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Optical millimeter-wave generation techniques: An overview

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ABSTRACT

With evolving bandwidth demands, there is a pressing need for transfer from lower to higher frequency spectrum especially in millimeter-wave range. Due to restricted frequency response of electronic devices, high frequency signals cannot be generated economically and efficiently. Therefore, generation of millimeter-waves in optical domain is proposed as a viable solution, as distribution of these high frequency signals can also be done using optical fiber in efficient manner. The fundamental concept behind microwave/millimeter-wave generation is optical heterodyne,wherein, light signals from two independent lasers operating at different wavelengths are combined using optical combiner and detected using photodiode. The photodiode provides electrical beat signal whose frequency is equal to frequency difference between two laser sources. As the two lasers are running independently, there is no phase correlation between the two output light signals. Therefore, resultant electrical beat signal is quite noisy. Different approaches have been proposed to enhance quality of resultant electrical beat signal, with good stability and frequency tunability. We generally refer these proposed approaches as optical millimeter-wave techniques. In this paper, an attempt has been made to explain working principle of different optical millimeter-wave generation techniques. Special emphasis has been provided to optical millimeter-wave generation using Mach-Zehnder modulators. Further, dependence of extinction ratio on optical band generation at different biasing points has been discussed. The millimeter-wave based radio-over-fiber systems have been classified in simplex, duplex and multichannel transmission networks. Also, modulator based systems with tunable frequency multiplication factor have been discussed.

1. Introduction

There has been a rapid increase in wireless communication since the advent of 21th century, as it provide mobility during communication. It is estimated that by 2022, global mobile data will reach 77exabytes per month, mobile-connected devices per capita will touch 1.5, and average global smartphone data rate will surpass 40 Mbps [1]. Also, number of global mobile devices is projected to increase from 8.8 billion in 2018 to 13.1 billion by 2023, out of those 1.4 billion will be 5G capable. Further, mobile machine-to-machine devices is expected to grow at a 30% compound annual growth rate from 2018 to 2023, which is much higher than 7% for smartphones in same period [2]. Fig. 1 shows the variation of few information and communication technology (ICT) indicators provided by international telecommunication union (ITU) over the past fifteen years. The proper definition of these indicators can be found at ITU statistical database [3]. It is quite clear from the Fig. 1, that there is a tremendous increases in number of mobile phone users and mobile broad-band subscriptions. There is a steady proliferation in number of portable devices, like smart phones and tablets, and on the top of that we have exponential increase in number of bandwidth hungry applications and services such

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