Sivers Insights

How to achieve sustainable 5G mmWave solutions

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Introduction

The main drivers behind deployments of fifth generation (5G) networks is to offer gigabit speeds and low latency services to homes and offices. Today, a variety of wireless options are available to address higher data rates, but primarily they follow the standards 802.11ax, 802.11ad/ay (also referred to as "unlicensed 5G") or 5G NR. In this context, the 802.11 ax is limited by less spectrum available. With a typical use of sub-6 GHz frequencies and maximum channel bandwidth of 160 MHz, there is a practical upper limit in data rate of approx. 1 Gbps (under exceptionally good conditions). To explore true gigabit speeds, there are two major options left, licensed and unlicensed millimeter wave spectrum.

Either you want to use the licensed millimeter wave bands (24-29.5 GHz and 37-40 GHz) or the unlicensed band (57-71 GHz), the challenges are the same and depending on how you choose to apply them, the environmental implications will primarily depend on how much power you use to create the gigabit data stream. There are, of course trade-offs like reliability and security to consider, but in the context of this Insight document, we will focus on how to design and deploy a solution and the effect it has on DC power consumption and hence how sustainable a 5G CPE solution really is.

As of today, the licensed 5G NR millimeter wave bands are n257 (26.50-29.50 GHz), n258 (24.25-27.50 GHz), n261 (27.50-28.35 GHz) and n260 (37.00-40.00 GHz). In these frequency bands the licenses typically give access to 100 MHz up to 800 MHz spectrum, but operators will most probably have access to 400 MHz channels. For the unlicensed 60 GHz deployments, an operator would have access to six channels, each providing a spectrum of 2,000 MHz.

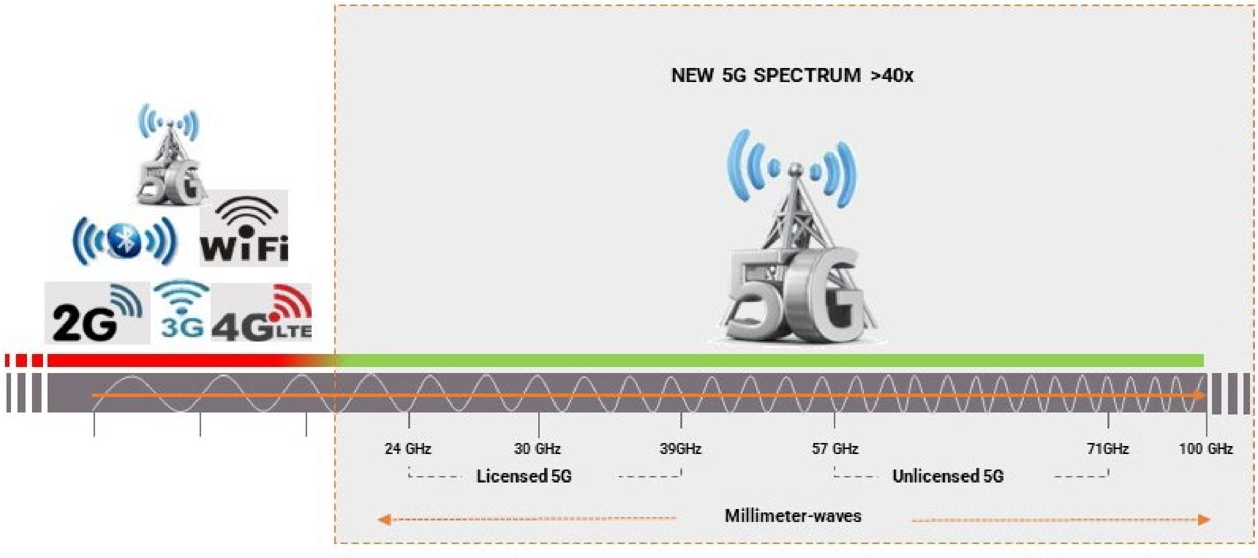

Figure 1. Frequency allocations of mobile systems

Sustainability impact

So, why is this important in the context of sustainability?

To simplify the technical mystery of signal processing, power consumption and analog millimeter wave RF design, we choose to compare the complexity of data throughput with the behavior of a garden hose vs. a fire hose. A garden hose cannot push more water than a fire hose, simply because of two reasons, the diameter of the hose and the pressure from the pump. In a wireless telecom network, the diameter of the hose can be seen as the available spectrum (the width of the channel) and the pressure from the pump can be seen as the type of modulation used (the spectrum efficiency used when "creating the data"). So, to push the most water through the hose, you need the optimum diameter as well as the optimum pump, given how much water you want to push (which is given by the use case you have. It is a great difference between putting out a fire and water your flowers in the garden).

Figure 2. Using the right tools for the right application

Similar terms apply in the wireless telecom world. Available spectrum combined with the suitable modulation scheme gives the data rate an end user can use. But higher modulation comes with a "cost penalty", since the more data you send, the receiver will require a cleaner signal, which translates to a better signal-to-noise ratio (SNR). To achieve higher data rates over the same distance, you will need to increase the output power in order to compensate for the better SNR required and this means a higher need for more DC power. To process more data also means the signal processing will require more DC power, which adds on to the total DC power need.

Below, we have listed four different approaches to enable gigabit speeds. In the table you can see the normal bandwidth for a channel and the related data speed. We have also included how much you need to back off your power to have the necessary SNR value plus the expected consequence in terms of how many RFICs you would need to achieve the higher output power from the antenna. It should also be noted that system features, like digital pre-distortion (DPD) can be used to improve the linearity and quality of the signal, but that will also contribute to more signal processing and greater power consumption. In this context we have not included the impact of DPD.

Modem solution	"Normal" bandwidth	Actual Data speed	Back-off need to reach good SNR	Number of "RF chips" that you need to use
5G-NR (64 QAM)	400 MHz	1386 Mbps / spatial stream	8 dB	2.5x
802.11ad/ay (QPSK - 4 QAM)	2000 MHz	2500 Mbps	1 dB	1x
802.11ax (1024 QAM)	160 MHz	1201 Mbps / spatial stream	12 dB	4x
5G-NR (DFT-s-OFDM pre-coded)*	100 MHz	94 Mbps / spatial stream	1 dB	1x

*Estimated maximum value. It should be noted that this solution normally has very low throughput as typically only a few subcarriers are allocated to each terminal. The possible combinations of configurations and sub carrier allocations are endless and in this context we put in the maximum theoretical value (estimated).

Including losses for overhead etc. the actual effect of the modulation is:
Single Carrier QPSK – 4 QAM gives: 17 times more data than a 4G/LTE reference channel (20 MHz)
DFT-s-OFDM pre-coded: 0.64 times less data than a 4G/LTE reference channel (20 MHz)
OFDM 64 QAM: 9.5 times more data than a 4G/LTE reference channel (20 MHz)
OFDM 1024 QAM: 8.2 more data than a 4G/LTE reference channel (20 MHz)
When comparing different options, there is an obvious benefit if you can use fewer RF chips. From a sustainability perspective, fewer chips means less resources during the manufacturing of these chips, but it also means far less power consumption.

We also believe the characteristics and features of your RF chip will add on to the environmental impact. By optimizing on the total performance of the system, where you address the optimum trade-off between how much power you send out over the air, how clean signal you can generate and how much power you consume to make this happen, becomes critical success factors for the total system solution.

As a reference, the subject of sustainability and power consumption of ”green radios” has been addressed in the ”MiWaves” project, funded by the EU. One of the major emphasis of the project was to address the importance and potential of using millimeter wave radios and directive antennas to reduce the emitted power and increase the efficiency of the spectrum usage together with a number of other implementations. The project target was to provide a reduction by a factor of 100 of the energy per bit used in the wireless access scenario compared to LTE/4G [1].

Sivers Semiconductors is putting lots of effort in developing products that can contribute to a better, safer and more sustainable world. It is not only about giving great performance on chip level, it is about reducing the total number of components needed and how to bring the best out of your system also from a sustainability perspective.

We are happy to talk more about how our products and capabilities can help you create the most sustainable 5G millimeter wave systems.

[1] *https://cordis.europa.eu/docs/projects/cnect/3/619563/080/deliverables/001-619563MiWaveSD86FinalprojectreportAres20176060869.pdf*