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A WFMT Transmitter for Cable TV Applications

ROMAN M. VITENBERG
Wavetone Technologies Ltd.
21b Habarzel St. Tel Aviv
ISRAEL
http://www.wavetonetech.com

Abstract: - In this paper we present a system design of an integrated Transmitter for broadcast and broadband applications in Cable TV System, based on the novel WFMT modulation. First, we describe the WFMT system suitability for Cable TV Applications. The effect of a quality wavelet synthesis on system performance is analyzed too. We then propose architecture of an integrated WFMT Transmitter for Cable TV. The architecture of this Transmitter is then analyzed. The overall performance of the proposed transmitter is illustrated by MATLAB Simulations.

Key Words: - FMT, filter-bank, Cable TV, OFDM, wavelet, multicarrier.

1 Introduction

During last years, the concept of multicarrier transmission has been generalized with introduction of filter-bank multicarrier systems.

These systems may be used in the area of high-speed wired access network and in the area of wireless. Many different names were used for filter-bank technologies: DWMT, DMT and FMT for digital subscriber line (DSL) systems, CMFB, OQAM, MC_CDMA, and CMT -for wireless.

In filter-bank based systems, the data symbols are transmitted over different subchannels after suitable pulse shaping. In particular, the pulse shape in filter-bank system is significantly longer than the subchannel symbol period, so, unlike OFDM the pulse waveforms of different symbols overlap in time. The number of carriers in filter-bank systems is significant less than in OFDM system with the same bandwidth. For example COFDM based DVB-H system comprises 2k carriers. The WFMT based Cable TV system uses only 128 carriers. The distance between carriers' center is 8 times bigger in WFMT, which causes significant reduction of synchronization errors, a major factor for high-speed data communication.

The Filtered Multi-Tone (FMT) Modulation was proposed by group of researches from IBM as alternative technology for xDSL [1]. This technology is based on Wavelet theory and uses complex filter-banks for synthesis and analysis of multi-channel signal.

The theoretical aspects of FMT Modulation for Wireless Application were developed by Cambridge University [2] and Udine University [3].

It was shown that in many cases FMT modulation guarantees better performance than OFDM.

The most significant advantage of FMT is absence of out of band side lobes and high rejection of narrowband RF noise. The FMT receiver works as high order band pass filter and minimizes requirements of analogy circuitry in the System front end. Another major advantage of FMT compared to OFDM is the absence of guard time interval (cyclic prefix). The cyclic prefix in OFDM System "wastes" precious bandwidth, up to 25% of OFDM symbol. That means that FMT system may have up to 25% better performance. Due to the high complexity of synthesis and analysis filter banks, the advantages of FMT as described, were not available at reasonable cost, thus didn't materialized to practical implementation.

A novel Wavelet based Filtered Multi-Tone Modulation (WFMT) was developed by Data-JCE Electronics Ltd in 2002 –2003 years [4]. A new DSP algorithm realizes a low complexly WFMT core that can be implemented in a small silicon chip. The new algorithm was published in [5], [6].

In this paper, we first describe a suitable WFMT system for Cable TV application. Then we introduce an architecture of the Cable TV integrated transmitter. Computer simulation results of the WFMT Transmitter spectrum will be presented, followed by the conclusion.

2 A WFMT based Cable TV System

A block schematic of the proposed WFMT based Cable TV system is shown on Figure 1.

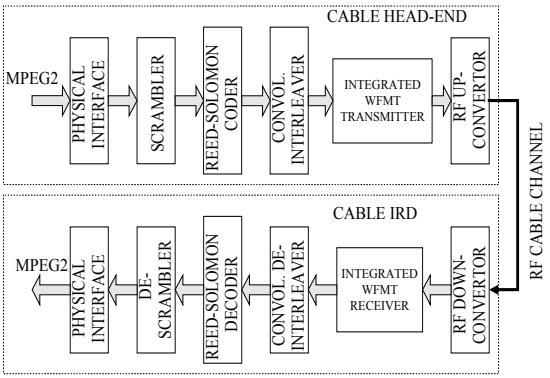

Figure 1- WFMT based Cable TV System Block-Diagram

The system comprises physical interface, randomization block, forward error correction block and interleaver in accordance with current ITU-T J.83 standard. The data frame structure is based on MPEG 2 Transport layer that is defined in ISO/IEC 13818-1. A coded information data is converted to multicarrier wavelet signal that has a 6-MHz bandwidth. This signal passes through RF UP-Converter to the cable network. All DSP operations those are necessary for transforming an information data in IF signal spectrum (41-47 MHz) are provided by integrated WFMT Transmitter that will be described later.

A Down Converter transfers the received RF signal to IF frequency band 41-47 MHz. An integral WFMT receiver processes the IF signal and decodes the received information data. After de interleaving and FEC decoding, the corrected data is converted in MPEG 2 Transport stream.

The performance of WFMT modulation depends on the quality of prototype wavelet. As was shown in [6] an ISI distortion in WFMT signal relates to the number of frequency components (cosines) that were used for the synthesis of the prototype wavelet. Figure 2 demonstrates a precision prototype wavelet that was developed for Cable TV applications. This wavelet is synthesized from 21- cosine functions and provides less then –56 dB ISI distortions.

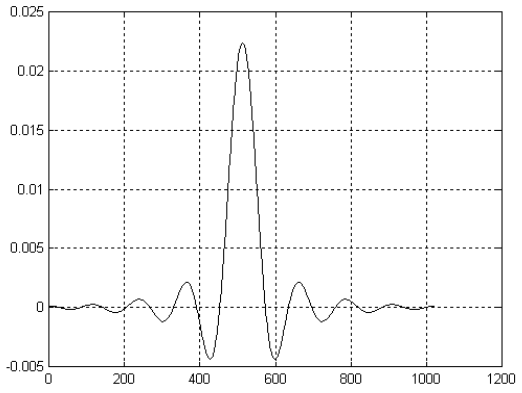

Figure 2. Precision Prototype Wavelet for Cable TV Applications

Such low ISI distortion makes it possible to transmit up to 13/14 bit of information per symbol. In this case the performance of WFMT based Cable TV system may be 50% higher than these of QAM256 based Cable TV system. Of course maximum performance may be achieved only in high quality cable network. The 256-point IFFT core was used for synthesis of baseband WFMT signal that comprises only five sub-bands channels, each of them has 1.2MHz bandwidth. The prototype wavelet length is about 19 μsec. Such long wavelet has good immunity to impulse noise and cable micro reflections.

3 An Architecture of the integrated WFMT Transmitter

Figure 3 illustrates architecture of the integral WFMT Transmitter designed for Cable TV Applications. A stream of a coded and interleaved information data (DATA) comes to an input of De-multiplexer that distributes this data between five QAM-modulators, each of them serves a correspondent sub-channel of multicarrier WFMT signal. A complex data from output of each QAM-modulator generates a set of 21 frequency components of sub-channel wavelets. All frequency components of all sub-

channel wavelets are passed to 256-point IFFT core. Only N= 21*5 = 105 inputs of IFFT core are used for synthesis of WFMT signal. Other inputs of IFFT core are connected to "0".

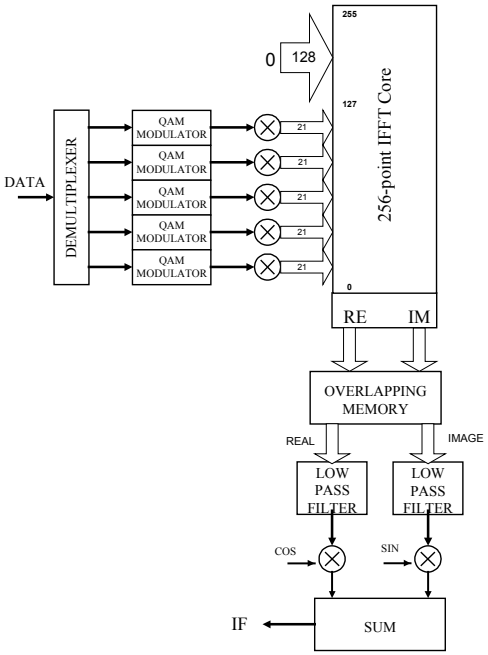

Figure 3- An Integrated WFMT Transmitter Block Diagram

As a result, IFFT core output signal comprises real and image components. Those components are necessary for proper generation of passband WFMT signal.

An overlapping memory block provides transform of individual wavelets in WFMT wavelet packets. After low pass filtering, real and image WFMT baseband packets are multiplexed by cosine and sine of an IF carrier frequency. A SUM block provides a real passband WFMT signal on its IF output.

Figure 4 shows a PSD of IF WFMT signal on output of an integral Transmitter. This spectrum demonstrates low level of out of band distortion that is one of key advantages of WFMT modulation. For transmission of data over TV channels is used five sub-band channels, each of them has 1.2 MHz of bandwidth and carries about 12 Mbps. The symbol rate in sub-channel is about 1 Msps. The QAM 4096 (12 bit per symbol) is used for modulation of wavelets. The maximum downstream bit rate in described CATV system is about 60 Mbps that is significantly higher then in existing CATV systems.

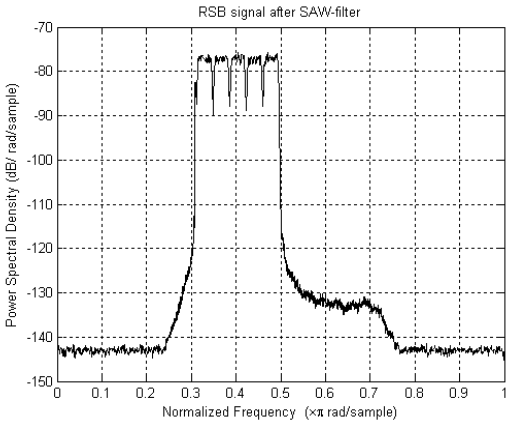

Figure 4- PSD of passband WFMT signal for Cable TV applications.

4 Conclusion

We have presented architecture of an integrated Transmitter suited for Cable TV applications and based on novel WFMT modulation that was described in [4] , [6]. A new prototype wavelet was developed for Cable TV application. This wavelet has better spectral characteristics and provides lower level of ISI distortion than wavelet, developed for VDSL application [8]. The MATLAB simulation of PSD of the passband WFMT signal on output of developed transmitter shows that a new modulation may be successfully used for Cable TV applications.

References:

[1] G. Cherubini, E. Eleftheriou, S. Oelser : "Filtered Multitone Modulation for Very High-Speed Digital Subscribe Lines", IEEE Journal of Selected Areas in Communications, VOL.20, NO. 5, 2002.

[2] Inaki Berenguer, Ian J. Wassell, "Efficient FMT equalization in outdoor broadband wireless systems", Proc. IEEE International Symposium on Advances in Wireless Communications, Victoria, Canada, Sept. 2002.

[3] Andrea Tonello "Discrete Multi-Tone and Filtered Multi-Tone Architectures forBroadband Asynchronous Multi-User Communications" Wireless personal Multimedia Communications Symposium - Aalborg, Denmark - September 9-12, 2001

[4] Roman M. Vitenberg "Method and system for Transmission of information data over communication line" US Patent Application 20050047513

[5] Andrea Tonello , Roman M. Vitenberg "An Efficient Wavelet Based Filtered Multitone Modulation Scheme WPMC 2004 –Albano Terme , Italy , September 2004

[6] Andrea Tonello, Roman M. Vitenberg "An Efficient Implementation of a Wavelet Based Filtered Multitone Modulation Scheme" ISSPIT 04 ITALY, ROME, December 2004.

[7] Andrea Tonello "Asynchronus Multicarrier Multiple Access : Optimal and Sub-optimal Detection and Decoding " , BLTJ vol.7 issue 3 pp 191-217, February 2003.

[8] Roman Vitenberg "A practical implementation of a Wavelet Based Filtered Multitone Modulation", WOSM'05 Conference . Tenerife, December 2005