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Physical Layer Considerations on Terahertz Networks

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Abstract

Terahertz band communication is attracting great interest and is expected to alleviate the capacity limitations of current wireless networks, and the upcoming 5G systems which incorporate millimeter wireless links but would still not be sufficient to keep pace with the rapidly increasing of global mobile data traffic. This paper reviews a recent progress in THz wireless communications first, and then presents our recent results on real-time indoor wireless links.

Keywords: Terahertz Networks; Physical Layer; Thz Wireless Communications; NLOS

Introduction

Global mobile data traffic is increasing exponentially and expected to reach to 50exabytes per month by 2021 [1] due to the sharply increasing of mobile devices and the rise of Internet of Things (IoT). Based on this trend, wireless network transmission rates above 100 Gbit/s and even to Tbit/s will not be far in numerous connections among base stations, end-user devices and so on. However, current allocated spectrum cannot provide enough bandwidth to meet such growing demand, even with complex modulation schemes and MIMO systems. So, lots of research works are concentrated on higher carrier frequencies, beyond 95 GHz where the US Federal Communications Commission (FCC) has not well-established service rules, to obtain much wider bandwidth for new generations of wireless systems [2-5].

Exploiting this frequency range in wireless communications is not so easy and there are many obstacles to overcome. One of the big is the significant power loss due to atmospheric attenuation. Transmission distance is limited by the attenuation, which can limit transmission distance but can be compensated by employing high power sources and highly directional (high gain) antennas. Besides, considering the strong dependence of atmospheric attenuation on frequencies, it could be more practical and commercial to operate in some frequency windows to avoid the relatively narrow absorption peaks as in Figure 1. These peaks are mostly attributed to water vapor and gaseous molecules. And most of the existing THz indoor and outdoor links really obey this to avoid the absorption lines around 180, 330, 380, 450, 560, 750 GHz, and obtain long-distance transmission. In addition, attenuation due to rainfall, fog, pollution and atmospheric turbulence should not be ignored for outdoor communications [6].

THz link distance is mainly limited by the serious atmospheric attenuation and decreases with increasing frequency as shown in Figure 1. Direct line-of-sight (LOS) techniques should be necessary to require obstruction-free paths between antennas. Also, considering Friis formula, the detection efficiency improves more than one order at THz frequency due to its much smaller wavelength. So THz wireless link would suffer less free-space diffraction effects. This indicates that it is more immune to signal eavesdropping and should be a good candidate for future wireless networks.

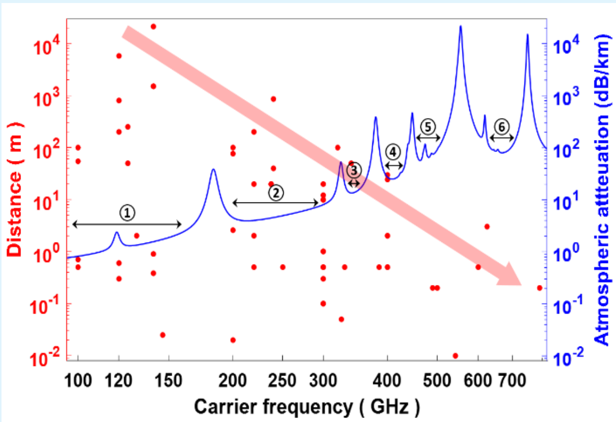

Figure 1: Summary of achieved link distance withover-95-GHz carrier frequencies at ①100–150 GHz,②200–300 GHz, ③330–360 GHz, ④390–430 GHz, ⑤460-520 GHz and ⑥600–700 GHz(red); Impact of atmospheric attenuation of THz waves under 60 % humidity (blue). References for this figure can be found in [7].

THz wireless links are good choices for several indoor scenarios, especially at high frequencies, due to its atmospheric limitation. However, the biggest problem one has to overcome is that it can't travel through obstacles such as walls, human bodies and other hard objects, which represents a major hurdle for any practical wireless networks. This is a trade-off for its less diffraction effect as mentioned above. To handle this, many are considering to employ specular non-line-of-sight (NLOS) paths for compensation. For an example, the signal can undergo NLOS reflections from walls around an object to avoid the full blockage. However, no one thinks this could be possible because of considerable absorption and dispersion effects by walls which would degrade the link performance seriously. Here, we succeeded to bounce a 200 GHz link around a room without much sacrifice of data. A configuration of the link setup is shown in Figure 2 with two specular NLOS reflections from the same sort of painted cinderblock wall around a corner. That means the loss is not so much as people have thought and the received power could be enough to support the idea of terahertz local-area networks in some conditions.

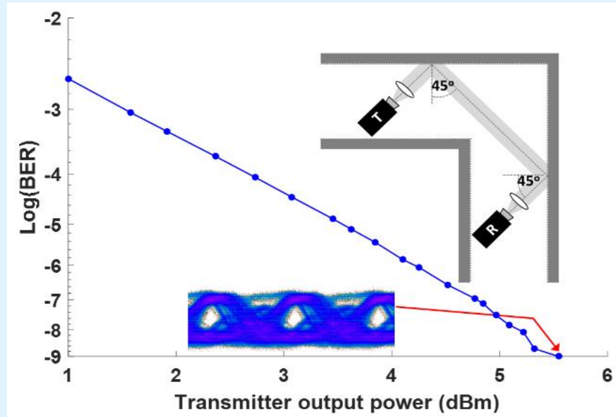

Figure 2: Log (BER) vs. transmitter output power for carrier frequency at 200 GHz. Top right: configuration of the NLOS link by double reflections around a corner.

Physical layer security is one of the most serious considerations for wireless communications. Free Space Optical (FSO) communication systems, which own larger available bandwidth and are more directional, are usually regarded as an inherently secure approach. But its high diffuse reflection losses and low transmission power budget due to eye safety restrictions limit the achievable data capacity. And one shows they could steal and decode data streams without any notice when the FSO link propagates through atmospheric turbulence [8]. Frequency at terahertz range, which does not own so high directionality, but is still much better than its lower frequency neighbours in micro- and millimeter ranges because of its smaller wavelength. This property also supports it to suffer the impact of atmospheric turbulence. So now, we can say that THz wireless links can be more immune to eavesdropping in transmission, even though this increases the influence of misalignment between transmitter and receiver.

Conclusions

In this paper, a summary of recent progress in THz wireless links is presented and implies the necessity of avoiding frequency absorption lines to obtain long-distance transmissions. Frequencies at THz band can be a good choice for future indoor wireless networks due to its inherent advantages in physical layer.

Acknowledgements

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References

1. Cisco (2017) Cisco Visual Networking Index: Forecast and Methodology, 2016–2021. Cisco public, pp: 1-17.
2. Federici J, Moeller L (2010) Review of terahertz and sub terahertz wireless communications. Journal of Applied Physics 107(11).
3. Ostmann KT, Nagatsuma T (2011) A review on terahertz communications research. Journal of Infrared Millimeter and Terahertz Waves 32(2): 143-171.
4. Kürner T, Priebe S (2014) Towards THz communications-status in research, standardization and regulation. Journal of Infrared Millimeter and Terahertz Waves 35(1): 53-62.
5. Nagatsuma T, Ducournau G, Renaud CC (2016) Advances in terahertz communications accelerated by photonics. Nature Photonics 10: 371-379.
6. Federici JF, Ma J, Moeller L (2016) Review of weather impact on outdoor terahertz wireless communication links. Nano Communication Networks 10: 13-26.
7. Ma J, Shrestha R, Moeller L, Mittleman DM (2018) Invited Article: Channel performance for indoor and outdoor terahertz wireless links. APL Photonics 3.
8. Martinez LFJ, Gomez G, Balsells GJM (2015) Physical-layer security in free-space optical communications. IEEE Photonics Journal 7(2): 1-14.