Analyze and Implementation of Inter-Carrier Interference Reduction Technique in OFDM System

T. Srinivas Reddy, J. Prabhakar, CH. Shekar

Abstract*: This article introduces a new method of self-cancellation (modified technique of self-cancellation) using a zero gab self- cancellation methodology. In the technique suggested, zero sub-carriers are often used to mitigate the interference of the two neighboring sub-carriers main lobes in addition to zero subcontractors and the method being proposed also used to limit the impact of other sub-carriers side lobes. The modified self-cancelling technology provides the best performance in respect of the CIR and the Bit-Error (BER) ratio only compared with the conventional technique. The adder module interference estimator also often needs data path units in this paper. Mostly as a result, a detailed explanation is still based on increasing the delay in capacity of the adder. The Ripple adductor and the output of the skip adder of each step depends on the previous carrier, but once it is returned to hold tree adders, it produces the transmission signals in O(log n) time and is regarded to have been the simplest and best VLSI output. The Kogge-Stone, Sparse Kogge-Stone and spanning tree adder are compared to the Ripple Carry Adder (RCA).

Index Terms: **Carrier to Interference Power Ratio, Orthogonal Frequency Division Multiplexing (OFDM), Inter Carrier Interference (ICI), Kogge stone adder, Spanning Tree adder**

I. INTRODUCTION

The OFDM plays a significant role in broad-band based communication systems, like high-definition Tele-vision's (HD-TVs), Digital Audio-Broadcasting (DAB), local wireless networks (such as HIPERLAN/2 and IEEE-802.11a). Generally, OFDM promises the supreme modulation scheme encoding digital data on many carrier frequencies [1]. And their subcarrier is elegantly spaced and overlapped, because of this overlapping spectrum; OFDM has a higher data rate transmission capability with a high bandwidth efficiency, making OFDM robust to multi-path fading. The OFDM case of multi-carrier modulation is very supreme. The general theory of OFDM is that by splitting the higher speeds in the data into numerous lower data rate and by modulating each one of these new low data rate signals with the orthogonal frequency channel or subcarrier, they are combined to generate the original signal at the receiver end.

Given the immense economic advantages, the OFDM scheme also has drawbacks including PAPR (peak-average power ratio); it may be more susceptible to frequency or phase offsets usually resulting from either a mismatch of frequencies of transmitter and oscillator receivers which impact on the orthogonality of OFDM structures and possibly cause intercarrier interference (ICI). The authors propose various techniques for ICI reduction, like [5-15], etc. These techniques are mainly used for the modulation techniques BPSK and QPSK. The self-cancelling technique is frequently always used to suppress ICI using the proposed methods due to its practicality and its easy operation. New methods are used in this paper to reduce the impact of ICI.

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Dr. T. Srinivas Reddy, Associate Professor, Dept. of ECE, Malla Reddy Engineering College (A), Main Campus, Hyderabad, India,.

J. Prabhakar, Assistant Professor, Dept. of ECE, Nalla Malla Reddy Engineering College, Hyderabad, India.

CH. Shekar, Assistant Professor, Dept. of ECE, Teegala Krishna Reddy Engineering College, Hyderabad, India

II. INTER-CARRIER INTERFERENCE (ICI) PROBLEM OVERVIEW

The loss of orthogonality among sub-carriers causes ICI, which affects both channel estimation and detection of OFDM data symbols. In OFDM, the sub - carriers ' spectra overlap, but stay orthogonal. ICI is alluded to as interference due to data symbols on adjacent sub-carriers.

Y(k) is the Discrete Fourier Transform of *y(n)*. Then we get,

$$Y(k) = \sum_{n=0}^{N-1} x_n \, exp\left(\frac{j2\pi nm}{N}\right) exp\left(\frac{-j2\pi nk}{N}\right) \quad (1)$$

$$= \sum_{n=0}^{N-1}\left(\frac{1}{N}\right)\sum_{n=0}^{N-1} X_n \, exp\left(\frac{j2\pi nm}{N}\right) exp\left(\frac{-j2\pi n(\varepsilon-k)}{N}\right) \quad (2)$$

$$= \left(\frac{1}{N}\right)\sum_{n=0}^{N-1} X_n \, exp\left(\frac{j2\pi n(m+\varepsilon-k)}{N}\right) \quad (3)$$

Carrier to Interference Ratio: The aim of all ICI reduction algorithms is to achieve a greater CIR value. The current standard OFDM mathematical CIR can be authored as:

$$CIR = abs(S(0)) \div \sum_{\substack{i=0 \\ i\neq k}}^{N-1} abs((l-k)) \quad (4)$$

This equivalence can be practical aimed at all types of modulation and any amount of subcarriers.

Several Schemes of ICI minimization are, shown below as;

- Time-Domain Windowing
- Frequency-Domain Equalization
- Self-Cancellation of ICI
- Shaping The Pulse values

The primary two of above-mentioned four schemes are initial approach; the other two are very attractive.

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III. SYSTEM MODEL FOR PULSE-SHAPING & SELF-CANCELLATION PERFORMANCE

Pulse shaping: It is clear that, the spectrum of each and every carrier of OFDM comprises of main theme accomplished by various sides with prominent minimization in amplitudes.
As well as, it is preserved orthogonally, then there is no inference over other carriers when presence of null-spectrum at top of each carrier. This is really the component of all other carriers even at that point. The single carrier would therefore be easily separated. Though when the frequency offset occurs, the orthogonally is destroyed just because the spectral null does not correspond with each carrier's peak. However, the power of some side lobes at center of adjacent carriers called as ICI power ranges. The ICI power is increased continuously by maximizing the frequency off-sets. The main aim of pulse forming is to minimize the lateral lobes. It may somehow decrease substantially with side lobes, and then the ICI power will indeed be minimized dramatically.

ICI self-cancellation: Either the discrepancy here between the ICI coefficients of two consecutive sub-carriers was shown to be quite tiny. This constitutes the basis for the self-annulment of ICI. The respective data symbol is always un-modulated elsewhere in single sub-carriers, although with two successive dual sub-carriers. If “a” is highly modulated on first sub-carrier then “a” is modulated as second sub-carrier. Thus, ICI in between of dual sub-carriers vanishes each-other. These techniques are appropriate for fading the multipath channels since no estimation of channels is necessary here. Due to the failure of estimates for the multipath channel as the channel changes randomly.

IV. ANALYTICAL EVALUATION OF ICI SELF-CANCELLATION SCHEME

The main concept of this scheme is to modulate the main input function ofone data symbol in a certain group of sub-carriers with estimated co-efficients based on produced ICI signals which are cancelled each other in that group named as self-cancellation. The ICI self-cancellation scheme requires that the transmitted signals be constrained such that

$$x(1) = -x(0), x(3) = -x(2)..x(N-1) = -x(N-2) \quad (5)$$

Then the received signal on subcarrier k becomes

$$Y'(k) = \sum_{l=0,l=even}^{N-2} x(l)\left[S(l-K) - S(l+1-k)\right] n_k \quad (6)$$

Signal received on subcarrier k+1 converts

$$Y'(k+1) = \sum_{l=even}^{N-2} x(l)\left[S(l-K-1) - S(l-k)\right] n_{k+1} \quad (7)$$

and the ICI coefficient $S'(l-k)$ is denoted

$$S'(l-k) = S(l-k) - S(l+1-K) \quad (8)$$

At the demodulator the received signal at the $(k+1)^{th}$ subcarrier, where k is even is subtracted from the k^{th} subcarrier. This is expressed mathematically as

$$Y''(k) = Y'(k) - Y'(k+1) \quad (9)$$

$$= \sum_{l=0}^{N-2} X(l)\left[-S(l-k-1) + 2S(l-k) - S(l-k+1)\right] + n_k - n_{k+1}$$

(10)

Subsequently, the ICI coefficients for this received signal becomes

$$S''(l-k) = S(l-k-1) - 2S(l-K) - S(l-k+1) \quad (11)$$

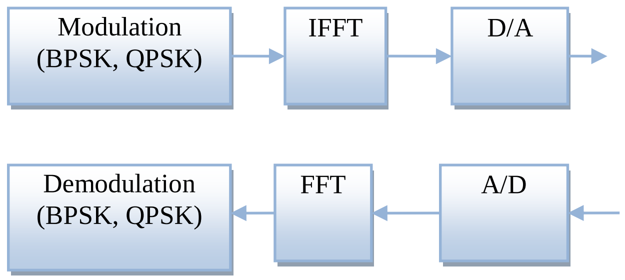

Fig.1: General OFDM structure

V. METHODS & METHODLOGY

Modified self-cancellation:
Either carrier comprises of a principal lobe in the OFDM continuum and simply follows several side lobes mostly with deteriorated amplitudes as illustrated in figure2. The approach (modified self-cancellation) is advocated just using a zero gab to mitigate noise from the main lobe (adjacent subcarrier) and also the traditional self-cancellation technology to alleviate the effect of side lobes. Using those same two methods and techniques, maybe the next portion looks slightly better results for CIR and BER. The entry symbol is modulated into three subcarriers, with one subcarrier carrying zeros so that the main lobe power is cancelled from the nearby subcarrier. The primary role of some of the other two subcomponents is to decrease ICI components from side-lobes. The main drawback to this mechanism is the incompetency in bandwidth, but it may be surmount by reducing the level of QAM or by expanding the number of sub-carriers. Maybe this technique reintroduces redundancy into the symbol because only one data symbol is transmitted for each three sub-carriers.

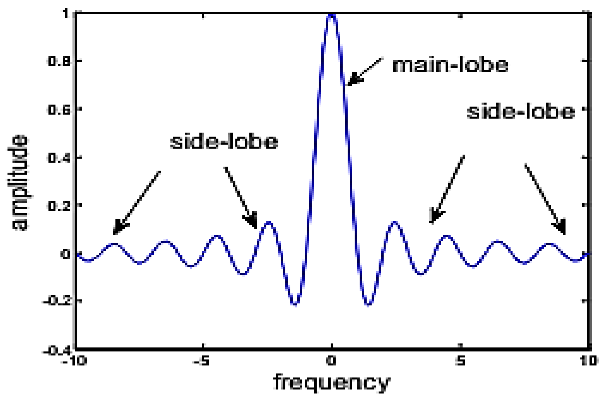

Fig.2: General OFDM spectrum

When the signal is moved in frequency and is adversely affected by an AWGN noise, the signal obtained at subcarrier k is indicated as follows:

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$$Y'(k) = \sum_{l=0,3,6}^{N-3} x(l)\left[S(l-K) - S(l+1-k)\right] n_k \quad (12)$$

and the received signal at sub-carrier $k+1$ is:

$$Y'(k+1) = \sum_{l=0,3,6}^{N-3} x(l)\left[S(l-K-1) - S(l-k)\right] n_{k+1} \quad (13)$$

This mitigates and neglects the adverse effect of main - lobe noise consumed in carriers k+2 and k-1 at the recipient. The main lobe noise is a critical component of the undesired signal.

Furthermore, the consequence of the particular side-lobe can be condensed by deducting *Y'k* from *Y'k+1*

$$Y_k'' = Yk' - Y(K+1)'$$

$$Y_k'' = \sum_{l=0,3,6}^{N-3} X(l)\left[-S(l-k-1)+2S(l-k)-S(l-k+1)\right]+n_k-n_{k+1} \quad (14)$$

$$Y_k'' = X_k(-S(-1)+2S(0)-S(1)+ \sum_{l=0,3,6}^{N-3} X(l)\left[-S(l-k-1)+2S(l-k)-S(l-k+1)\right]+n_k-n_{k+1} \quad (15)$$

Somewhere above eq. (15) is the signal obtained when after de - mapping. There are three components on the right side of this equation: from eq.(16) it can be determined that the CIR for the technique suggested is offered mostly by:

$$CIR = \frac{(-S(-1)+2S(0)-S(1))}{(\sum X(l)_{(l=0,3,6)}^{(N-3)}[-S(l-k-1)+2S(l-k)-S(l-k+1)]+n_k-n_{(k+1)}))} \quad (16)$$

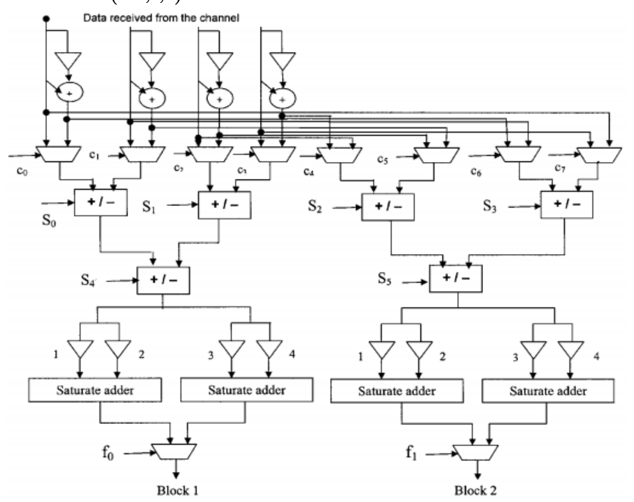

Fig.3: Interference adder

Proposed Parallel prefix adders:

The proposed adder is that we really using the PPA in place of simply saturated adder like a carry look ahead adder. Perhaps the production of carriers with prefix adders [16] can be predicated on the additional requirements in many completely different ways. Maybe we just use tree structure particular form to significantly increase arithmetic operation speed [3]. Faster adders [16] are parallel prefix adders [4] that can be used for high-performance arithmetic structures in industry. The addition of the parallel prefix is done in 3 steps.

Pre-processing stage: In this section the generation and propagation of signals that are supposed to generation input carry for every adder section

$$P_i = A_i \text{ EX-OR } B_i \quad (17)$$

$$G_I = A_i \text{ AND } B_i \quad (18)$$

Carry generation network: In this section the computation of carry for every bit is carried out where it utilizes the propagate and try to generate as intermediate signals.

$$P(i:k) = P(i:j) \,.\, P(j-1:k) \quad (19)$$

$$G(i:k) = G(i:j) + (G(j-1:k) \,.\, P(i:j)) \quad (20)$$

Post processing stage: It is the last stage that calculates the accumulation of the input bits. It is identical for all the adders and sum bit equation given

$$S_i = P_i\, C_i. \quad (21)$$

$$C_{i+1} = (P_i.C_0) + G_i \quad (22)$$

VI. RESULTS & DISCUSSION

It is clear that the OFDM transceiver has been used and simulated using MATLAB. The modulation new scheme has been chosen, completely different values have been used for the standardized frequency (0.2, 0.4, 0.6 and the outcomes are shown respectively in the actually figure below.

Table 1: Simulation Parameters

Parameters	Value
N	128
Sym_no	1000
Normalized frequency(ep)	0.2,.0.4,0.6
SNR	[0:0.5:20]
Transmission mode	MIMO=4

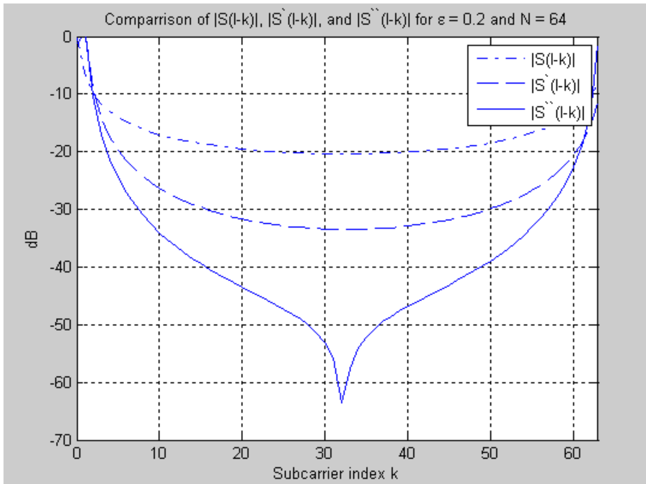

Fig.4: Comparison of |*S (l-k)*|, |*S` (l-k)*|, and |*S`` (l-k)*| for *N* = 64 and ε = 0.4

Figure.4 shows the attractive comparisons between |*S' (l-k)*| & |*S (l-k)*| based on log-scale. It shows the |*S' (l-k)*| << |*S (l-k)*| is valuable for certain *l-k* values.

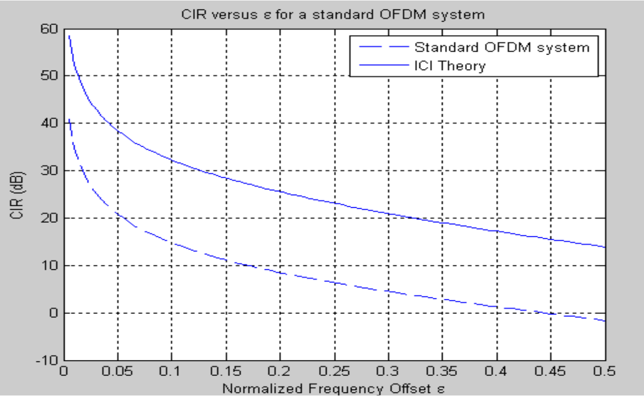

Fig.5: CIR versus ε for a standard OFDM system

Figure.5 illustrates the contrast, computed, the CIR of a regular OFDM system of self-cancelled ICI system. Although, the self-cancelled ICI strategy comprises of various trade-offs between the power traffic and bandwidth.

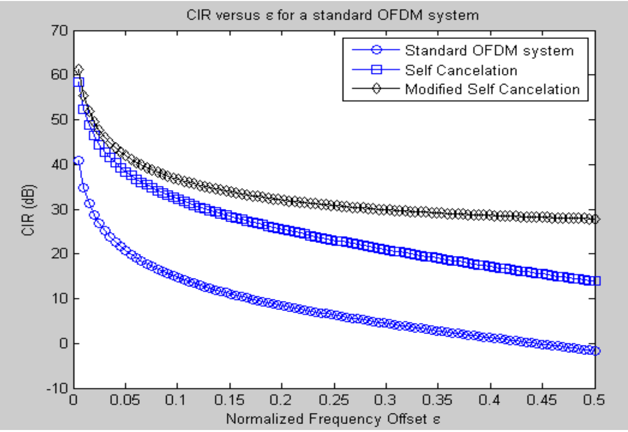

Fig.6: CIR curve for different schemes. (Theo ≡ theoretical).

The CIR is being used to equate and assess the outcomes of the two drastically different cancelation strategies. The CIR ratio of the suggested frequency offset system can also be seen in Figure.6 above, epsilon= 0.5. CIR is the percentage of carrier signal strength obtained to the noise signal obtained at the receiver. In decibels (dB), CIR is represented. The Carrier-to-Interference (CIR) ratio is high for low frequency offset values as the frequency offset µ also often reduces the carrier-to-interference ratio. When the CIR ratio is high, the quality of the received signal will be considerably better.

ISE Simulator (ISim):

ISim offers an excellent, total, ISE-integrated HDL simulator. ISE Simulator (ISim) is a Hardware Description Language (HDL) simulator that allows us to start performing VHDL, Verilog and mixed-language functionality (behavioral) and timing simulations. The ISE project browser generates all commands for simulation to prepare the ISim simulation and automatically runs in the background during the simulation with the Kogge Stone Adder flow. Table-2 shows the use of these adders for delays, power and devices. We have observed that the adders of parallel prefixes are quicker as related to adder. The outcomes of the various parallel prefix adders are shown below.

Synthesis result

The utilized device consists of following, such as

Logic Distribution
Logic Utilization
Total Gate-Count

The summary of utilized devices are shown above with a certain details of pre-requisite devices utilized from respective devices.

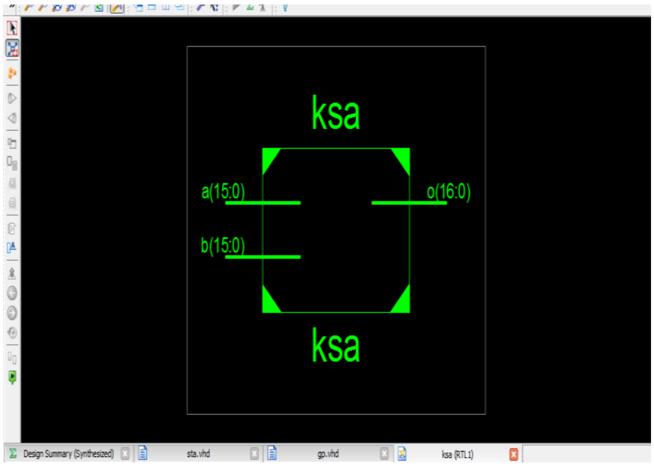

Fig.7: RTL schematic of kogge stone adder

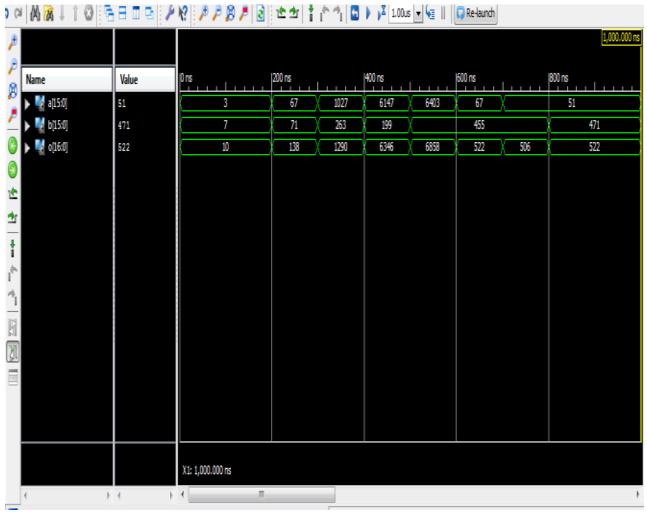

Fig.8: simulation result of kogge stone adder

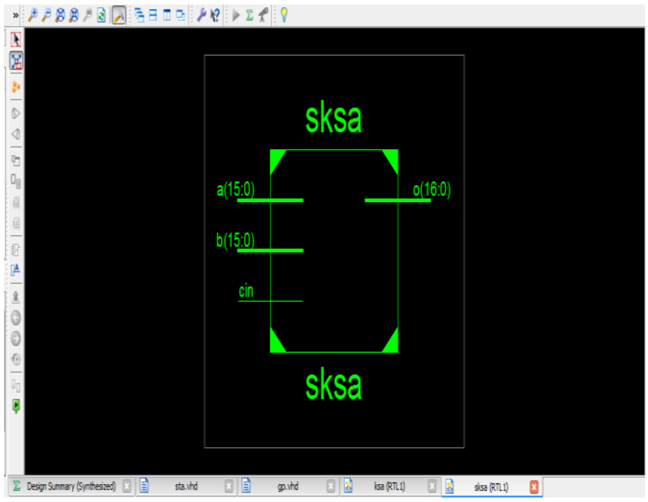

Fig.9: RTL schematic of sparse kogge stone adder

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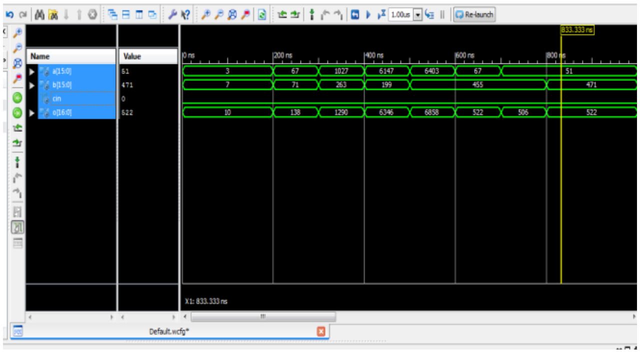

Fig.10: Simulation result of sparse kogge stone adder

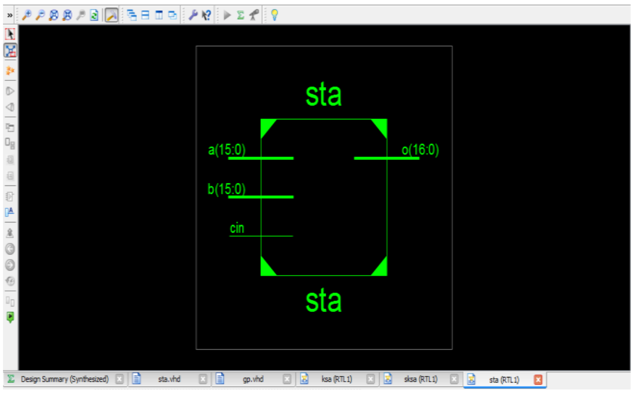

Fig.11: RTL schematic of spanning tree adder

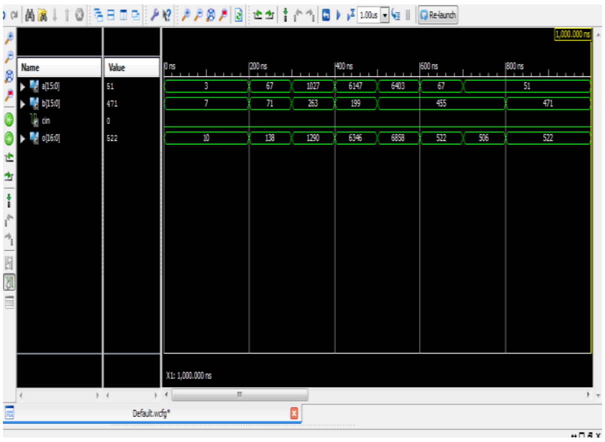

Fig.12: simulation result of spanning tree adder

Table-2 Delays, Power and Device Utilization for various Adders

Adder Name (16 bit)	Xilinx ISE 13.2 Tool delay (in ns)	From Ref [2] Delay (in ns)	Power (in Watts)	Device Utilization in (LUTs, IOBs) (69120, 640)
Ripple carry adder	3.853	2.578	1.211	5,13
Kogge stone adder	6.688	6.286	1.220	71,50
Sparse Kogge stone adder	8.014	-------	1.179	28,50
Spanning tree adder	6.667	-------	1.179	30,49

VII. CONCLUSION

In this paper, we made an attempt of reintroduce some of the ICI cancellation approaches which in turn improvise the OFDM environment in the wireless communication system. The primary attempt made on the self- cancellation methods for guarding the ICI in OFDM for various frequencies offset values explicitly. Secondly the implementation of kogge-stone adder is generating with help of FPGA and tries achieving low power and area resources.

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