Semester Project

Department of Information Technology and Electrical Engineering

Mixed Radix FFT Core Generator

Lorenz Koestler <lorenz@koestler.ch>

Winter Term 2012

Supervisors:
Harald Kröll <kroell@iis.ee.ethz.ch>
Sandro Belfanti <belfanti@iis.ee.ethz.ch>

Abstract

The Discrete Fourier Transform (DFT) processor is a key component in Orthogonal Frequency-Division Multiplexing (OFDM) communication systems and often needs to support different input sample sizes. To reduce the development effort when experimenting with new mobile standards, a Fast Fourier Transform (FFT) Core Generator was implemented which can generate a FFT Core for a specific application. Even tough our core generator is focused on OFDM, it can also be used for many different applications. It was designed to achieve a reasonable throughput and latency on the smallest area possible while being configurable in terms of FFT point sizes and word widths.

Acknowledgments

Contents

Chapter 1

Introduction

1.1 Motivation

The DFT is one of the algorithms used in most of toady's communication systems. It provides the transition from the time-domain into the frequency-domain and, using the almost identical Inverse Discrete Fourier Transform (IDFT), from the frequency-domain into the time-domain. This can be used for filtering since a costly convolution in the time-domain is a simple multiplication in the frequency-domain. It is also of fundamental importance in orthogonal frequency-division multiplexing receiver. An FFT is often used after the Analog to Digital Converter (ADC), which produces a discrete time signal. In the frequency-space the symbols can than be differentiated using simple thresholding.

1.2 Mobile Standards

Rapidly evolving mobile standards demand for increasing throughput and better energy efficiency. They also become more complex because of backwards compatibility issues which result in a number of different transmission parameters. Current standards use different configurations to achieve the needed data throughput with minimal energy consumption and to compensate for difficult channels. Standards like Long Term Evolution (LTE) and Digital Audio Broadcasting (DAB) use orthogonal frequency-division multiplexing and are often implemented using a FFT processor [1]. This FFT processor than needs to support a configurable set of FFT sizes.

Abbreviations

ADC   Analog to Digital Converter.

DAB   Digital Audio Broadcasting.
DFT   Discrete Fourier Transform.
DIF   Decimation-in-Frequency.
DIT   Decimation-in-Time.

ETH   Swiss Federal Institute of Technology.

FFT   Fast Fourier Transform.

GE   Gate Equivalents.

IDFT   Inverse Discrete Fourier Transform.
IFFT   Inverse Fast Fourier Transform.
IIS   Integrated Systems Laboratory.

LTE   Long Term Evolution.
LUT   Look-up Table.

OFDM   Orthogonal Frequency-Division Multiplexing.

RAM   Random-access Memory.

SPDF   Single-Path Delay Feedback.

VHDL   Very High Speed Integrated Circuit Hardware
        Description Language.

List of Figures

List of Tables

Bibliography

[1] The digital video broadcasting standart. [Online]. Available: http://www.dvb.org