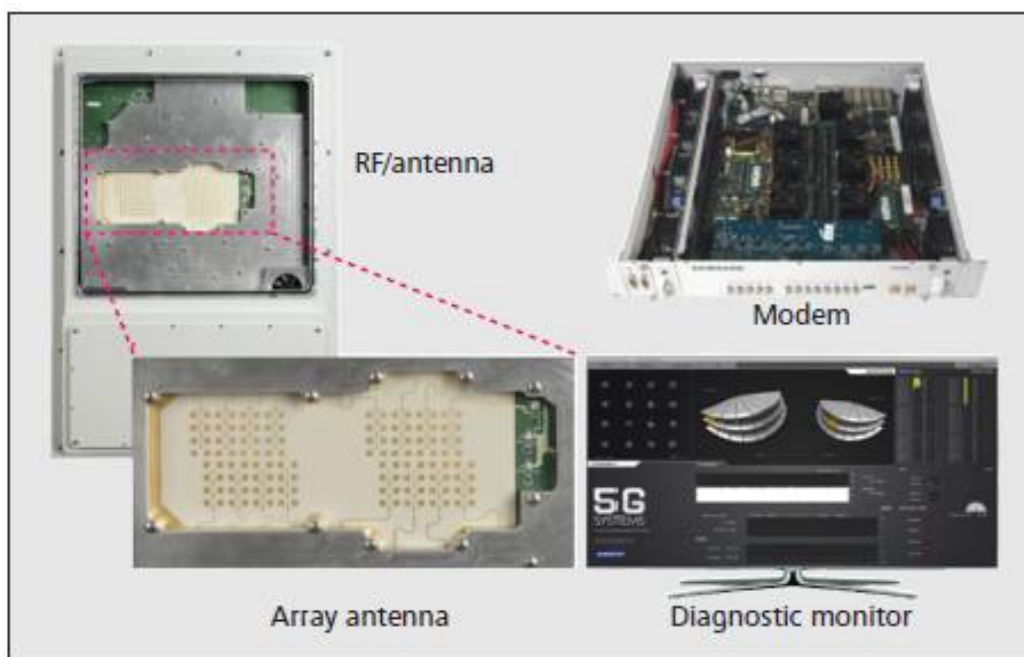


Figure 4. Configuration of the mmWave beam forming prototype.

In this fashion, the base and mobile stations quickly establish the wireless communications link and adaptively sustain the link even in high mobility conditions.

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Key system parameters	Values
Carrier frequency	27.925 GHz
Bandwidth/FFT size	520 MHz/4096-FFT
Subcarrier spacing	244.14 kHz
Cyclic prefix size	0.18 × OFDM symbol
Modulation, coding (data rate)	QPSK, LDPC 1/2 (264 Mb/s) 16QAM, LDPC 1/2 (528 Mb/s)
Maximum transmit power	31 dBm (with 9 dB back-off), 1.26 Watts
Array antenna configuration per channel	8-element by 4-element (32 antennas) Uniform Planar Array
Array gain	18 dBi
FWHM	10° (Horizontal)/20° (Vertical)
Beam scanning range	±30° (Horizontal)
Effective isotropic radiated power (EIRP)	Max 49 dBm (Nominal 41 dBm)
Adaptive beam searching and switching time	45 ms

Table 1. Key system parameters of the mmWave beam forming prototype

VI. CONCLUSION

This article shows how these high frequencies exhibit themselves as strong candidates for cellular bands with recent channel measurement, simulation, and prototype results. The test results provide valuable insights and understanding of the high frequency bands for future cellular usage and urge experts in the industry to endeavour to research in this promising area.

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