Analysis of BER for Millimeter Wave Photonic Integrated Circuits

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ABSTRACT : *Photonic integration technology operating in millimeter wave frequency range (30-300 GHz) is one of the most advanced methods in wireless communication systems. Dual wavelength source is generated by active and passive integrated optical methods. This paper mainly focuses on the high data transfer enabling. The laser heterodyne signal is analyzed and by using simulation technique BER of transmitted signal is measured.*

Keywords *- Integrated photonics, DFB lasers, millimeter wave communication. OFDM.*

I. INTRODUCTION

By means of advanced modulation scheme and signal processing technologies data capacity has been improved by increasing spectral efficiency for communication systems operating at microwave frequencies. Complete signal generation is achieved by integrating active and passive photonic components [1]. Due to electronic limitation conventional techniques cannot generate millimeter wave. Frequency conversion method is widely used in communication system to move information from one frequency channel to other [2]. In frequency division multiplexing (FDM) bandwidth capacity is shared by using different frequencies. Entire frequency band is divided into sub-carrier frequency bands which can be used by different users [3]. Terahertz wave is located between millimeter wave and infrared light wave in the electromagnetic spectrum. Millimeter wave band is from 30GHz-300GHz with a bandwidth of 270GHz [4]. 60GHz band proposed by FCC has drawn considerable interest for different applications. Stable and tunable millimeter wave and Terahertz signal is used for tomography, gas sensing and imaging for security systems [5]. AWGN is commonly used channel mode in which linear addition of wideband or white noise with a constraint spectral density and a Gaussian distribution of amplitude is the only impairment to communication.

II. OPTICAL HETERODYNE TECHNIQUE

In heterodyne, carrier signal is multiplied by local oscillator. For FM receiver, intermediate frequency of 10.7MHz is created by local oscillator. Using heterodyne mixing on a photodiode or other type of opto-electronic transducer high frequency electric signal is generated.

A. Millimeter wave generation

Optical signal source generates two different wavelengths that are mixed into photodiode or photoconductor. Electrical output of photo detector consists of two dc terms (intensity of two laser fields) plus frequency difference term [6]. Frequency domain and time domain are used for defining frequency stability.

B. Device description

Millimeter wave transmitter consists of two distributed feedback lasers (BFB), optical combiner, electro optic modulators, integrated high speed photodiode (PD). Semiconductor optical amplifier (SOA) are also included to compensate optical losses. Two laser outputs are combined after passing through SOAs using a multimode interference (MMI) coupler. In order to have optical access to the chip, light from DFB laser is combined in a MMI coupler on the other side of chip. Each DFB laser's tone is generated from which output power can be adjusted using two independently connected SOAs [7]. Two optical tones are sent to the uni travelling carrier photodiode (UTC-PD) to convert optical signals to electric signals at a frequency equal to the optical frequency difference. Whole device is 4.4 mm long and 0.7 mm wide shown in Figure. 1

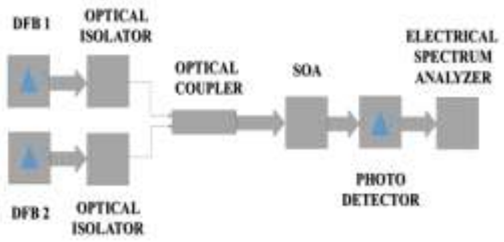

Fig 1 Generating Millimeter Wave Signals By Using Optical Heterodyne Technique.

C. Wireless transmission

Frequency bands of 71-76 GHz and 81-86 GHz had been allotted for broadband services in Asia, Europe and North America. As they suffered only much lower atmospheric attenuation 10 GHz frequency band is much useful for wireless transmissions over distance in excess of 1 Km. As a result multi gigabit capacities transmission had been possible by simple modulation scheme.

Hence, there is a growing demand for developing tailored integrated photonic components that can exploit the 10 GHz bandwidth within the 70 GHz and 80 GHz bands and enable full duplex broadband wireless transmission. A key component required for wideband wireless system is a photo receiver exhibiting a flat frequency response in the frequency band of interest and providing the required power levels for wireless transmission [8]. Thereafter, we present a compact setup for wireless transmission within the 60-90 GHz frequency range.

III. Simulation Result

a. OFDM

It consists of 64 sub carriers out of which 48 sub carriers are data information carrying carriers while the remaining 16 carriers are signaling and control sub carriers. These 64 subcarriers are completely orthogonal to each other to avoid inter channel interference (ICI). Thus OFDM transmits high speed serial information bits into lower speed sub signals simultaneously and in parallel. Pilot sub carriers are used to prevent frequency and phase shift errors. AWGN is a noise (effect of thermal noise generated by thermal motion of electron in all dissipative electrical components) that affect the transmitted signal when it passes through the channel and it contains a uniform continuous frequency spectrum over a particular frequency band. This research has been focused on the study and the performance of high data rate modulation scheme at these channels.

b. QPSK and QAM

Consisting the BPSK modulation 2 bits are used to represent 4 levels. This gives us 4 input combinations. Modulation is done by using QPSK modulation. If the input to the QPSK is"00" then the output of QPSK is real part (-1) and imaginary part (-1). If the input to the QPSK is"10" then the output of QPSK is real part (1) and imaginary part (-1). Here the real part is 2"s complement of the carrier signal. If the input to the QPSK is"01" then the output of QPSK is real part (-1) and imaginary part (1). Here the imaginary part is 2"s complement of carrier signal. Quadrature Amplitude Modulation or QAM is a form of modulation which is widely used for modulating data signals onto a carrier used for radio communications. It is widely used because it offers advantages over other forms of data modulation such as PSK, although many forms of data modulation operate alongside each other. Quadrature Amplitude Modulation, QAM is a form of a signal in which two carriers shifted in phase by 90 degrees are modulated and the resultant output consists of both amplitude and phase variations. The modulated signal has a combination of amplitude and phase variations.

c. Constellation Diagrams

Quadrature amplitude modulation (QAM) is used to achieve high data rate digital transmission for radio communication then amplitude and phase modulation schemes. The number of points on the constellation is indicated in the modulation format description, example 16 QAM uses a 16 point constellation. The number of points on the constellation is indicative of the no of bits transmitted. But as these points increase, the system becomes prone to noise and data errors. When used for digital transmission for radio communications applications is able to carry higher data rates than ordinary amplitude modulated schemes and phase modulated schemes. As with phase shift keying, etc., the number of points at which the signal can rest, i.e. the number of points on the constellation is indicated in the modulation format description, more points on the constellation, it is possible to transmit more bits per symbol.

The QAM modulation scheme helps to encodes data by varying both amplitude and phase of the carrier signal. Thus, it is sometimes viewed as a combination of ASK and PSK modulation. A more fundamental way of viewing QAM is that it encodes data by varying the amplitude of two carrier signals that are in-quadrature (phase difference of 90°).

d. BER analysis

In telecommunication transmission, the bit error rate (BER) is defined as the percentage of bits that have errors relative to the total number of bits received in a transmission. For example, a transmission might have a BER of 10^{-6}, meaning that, out of 1,000,000 bits transmitted, one bit was in error. The BER is an indication of how often data has to be retransmitted because of an error. A high BER would indicate that a slower data rate would actually improve the overall transmission time for a given amount of transmitted data since the BER might be reduced, thus lowering the number of packets that had to be present. This BER may be improved by choosing a signal having a strong strength (unless this causes cross-talk and more bit errors), by choosing a slow and robust modulation scheme.

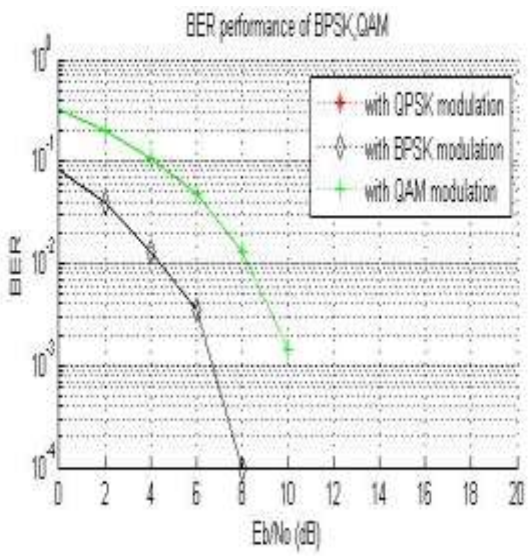

Fig. 2. Performance comparison of BPSK and QAM

In this approach, the simulation is successfully done using QPSK modulation technique. The desired BER graphs are obtained for simulation in AWGN channel. From Figure. 2. BPSK and 16-QAM modulation techniques in AWGN channel has good performance when it is compared to that of Multipath Rayleigh channel. The performance of AWGN channel is the best of all channels because it has the lowest bit error rate (BER) under QAM, 16-QAM & 64-QAM modulation schemes. The total amount of noise occurs in the BER of this channel is quite lesser than the fading channels. Each time a bit-error-rate simulation is run, a fixed number of bits is transmitted and received. We are able to determine how many of the received bits are in error and are then able to compute the bit-error-rate as the number of bit errors divided by the total number of bits in the transmitted signal. Once enough simulations are performed to obtain valid results, that is, SNRs of interest, the results are plotted. We begin by creating vectors for both axes. The X-axis vector will contain SNR values, while the Y-axis vector will contain bit-error- rates. The Y-axis is plotted on a logarithmic scale, whereas the X-axis is plotted on a linear scale.

IV. CONCLUSION

In this research, the millimeter wave communications offer an alternative for future wireless communications systems, especially for indoor applications such as WLANs and WPANs. The huge bandwidth of Terahertz wave can achieve data rates of 10 Gbits per second or even higher with single data modulation. BER has been analyzed for BPSK and QAM. As the AWGN channel has the lowest BER under QAM, 16-QAM & 64-QAM modulation schemes, the performance of this channel has been the best.

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