Progress Standardization Activities on 5G Technology

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***Abstract* —This paper presents the progress standardization activities on 5G wireless technology in telecommunication sector. Some of the 5G candidate frequency bands below 6 GHz (Sub-6 GHz) and above 6 GHz (mmWave) are illustrated. Simulated output power spectra of the power amplifier for 5 MHz FBMC waveform and input power level of 0 dBm is shown.**

Keywords — ***The fifth generation (5G technology), WRC, ITU-R, ITU-T, Standardization, Frequency Spectrum***

I. INTRODUCTION

The fifth generation (5G) technology is one of the most hyped topics in technology with enthusiasts promising it will be the gateway to virtual reality (VR), augmented reality, the Internet of Things (IoT), 3D services, pervasive high resolution video and self-driving cars.
The development of wireless communication over the last three decades has revolutionized our lives. In the past decade there has been a proliferation of wireless services and devices, followed by increasing demands for higher data rates.
More and more information needs to be transmitted over a limited radio spectrum. As consumers increasingly adopt smart phones and use high speed mobile data for emails, apps and particularly video on mobile devices, the demand for radio spectrum is growing exponentially. Global mobile data traffic is just about doubling every year, and will continue to do so through the next decade [1]. Total wireless data traffic is expected to more than double every two years, with compound annual growths of more than 40%, over the next 5 years.

This growth will not only occur in cellular systems but also non-cellular systems such as WiFi and the Internet-of-Things (IoT). It is predicted that within the next ten years, trillions of devices will connect to mobile networks. They will generate a thousand-fold increase in total mobile traffic [2] and cause a spectrum shortage and clogged cellular networks. The spectrum shortage will propel an increase in dropped calls, a rise in mobile data prices and slowing of data speeds, a nightmare scenario for wireless operators and consumers. New technologies in higher parts of the radio spectrum are needed to enable efficient and low cost wireless data services. Cellular networks have occupied lower frequency bands, below 3 GHz. But this frequency spectrum has already been heavily used, making it difficult for operators to acquire more of it. A variety of physical layer enhancements have been pursued to increase the network spectral efficiency and energy efficiency which has become a significant issue because wireless communication systems are becoming significant worldwide consumers of energy.

Since the current technologies have already approached the information theory capacity limits, there is not much scope for further gains in the capacity in the bands below 3 GHz. There is growing interest in wireless transmission over millimeter wave (mmWave) frequencies, above 20 GHz, as a potential solution to the radio spectrum shortage. In particular, the frequency bands 24.25 - 29.5 GHz, and E-band (71-76 GHz and 81-86 GHz), have been released by the International Telecommunication Union (ITU) to provide broadband wireless services.

Many of new technologies will rely extensively on enhancements to Multiple-Input-Multiple-Output (MIMO) systems including systems such as mmWave cellular systems and massive MIMO. We can also, apply, full duplexing, non-orthogonal multiple access (NOMA), beamforming antenna technology etc. According to the Ericsson' June 2017 Mobility Report the proportion of mobile subscribers in each region that will have 5G come 2022 is shown in Fig. 1. This paper highlights the progress standardization activities on 5G technology in telecommunications sector.

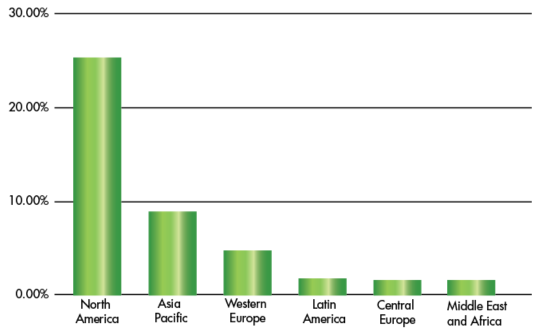

Fig. 1. Proportion of mobile subscribers in each region

II. STANDARDIZATION ACTIVITIES ON 5G TECHNOLOGY

The IEEE, 3GPP and International Telecommunication Union (ITU) are the three major players for 5G standardization. ITU Telecommunication Standardization Sector (ITU-T) and ITU Radio Communication (ITU-R) have been conducting system review and proof-of-concept studies on IMT-2020 by its Study Group 13. The 5G network layout is shown in Fig. 2. The timeline for the development of 5G technology has not been officially confirmed. It is widely expected that a formal discussion as well as standardization activities will be completed by late 2019, and commercial deployment is expected to happen in 2020 [3-4]. The first certified 5G standards and the standardization are expected to be completed by late 2019.

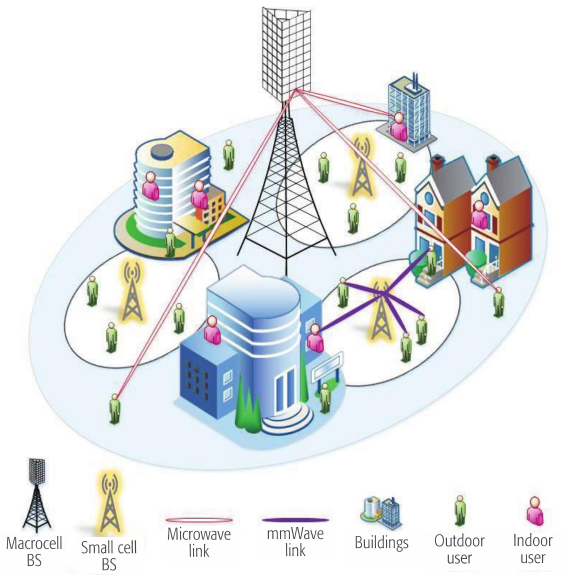

Fig. 2. 5G architecture

III. 5G FREQUENCY SPECTRUM

The lifeblood of the cellular industry and a scarce resource is frequency spectrum. 5G network operators are responding by adding capacity in the Sub-6 GHz and mmWave frequency bands. To align the standardization of mmWave frequencies, the International Telecommunication Union (ITU) has proposed frequencies between 2.30 GHz and 86 GHz globally. Different regions are assigned to 5G certain frequency bands, with adequate definition of the corresponding technical conditions. Some of the 5G candidate frequency bands above 6 GHz (mmWave) and below 6 GHz (Sub-6 GHz) are shown in Table 1.

Each band comes with tradeoffs in terms of range and capacity. According to new findings from ABI Research, the 3.5 GHz band will likely be most used to deliver nationwide coverage, while the use of mmWave is one of the most distinguishing features of 5G. In 5G we will have caps of 100 MHz below 6 GHz and 400 MHz above 6 GHz. Below 6 GHz 400 MHz will be achieved through Carrier Aggregation (CA) (e.g. 4x 100 MHz), while in 4G we had 20 MHz and 100 MHz through CA (e.g. 5 x 20 MHz) maximum. Therefore, 3GPP have built the potential for a 20x increase in channel capacity right into the spectrum planning in moving from 20 MHz to 400 MHz maximum. The allocation of 5G frequency spectrum for cellular applications will be analyzed at World Radiocommunication Conference 2019 (WRC-19), Sharm el-Sheikh, Egypt, 28 October to 22 November 2019.

Table I. 5G Candidate Bands

Region	Frequency band
EU	40.50 – 43.50 GHz 31.80 - 33.40 GHz 24.25 – 27.35 GHz 3.40 – 3.80 GHz 2.57 - 2.62 GHz
US	64.00 – 71.99 GHz 38.60 – 40.00 GHz 37.00 – 38.60 GHz 27.50 – 28.35 GHz 3.55 – 3.90 GHz 2.496 - 2.690 GHz
China	37.00 – 43.50 GHz 24.25 – 27.50 GHz 2.30 - 2.40 GHz 2.555 -2.655 GHz 3.30 – 3.60 GHz 4.40 – 4.50 GHz 4.80 – 4.99 GHz
Japan	27.50 – 29.50 GHz 4.40 – 4.90 GHz 3.60 – 4.20 GHz 3.40 – 3.60 GHz 2.496 - 2.690 GHz
South Korea	37.00 - 40.50 GHz 26.50 – 29.50 GHz 3.40 – 3.70 GHz

IV. Beamforming Antenna Technology

Beamforming antenna technology is required to increase the range of mmWave radio systems. This is done by electronically steering, or directing, the signal in the desired direction. Directing the radio signal also helps to reduce interference and it improves the quality (data rate) of the radio link. There are several beamforming antenna technologies such as RF beamforming, analog beamforming, LO beamforming, digital beamforming and hybrid beam forming. In digital beam forming, each antenna element utilizes independent transceivers, data converters, and upconverters. This technology employs complex hardware, is dissipates a significant amount of power and computationally intense. Therefore, the high power consumption of digital beamforming does not make it a good solution for initial mmWave 5G implementations. A traditional approach where the beam is formed in the analog/RF domain close to the antenna element is RF beamforming. A single signal source for the entire array is provided by one transceiver. This technology can be cost effective but it is the least flexible approach and will likely not be acceptable for UE designs because a power amplifier or low noise amplifier is required at each antenna element which consumes a significant amount of power. The hybrid beamforming is the most promising technology. This technology combines elements of the RF and digital approach. This approach allows for some level of dynamic configuration. Sub-arrays can be configured in the baseband, while the beamforming occurs closer to the antenna in the RF domain in this approach. This technology negates some of the power consumption and cost advantages and makes this approach very challenging for the UE.

V. Results

There are several multicarrier waveform candidates for 5G application such as Filter Bank Multi-Carrier (FBMC) which transmits data by filtering each sub-carrier individually rather than the whole sub-band, and Universal Filter MultiCarrier (UFMC). In contrast to 4G CP-OFDM, the low side-lobes, steep slope at the edges of the signal band and the use of larger number of subcarriers during transmission all help to improve spectral efficiency at the output of the wireless transmitter. 4G can only support a maximum carrier bandwidth of 20 MHz whilst 5G is expected to use a minimum carrier bandwidth of 400 MHz.

In this section, a 5 MHz 5G FBMC waveform are evaluated at 25 GHz as one of the main potential 5G mmWave bands. Experimental data for the HMMC 5026 Keysight/Agilent power amplifier at 25 GHz were extracted and used in Kewsight ADS. In order to evaluate the level of the nonlinear distortion, power spectrum for 5 MHz 5G FBMC signal at the output of the power amplifier (HMMC 5026) with input power level of -10 dBm at 25 GHz is shown in Fig. 3.

The nonlinear distortion in this case is about 43 dBc. The simulated output power spectrum of the power amplifier for the same 5G waveform and input power of 0 dBm is shown in Fig. 4.

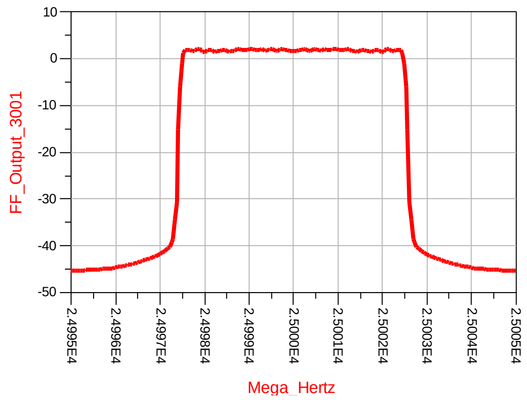

Fig. 3. Simulated output power spectrum of the power amplifier for 5G FBMC 5 MHz waveform and input power of -10 dBm

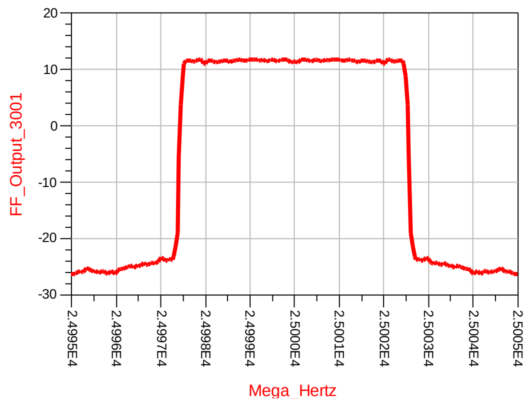

Fig. 4. Simulated output power spectrum of the power amplifier for 5G FBMC 5 MHz waveform and input power of 0 dBm

VI. Conclusion

In this paper, the progress standardization activities on 5G wireless technology in telecommunication sector has been presented. List of some of the 5G candidate frequency bands below 6 GHz (Sub-6 GHz) and above 6 GHz (mmWave) has been illustrated. Power spectra for 5G FBMC 5 MHz waveforms at the output of the power amplifier (HMMC 5026) with input power level of -10 dBm and 0 dBm at 25 GHz, respectively has been presented

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