SIGNAL TRANSFORMS WITH BUS INVERT ENCODING FOR LOW POWER APPLICATIONS

Karnakar Patil[1] Sachin Madabal[2] Abhishek Motagi[3]
Department of Electronics and Communication Engineering
V.P.Dr.P.G.Halakatti College of Engineering and Technology, Vijayapur.

***Abstract*—Ultra low power consumption is a driving factor in consumer electronics in the present scenario. Signal transforms with bus invert encoding for low power applications is presented which will considerably reduce power requirement for large datasets. The main block of circuit is constructed with a microchip, which includes a block of codes used for signal transforms and a bus invert encoder for low power applications. A digital signal is fed as input to the microchip and a transformed low power signal is obtained as a output.**

Keywords—Microchip; Bus invert encoder; Low power; Signal Transforms

I. INTRODUCTION

A signal can defined as a function that conveys information. Although signals can be represented in many ways, in all cases the information is contained in some pattern of variations. Many different transforms in signal processing such as Fourier transforms, Laplace transforms and Z transforms. The reason behind using these transforms is that they are extremely powerful mathematical tool that allows you to view your signals in different domains, inside which several difficult problems become very simple to analyze[1]. Here using three signals transforms,

- Fourier transform: The Fourier transform of a function of time itself is a complex-valued function of frequency, whose absolute value represents the amount of that frequency present in the original function, and whose complex argument is the phase offset of the basic sinusoid in that frequency.
- Laplace transform: Laplace transform is an integral transform. It takes a function of a positive real variable t (often time) to a function of a complex variable s (frequency). It is complex function of complex variable.
- Z transform: Z-transform converts a discrete-time signal, which is a sequence of real or complex numbers, into a complex frequency domain representation.

In this paper signal transforms with bus invert encoding for low power applications is proposed. The codes transform the signal using appropriate transformation. This transformed signal is fed to Bus invert encoder. Bus invert encoding is a example of Bus encoding where an additional line named INV is added to the bus lines. Depending on the value of the INV line, the other lines will be used with or without inversion.

II. BLOCK DIAGRAM

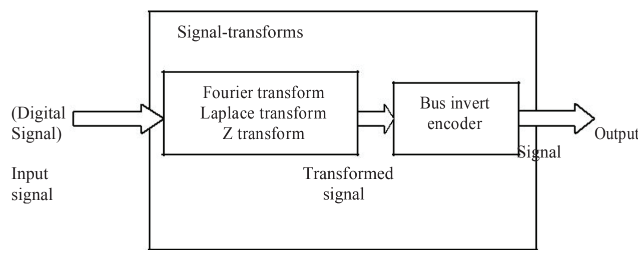

FIGURE 1: SIGNAL TRANSFORM AND BUS INVERSION

III. EXPLANATION

A digital signal is given as an input, depending on the input the following transform will takes place.

Many signal transforms can be represented by a transformation matrix , which is multiplied by an input data vector **X** to produce the desired output vector **Y=AX** . To allow for fast implementations, the transformation matrices can often be factored into a product of structured matrices. Further, these factorizations can be represented by mathematical formulas, and a single transform can be represented by many different, but mathematically equivalent, formulas[1].

The Fourier transform decomposes a function of time (a signal) into the frequencies that make it up, similarly to how a musical chord can be expressed as the amplitude (or loudness) of its constituent notes. The Fourier transform of a function of time itself is a complex-valued function of frequency, whose absolute value represents the amount of that frequency present in the original function, and whose complex argument is the phase offset of the basic sinusoid in that frequency. The Fourier transform is called the *frequency domain representation* of the original signal. The term *Fourier transform* refers to both the frequency domain representation and the mathematical operation that associates the frequency domain representation to a function of time. The Fourier transform is not limited to functions of time, but in order to have a unified language, the domain of the original function is commonly referred to as the *time domain*. For many functions of practical interest one can define an operation that reverses this: the *inverse Fourier transformation*, also called *Fourier synthesis*, of a frequency domain representation combines the contributions of all the different frequencies to recover the original function of time.

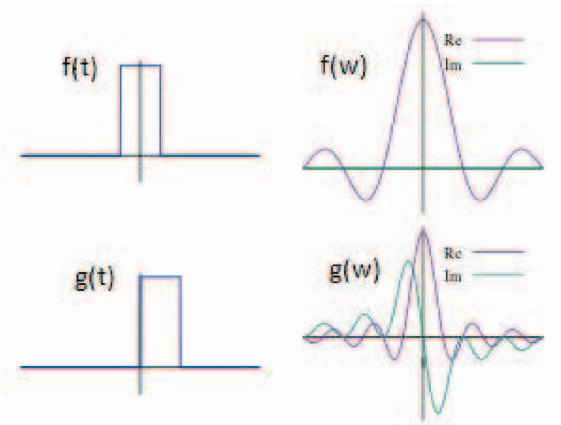

Figure in the first row shows the unit signal f(t) and its fourier transform f(w).

Figure in the second row shows delayed unit pulse g(t) and its fourier transform g(w).

Fourier transform formulae are very frequently called Fourier integrals. However, the word "transform" seems more appropriate with the expansion of transform theories[2].

The Laplace transform is very similar to the Fourier transform. While the Fourier transform of a function is a complex function of a *real* variable (frequency), the Laplace transform of a function is a complex function of a *complex variable*. Laplace transforms are usually restricted to functions of t with $t > 0$. A consequence of this restriction is that the Laplace transform of a function is a holomorphic function of the variable s. So unlike the Fourier transform, the Laplace transform of a distribution is generally a well-behaved function. Also techniques of complex variables can be used directly to study Laplace transforms. As a holomorphic function, the Laplace transform has a power series representation. This power series expresses a function as a linear superposition of moments of the function. This perspective has applications in probability theory. Laplace transforms are more appropriate since the discrete Fourier transform is theoretically a method to analyze periodic signals[3].

In mathematics and signal processing, the Z-transform converts a discrete-time signal, which is a sequence of real or complex numbers, into a complex frequency domain representation . Z transform power spectra and weighted energy spectra along mainly circular and radial contours in the Z plane have been applied to pole-zero estimation using "discrete Z transforms" (DZT's) and to the mathematical modelingof discrete timelinearsystems[4].

IV. BUS ENCODING

Bus Encoding refers to converting/encoding a piece of data to another form before launching on the bus. While bus encoding can be used to serve various purposes like reducing the number of pins, compressing the data to be transmitted, reducing cross-talk between bit lines, etc., it is one of the popular techniques used in system design to reduce dynamic power consumed by the system bus. Bus encoding aims to reduce the hamming distance between 2 consecutive values on the bus. Since the activity is directly proportional to the hamming distance, bus encoding proves to be effective in reducing the overall activity factor thereby reducing the dynamic power consumption in the system.

V. INVERSION ENCODING

Inversion encoding is another implementation of bus encoding where an additional line named INV is added to the bus lines. Depending on the value of the INV line, the other lines will be used with or without inversion. e.g. if INV line is 0, the data on the bus is sampled as it is but if INV line is 1, the data on the bus is inverted before any processing on it.

For a 32-bit data bus,
value 0 translates to
0x00000000 (0000 0000 0000 0000 0000 0000 0000 0000) while
(-1) translates to
0xFFFFFFFF (1111 1111 1111 1111 1111 1111 1111 1111) in a 2's complement representation.

0 will be represented as 0x00000000 with INV=0 and
-1 will be represented as 0x00000000 with INV=1.

Since INV=1, receiver will invert the data before consuming it, thereby converting it to 0xFFFFFFFF internally. In this case, only 1 bit (INV bit) is changed over bus leading to an activity of factor 1. In general, in inversion encoding, the encoder computes the hamming distance between the current value and next value and based on that, determines whether to use INV=0 or INV=1. It has been known that a significant power reduction can be achieved by using a bus encoding to reduce the number of transitions on high capacitance I/O lines at the cost of increasing the number of transitions inside the CMOS circuit on low capacitance lines[5].

For example if a 8-bit data (1111 1001) is fed to bus invert encoder, based on the power consumption its send 8-bit data (0000 0110) with INV=1 to the output.

VI. ALGORITHM

1) The input signal is given to microchip.
2) Based on the given signal appropriate transformation is applied and the transformed signal is obtained.

3) This transformed signal is given to bus invert encoder.

4) Bus invert encoder decides whether to send inverted or non-inverted output signal based on dynamic power consumption of system bus.

VII. ADVANTAGES

1) Low dynamic power consumption by the system bus.

2) This system can be used for analyzing the behaviour of input signal.

4) This system is applicable in many fields of science and technology such as Control engineering, Communication.

VIII. REFERENCE

[1] "Automating the Modeling and Optimization of the Performance of Signal Transforms"
Bryan Singer and Manuela M. Veloso IEEE TRANSACTIONS ON SIGNAL PROCESSING, VOL. 50, NO. 8, AUGUST 2002.

[2] FOURIER TRANSFORM ANALYSIS
By M. M. Levy *(Member)**
JOURNAL OF THE BRITISH INSTITUTION OF RADIO ENGINEERS.

[3] "AN IMPLEMENTATION OF NUMERICAL INVERSION OF LAPLACE TRANSFORMS ON FPGA"
Akihiro YONEMOTO, Takashi HISAKADO and Kohshi OKUMURA Department of Electrical Engineering, Kyoto University, Japan.
C&7803-7761-3/03/ 2003 IEEE

[4] "Rewriting Laplace and z Transforms"
Michael J. Corinthios, Fellow IEEE, FIEE Professor, Ecole Polytechnique de Montrbal Campus Universitb de Montrbal 2500 Chemin de Polytechnique, Montrkal, Qc, H3T lJ4 Canada.

[5] "Enhanced Bus Invert Encodings for Low-Power"
Unni Narayanan', Ki-Seok Chung' Taewhan Kim3
'Intel Corporation, Santa Clara, CA, USA
*Department of Computer Engineering, Hongik University, Korea 3Department of Electrical Engineering & Computer Science and Advanced Information Technology Research Center, KAIST, Korea.
0-7803-7448-7/02/ 2002 IEEE