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Transmission of 60 GHz Ultra Wideband Radio Over Optical Fiber Using MB-OFDM

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ABSTRACT

Ultra wideband radio over optical fiber (UROOF) technique enables the transmission of ultra wideband (UWB) radio signals over optical fibers by superimposing the UWB radio frequency signals of several gigahertz's on the optical continuous-wave carrier. UWB signals are characterized by an extremely large bandwidth. UWB frequency bands belong to 3.1-10.6 GHz according to the spectral mask defined by the Federal Communications Commission. This paper examines how by using multi-band orthogonal frequency division multiplexing (MB-OFDM) technique UWB transmission can be extended up to 60 GHz. MB-OFDM divides the spectrum into six band groups and 14 non-overlapping sub bands of 528 MHz bandwidth each. Each OFDM symbol is composed of 128 orthogonal subcarriers spaced 4.125 MHz apart.

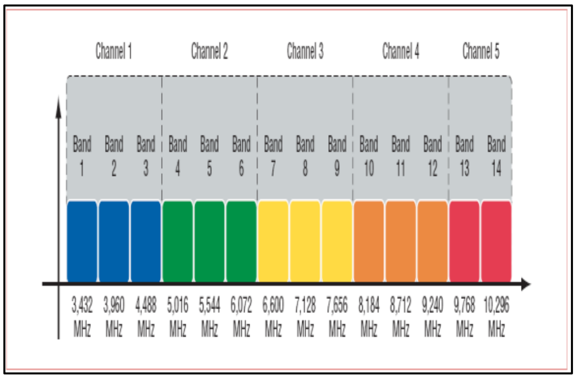
Keywords: *Ultra Wideband Radio Over Optical Fiber; Ultra Wideband; Multi-Band Orthogonal Frequency Division Multiplexing.*

1.0 Introduction

The key goal of UROOF technology is to enable the transmission of UWB signals in the range of 3.1-10.6 GHz. UWB is a promising method to provide short-distance high speed wireless communications in 4G systems and wideband personal access networks [1]. There are two types of UWB signals: one is multi-band orthogonal frequency division multiplexing UWB and the other is impulse radio UWB. Multi-band orthogonal frequency division multiplexing has been proposed by the European Computing Machineries Association (ECMA) [2]. MB-OFDM becomes very attractive because it exhibits robustness in multipath fading environment, good spectral efficiency, high data rate capabilities between 55 and 480 Mb/s, and low power consumption. Thus introducing MB-OFDM Technique in optical fiber, the millimeter-wave band in radio over fiber (RoF) system can be used not only for short distance but also for long- range transmission at very high data rate. Below figure shows how the channels are divided into sub-bands by using MB-OFDM technique.

With a central station (CS) and a base station (BS), transmission of both the signals i.e. subcarrier Microwave signal and UWB signals occur via an optical fiber by using a wavelength multiplexer. At the base station, the carrier frequency is photo detected, modulated by data and then up-converted to millimeter-wave band.

Fig 1: Division of Bands in MB-OFDM



1.1 Preliminaries

2.0 UWB Preliminaries

UWB is a radio technology which can be used at very low energy levels for short-range communications by using a large portion of the radio spectrum. UWB wireless systems are raising great interest since they allow for high data throughput-

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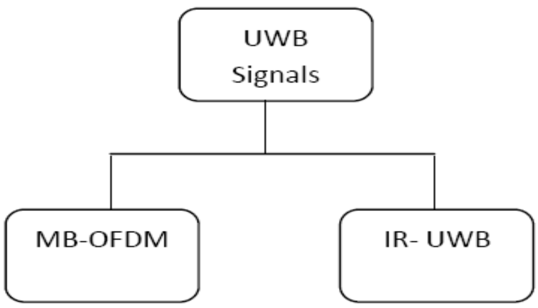
with low power consumption which is very applicable to digital home requirements. In February 2002, UWB was defined by the United States Federal Communications Commission (FCC) for signals exhibiting a bandwidth of at least 500 MHz, a maximum equivalent isotropic radiated power spectral density (PSD) of no more than -41.3 dBm/MHz in the 3.1-10.6 GHz band for unlicensed indoor communications [1]. UWB signals are characterized as:

Fig 2: UWB Signals Configuration



Impulse radio (IR) UWB communication technique is carrier free and uses for communication between transmitter and receivers, very narrow radio frequency pulses generated from the UWB pulse generator, while traditional transmission systems transmit information by varying the power, frequency, and/or phase of a sinusoidal wave in a modulation process. The selection of the impulse signal type for IR UWB communication system is essential since it determines the system performance. Gaussian pulses are the most widely used waveforms due to their simplicity and achievability.

MB-OFDM UWB signals enable the transmission up to 60 GHz through optical fiber link using central station and base station configuration. base station configuration properly and second by using cascaded external modulators.

A. Central Station and Base Station Configuration Figure 2 show the central and base station configuration. Use of multiplexer and frequency multiplication blocks allow the transmission within the required 60 GHz range. Firstly electrical to optical (E/O) conversion is done. E/O block gets two signals, one is ultra wideband signal and other is distributed feedback laser output. After conversion, output signal goes to multiplexer, which is 2x1 multiplexer. The output of multiplexer is connected to a 1.55 μm standard single mode fiber (SMF) with a chromatic dispersion of 17 ps/nm.km and attenuation of 0.2 dB/km. From SMF signal goes to optical to electrical (O/E) conversion block. This electrical signal is then fed to frequency multiplication block, where frequency is raised up to level 60 GHz and finally signal is transmitted via antenna.

Fig 3: CS and BS Configuration

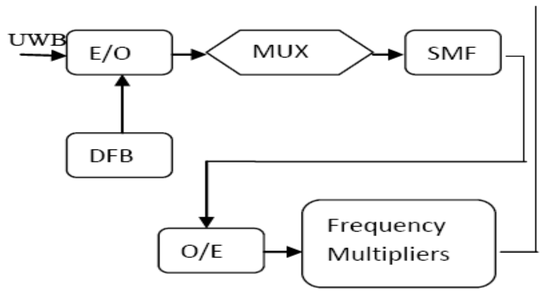
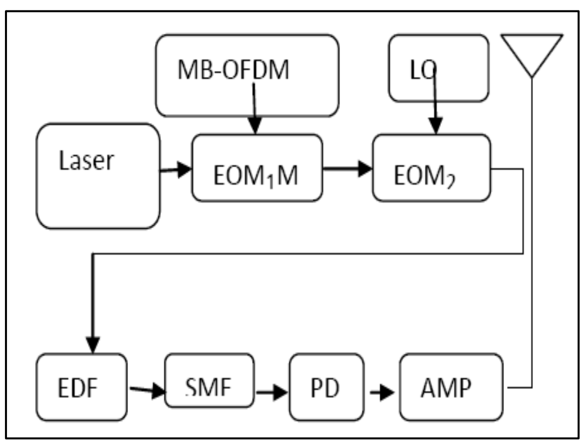


Figure 3 shows the use of cascaded external modulators for 60 GHz ultra wideband signals transmission. Two electro-optical modulators are used in cascade. First electro-optical modulator receives signals from laser diode and MB-OFDM block. Output of external modulator goes to second external modulator, which also receives signal from local oscillator. Second electro-optical modulator output optical signal is injected into an erbium-doped fiber amplifier (EDFA), transmitted over SMF and then photo detected with a 60 GHz photo detector and finally after amplification transmitted from antenna section.

The range of ultra wideband signals can be increased up to 60 GHz by using these two methods.

Fig 4: EOM 60 GHz Transmissions



3.0 Results

Figure 4 shows the two graphs, one showing measured spectrum of reference ultra wideband OFDM sub band and other is showing the electrical ultra wideband OFDM sub band signal transmission in the 60 GHz. From the graphs, it is clear that using MB-OFDM technique, UWB signals can be transmitted up to 60 GHz band. This enables the long distance transmission with less attenuation.

From the blow graphs, it was found that transmission in the 60 GHz band has occurred in the same way as in 3.1-10.6 GHz band and gave the same results with lesser attenuation. Hence the transmission distance is increased and millimetre-wave band architecture of UWB transmission systems with optical link has been developed for long distance coverage. It was found that the transmission of MB-OFDM signals has been successfully achieved along the whole system.

Fig 5: Measured Spectrum of Reference UWB-OFDM Sub Band

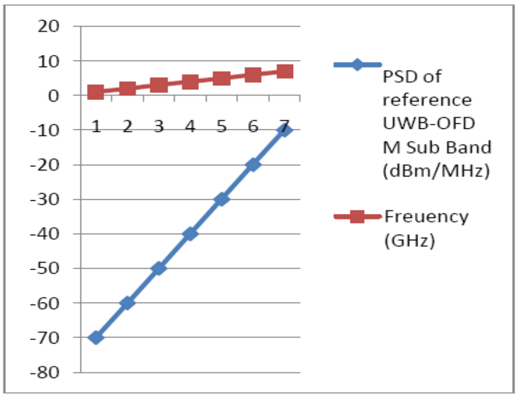
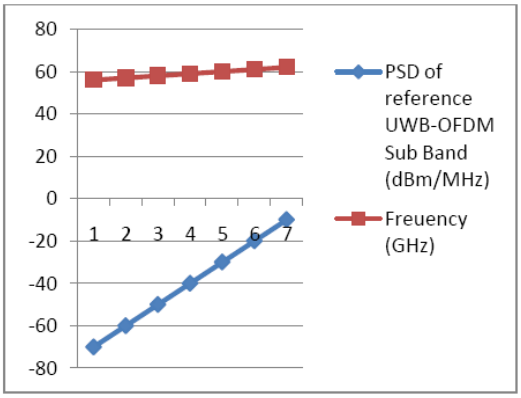


Fig 6: Electrical UWB-OFDM Sub Band Signal Transmission in the 60 GHz Band



5.0 Conclusion

This paper presents the methods for transmitting UWB signals up to 60 GHz using OFDM technique. It is based on modulation of a microwave carrier by UWB data at a photo detector. The aim of this architecture is to increase the system transparency to modulation schemes. The proposed architecture provides an efficient alternative to millimetre-wave fiber radio communication systems by reducing the architecture complexity and offering a very cost-effective solution for high data rate distribution at 60 GHz. OFDM has found its way as fiber-wireless indoor wideband communication systems due to its robustness in multi-path channels, immunity to fading channels and tolerance of delay spread. Thus, introducing OFDM modulation in optical fiber, the millimetre-wave band in radio over fiber system can be used not only for short distance but also for long-range transmission at very high data rate. So, this increases the flexibility of the system and provides a very large coverage area without increasing its cost and complexity very much. This high data rate transmission will be very useful in various applications such as wireless local area networks and digital television broadcasting etc.

However this paper deals with only MB-OFDM ultra wideband signals. Another type of UWB signals i.e. IR ultra wideband signals can also be used for transmission and useful transmission capacity can be increased.

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