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Performance Evaluation Of LDPC Coded DWT/IDWT MB-OFDM UWB for Power Line communication

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Abstract: Power Line Communication (PLC) is a promising technique for information transmission using existing power lines. However, the power line was not oriented for data transmission providinga rather harsh environment. To overcome the difficulties, advanced modulation and channel coding schemes should be employed. In this research a physical layer architecture that recommends the use of OFDM architecture supporting peak data rates between 14 Mbps- 200 Mbps is modelled where OFDM multi-carrier transmission technique could decrease the inter-symbol interference and frequency selective fading. Moreover Low Density Parity Check code (LDPC) is employed to reduce the loss caused by various kinds of effects in the channel especially the noise . The novel architecture in DWT with DUC/DDC is integrated with MB-OFDM and LDPC for PLC. Further, the MB-OFDM integrated with DUC/DDC, consumes a total power of 42.66 mw for the operating frequency in the range of 50-578 MHz. BER performances of MB-OFDM with DWT and LDPC have been obtained based on the proposed model and have been demonstrated to achieve a higher BER for a given noisy channel.

Key words: LDPC, DWT/IDWT, MB OFDM , DUC/DDC, PLC

INTRODUCTION

Power Line Communication (PLC) is a promising technique for information transmission using existing power lines. Since the power line network has originally been designed for electricity distribution and not for data transfer, the power line as communication channel has various noises and disturbance characteristics, resulting in an unreliable channel. Ultra Wide Band (UWB) is gaining popularity in modern communication technologies as it can provide very high data rates using a very wide frequency range of 500 MHz. in power lines. OFDM is considered as one of the most promising modulation methods for powerline communications. PLC adopts OFDM technique to achieve higher data rates.

However, meeting an ever increasing demand for higher data-transmission rates for applications such as Internet Protocol Television (IPTV) and high-definition video streaming makes it insufficient Some of thekey issues in PLCs are Hazardous medium for communications. The major issues concerning PLCs are the demand for higher datarates over existing PLC infrastructure and the channel noise.

When the errors introduced by the information channel are unacceptable, then channel coding is needed to reduce the error rate and improve the reliability of the transmission. One of the problems faced by PLC systems is the excessive amount of radiated interference (Sreedevi and Jenopaul, 2011). This could be mitigated by reducing transmittedsignal power at the expense of reducing Signal-to-Noise Ratio (SNR), which leads to anincrease of Bit Error Rate (BER). There comes the importance of choosing good Forward Error Correction (FEC) codes,

For efficient performance on hardware MB-OFDM for PLC, it is required to integrate OFDM with down converters for high speed applications and with proper error correction codes.

Therefore in this research, we have proposed a MB-OFDM architecture with DWT that is an integrated MB-OFDMwith DUC/DDC and LDPC Codes which has not been reported in literature so far. In this research, a novel architecture for OFDM is designed, modelled and evaluated for its performance. DUC/DDC and LDPC codes has been designed novel to improve the architecture performance.

MATERIALS AND METHODS

DWT/IDWT based MB-OFDM UWB system with DUC/DDC and LDPC codes for PLC: DWT-OFDM

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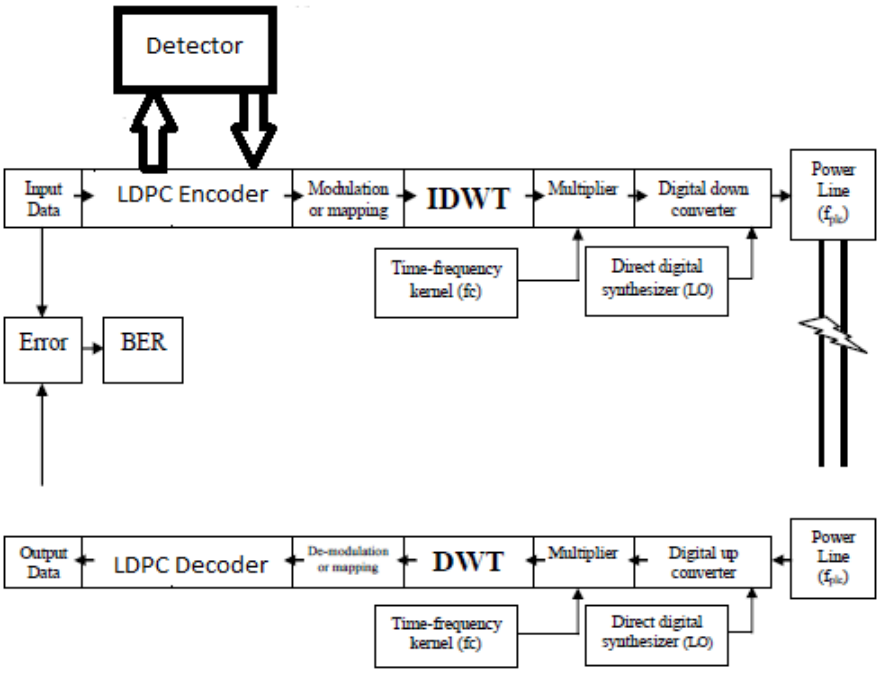

Fig. 1: Properties of waveleng

provides performance gains due to superiorspectral containment properties of wavelets In wavelet based OFDM transmitter, the information bit sequence is subjected to space timeencoding and then the bits are mapped to symbols. The symbol sequence isconverted to parallel format and IDWT is applied and then the sequence isonce again converted to the serial format. At the receiver, the sequence isconverted to parallel format and then DWT (DWT-OFDM demodulation) operation is applied. The output is then serialized and symbol de-mapping isdone to get back the coded bit sequence shown in Fig. 1 (Troya *et al*., 2008).

Proposed architecture for DWT MB-OFDM UWB with LDPC CODES: The building blocks serve as a macrothat computes the high pass and low pass outputs based on the filtercoefficients. Sub-carriersmodulation is performed after the IDWT process. In this work GaussianMinimum Shift Key modulation is used, the advantage of GMSK over othersmodulation technique is that it has phase continuity (Grau *et al*., 2008). In MB approach, thespectrum is divided into 14 bands (each with a bandwidth = 528 MHz) and devices are allowed to statically or dynamically select which bands to usefor transmission. The receiver consists of LPF, ADC, Demodulation DWT, Deinterleaver, LDPC decoder and descrambler. It has less power compared to other devices bytaking the PSD of the output. The PSD of all harmonics is <15 dB compared to the message signal. The normalized frequency is plotted against power spectral magnitude. The input signal is modulated using multiband OFDM technique and is transmitted to noisy channel. The received signal isdemodulated and the message is extracted. The output message isdemodulated and compared with input PSD. From the comparison results, it is found that the PSD resembles in both cases, thus ensuring there construction capabilities of MIMO OFDM.

Design of DDC and DUC for MB-OFDM UWB: Power Line Communication or Power Line Carrier (PLC) also known as Power line Digital Subscriber Line (PDSL), mains communication, Power Line Telecom (PLT) Power Line Networking (PLN), or Broadbandover Power Lines (BPL) are systems for carrying data on a conductor alsoused for electric power transmission. Various stages of electrical power transmission are high voltage transmission lines, distribution over medium voltage and allocation at lower voltages inside buildings. At each stage, Power line communications can be applied. Most PLC technologies bound themselves to the distribution network and premises wiring. Technologies have been developed to bridge multiple PLC technologies to form very large networks. In the previous works of DUC, The base band signal is translated to the desired channel using the DDS and mixer comprising the multipliers. The sample rate is adjusted to match the channel band width. This is performed by the multistage multi-rate filter consisting of cascaded Integrator comb filter inter polator

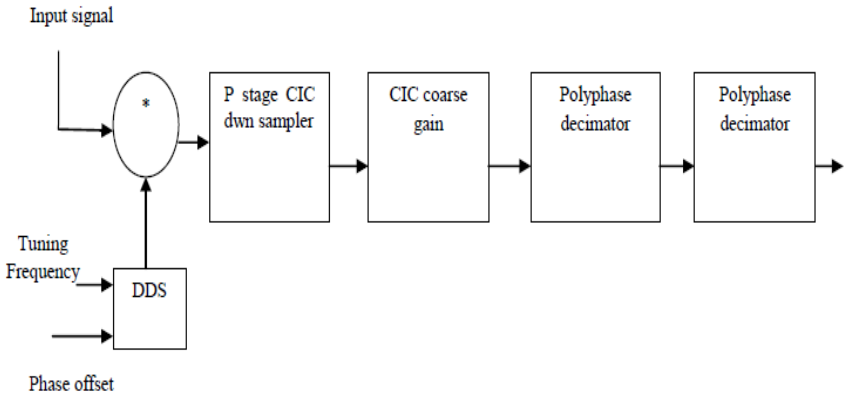

Fig. 2: Modified DDC for MB-OFDM

(Jamin and Petri, 2005). The full precision output of one stage is carried forward forprocessing by next stage. This will generate more number of bits at the output. Hence the full precision results of one stage would be reduced beforeit is processed. This is done by using Bias-free convergent rounding. This willbe inserted after each CIC filter and mixer. The input to the DUC is an AF composite signal ranging infrequency from 50-578 MHz. The composite signal comprises of Speech, Data, Tele protection and Pilot. The 8-bit sampled composite digitized inputsignal is fed to the series of two stages CIC interpolation filters. A CIC filterup-samples the output by a factor of 8. The up-sampled signal is now given tothe multiplier as the first input. Variable DDS is used to generate carrier frequencies in the range of 4460-5100 MHz is given as a second input to themultiplier. This multiplier output is the up-converted signal. This DUC outputis given as an input for DDC. In the previous researches of DDC, The desired channel is translated to baseband using the digital mixer comprising the multipliers and adirect Digital Synthesizer (DDS). In order to generate precise MB-OFDM signal in the given range ofsub carrier frequencies, a modified DDC is proposed in this research , that consists of two stages of CIC and two stages of PFIR as shown in Fig. 2

The sample rate of the signal is then adjusted to match the channel band width. Matching of channel ban dwidth is achieved using a multi-stage, multi-rate filter consisting of the Cascaded Integrator Comb (CIC) filter Decimator. The full precision of a processing stage, i, may be carried forward for processing by stage i+1. Typically this would not be the case and the full precision results of one stage would be reduced before it is processed by asubsequent stage. Bias-free convergent rounding is employed in this process. A Simulink modelling of digital up converter is done and corresponding results are obtained.

The output of the sine wave block is taken as the input for the CIC interpolationfilter. The block parameters of CIC interpolation are, Interpolation factor of 8, Differential delay (M) of 1 and the number of sections of 3. Compensation filter is a type of FIR filter used to compensate forloses in CIC filter in the typical interpolation filtering applications. Areasonably flat pass band and narrow transition region filter performance isrequired. These desirable properties are not provided by the CIC filters alone with their drooping pass band gains. The decimal values at the output of DDC in Simulink are taken. For these values, FFT (Fast Fourier Transformation) is calculated as in the Eq (1). FFT is calculated in MATLAB using the Eq (2) and isexpressed in decibel using the Eq (3) and is plotted as shown in Fig. 3. Signal to noise ratio is calculated from Eq (4). From the Simulink output, SNR is given by Eq. (5) and the harmonic distortion (THD) is calculated as in Eq 6). From the THD value, it is found that the harmonic component isnot very dominant in the UWB system over PLC:

$$x = \begin{bmatrix} 1529, 4012, 5859, 6784, 6688, 5573, 3598, \\ 1050, -1688, -4171, -4171, -, -5988, -6912, \\ -6816, -5701, -3726, -1179 \end{bmatrix} \quad (1)$$

$$Y = \mathrm{fft}(x) \quad (2)$$

$$z = 20 * \log 10(\mathrm{abs}(y)) \quad (3)$$

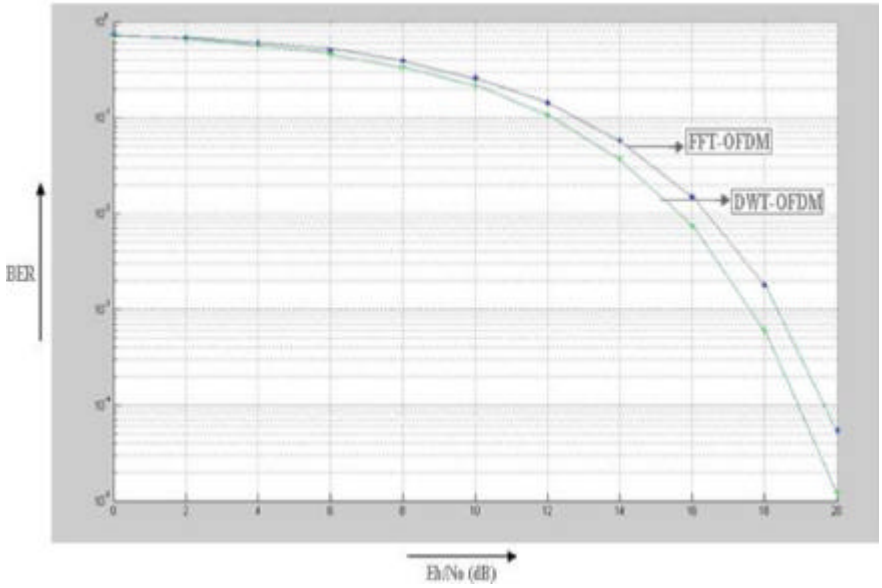

Fig. 3: Comparing the performance

$$SNR_{dB} = A_{signal} - A_{noise} \quad (4)$$

$$SNR = v2 - v1 = (250 - 125) \quad dB = 125dB \quad (5)$$

$$THD = \frac{\sqrt{v12 + v32 + v42 + v52 + v62}}{v2} = 1.281 \quad (6)$$

Error correction by LDPC codes: If $i = \{i_0, i_1, \ldots i_{k-1}\}$ be the k bit information vector that will be encoded into an n bit codeword, $C = \{c_0, c_1, \ldots . c_{n-1}\}$ For linear codes, the encoding operation essentially performs the following vector-matrix multiplication: C = i.Gwhere G is a k x n generator matrix (Gallager, 1963; Kou *et al*., 2001). The validity of a receivedencoded vector can be checked with the Parity-Check matrix which is an (n-k) x n binary matrix named H . The checkingor detecting operation is basically summarized as the followin gvector-matrix multiplication: $S = C.H^T$ The (n-k) bit vector is called the syndromevector. A syndromevector is zero if C is a valid codeword and nonzero if C isan erroneous codeword. Each code is uniquely specified by itsgenerator matrix or parity-check matrix. A code is a systematiccode if every code word consists of theoriginal k bit information vector followed by (n-k) parity bits With this definition, the generator matrix of a systematiccode must have the following structure: G = [I : X] Where I is a k x k identity matrix and X is a k X (n-k) matrixthat generates the parity-bits. The advantage of using systematiccodes is that there is no need for a decoder circuit to extract theinformation bits. The information bits are simply available inthe first k bits of any encoded vector.

RESULTS AND DISCUSSION

The proposed integrated architecture is modelled using matlab and simulink and found to have the following BER Performances and realised on FPGA platform. The developed architectures have optimized area, timing and power performances and hence can be well suited for MB-OFDM UWB in PLC .

BER PLOT of FFT AND DWT MB-OFDM UWB with LDPC coded: The simulated results showing and comparing the BER performance of FFT and DWT OFDM with LDPC coding. From the BER plot above, it is seen that DWT with LDPC outperformed FFT-MB-OFDM UWB system by nearly 1.5 dB for the same BER of 0.001. Thus the proposed system is well suited for higher data rates and better BER performances. Shown in Fig. 3

BER VS SNR for MB-OFDM UWB WITH LDPC CODES: For SNR between-10 dB and 5 dB, BER varies between 6.6e10-3-5.9e10-3 thus the BER remains constant for SNR with 20 dB variation. This is comparatively better than the other architectures proposed so far as shown in Fig. 4.

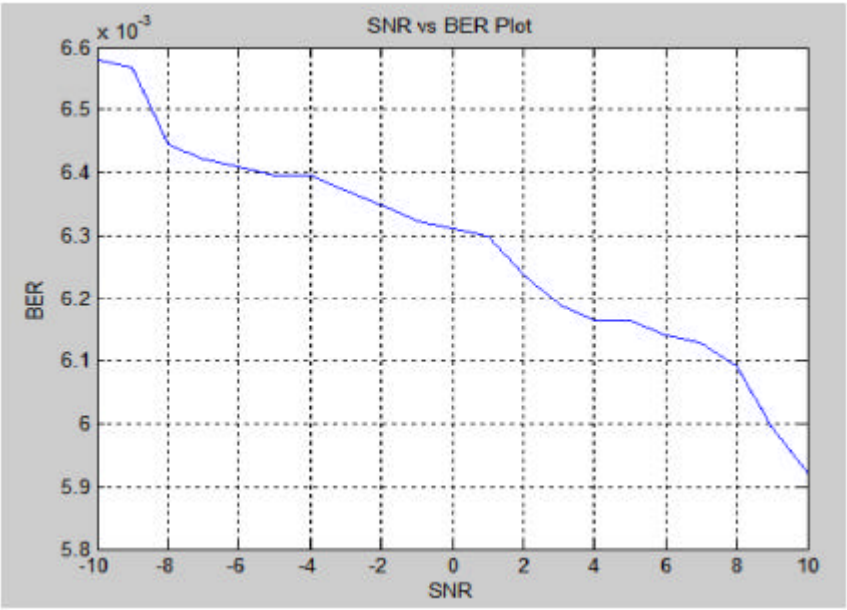

Fig. 4: BER vs SNR for MB-OFDM UWB with LDPC codes

CONCLUSION

In this research, novel architectures that improve the bit errorrate performances and data rate of OFDM architecture are proposed, designed, modeled and implemented on an FPGA platform. The proposed architecture reduces thestorage space almost by 97.5% and the architecture is implemented on Xilinx FPGA. The BER performances of MB-OFDM with DWT and LDPC codes have been obtained based on the proposed model and have been demonstrated to achievea higher BER for a given noisy channel. The developed architectures havebeen optimized for area, timing and power performances and hence can beused as IPs on FPGA platforms.Evaluation of hardwareperformance in real time for the proposed architecture imposes challenges forfurther scope of research.

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