Sudan University of Science and Technology

College of Engineering

School of Electronic Engineering

Implementation of Reed-Solomon Code on DSP Starter kit

A Research Submitted in Partial Fulfillment for the Requirements of the Degree of B. Sc. (Honors) in Electronics Engineering

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بسم الله الرحمن الرحيم

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صدق الله العظيم

چ سـورة التوبــة، الآيـــة □ چ

Dedication

Our special dedicate for our parents whom without them it will be a day without a sun guiding us in the darkness

Our teacher whom they gave us great knowledge and information that we used and still we will be using it in our daily coming days and all staff in Sudan University of sciences and technology

Finally and yet importantly, we dedicate this project for every one whom helped and supported us to be at the place that we are today

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Firstly thanks to almighty god who blesses us and give us the power to complete this work and we call him the benefit the Muslims.

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Abstract

In the digital communication system the messages are encoded into the communication channel and then decoding it at the receiver end. During the transfer of message, the data might get corrupted due to lots of disturbances in the communication channel. So it is necessary for the decoder tool to also have a function of correcting the error that might occur. Reed-Solomon codes are type of burst error detecting codes which has got many applications due to its burst error detection and correction nature. Main aim of this project is to implement this Reed-Solomon (255,223) in DSP Starter Kit (TMS203C6713).

The encoder takes a 223-byte date block and generates a 255-byte code block to be transmitted on a digital communication channel. This code is defined over a Galois Field GF (2^8) and has the capability of correcting up to sixteen short bursts of errors. The decoder logic circuit comprises multiple units in order to perform a parallel computation for the syndrome calculation. The Berlekamp's iterative algorithm is used to determine the coefficients of the error location polynomial. At the same time, the Chien's searching algorithm is used to calculate the roots of the error location polynomial, their error values, and perform the correction of the found errors. The software part of the design is written in C language, and implemented in the DSK.

المستخلص

في نظام الاتصال الرقمي يتم ترميز البيانات المرسلة عبر قناة الإتصال، ومن ثم يتم فك الترميز من قبل المستقبل.اثناء عملية الارسال يمكن ان تتعرض هذه البيانات الى تشويه نسبة لمرورها عبر قناة الاتصال،لهذامن الضروري لجهات فك الترميز ان تمتلك الآلية المناسبة لتصحيح هذه الاخطاء.

شفرة ريد-سلمون نوع من الانواع المستخدمة لتصحيح الأخطاء المتتابعةالتي تحدث في نفس الزمن .في جهة ترميز البيانات يقوم المشفر بأخذ 223 بايت وتمثيلها ب 255 بايت ليتم ارسالها عبر قناة الاتصال.هذا الكود معرف في حقل قاليوس (2^8) وهذا الكود له المقدرة على تصحيح ستة عشر من الأخطاء المتتابعة. في جهة فك ترميز البيانات يتم استخدام خوارزمية بيرليكامب

لمعرفة موقع الخطأ ومن ثم تصحيحه. يتم برمجة الريد-سلمون بإستخدام لغة البرمجة سي ومن ثم بإستخدام معالج الاشارة الرقمية من العائلة TMS203C6713 يتم تطبيق هذا الكود.

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List of Abbreviations

ADSL	Asymmetric Digital Subscriber Line
ALUs	Arithmetic Logic Units
CCS	Code Composer Studio
CD	Compact Disk
DSK	Digital Signal processing Starter Kit
DSL	Digital Subscriber Line
DSP	Digital Signal processor
DVB	Digital Video Broadcasting
DVD	Digital Versatile Disc
GF	Galois Fields
IDE	Integrated Development Environment
LFSR	Linear Feedback Shift Register
MAC	Multiply and Accumulate
MIPS	Million Instructions Per Second
RS	Reed-Solomon
TI	Texas Instruments
VLIW	Very Long Instruction Word

List of Symbol

N	Block Length
K	No. of Original Message symbols
T	Capability of error correction
A	Primitive element of Galois Field
Λ	Error locater number
D	Minimum distance
M	Symbol size
p_E	Error probability
S	Syndrome
σ	Number of errors
Ω	Error magnitude

Chapter One

Introduction

Chapter One

Introduction

1.1 Introduction

Reed Solomon Forward error correction codes have become common place in modern digital communications. Although invented in 1960 by Irving Reed and Gustave Solomon, then working at MIT Lincoln labs, it was many years before technology caught up and was able to provide efficient hardware implementation. In turn Reed Solomon based on an area of mathematics invented by French mathematician Evariste Galois in 1830's. It pains some mathematicians to find the field of number theory, one of the more esoteric areas of mathematics which Galios helped found has proved so useful [1].

Reed-Solomon codes are block-based error correcting codes with a wide range of applications in digital communications and storage. Reed-Solomon codes are used to correct errors in many systems including [2]:

1. Storage devices (including tape, Compact Disk, DVD, barcodes, etc)
2. Wireless or mobile communications (including cellular telephones, microwave links, etc)
3. Satellite communications
4. Digital television / DVB
5. High-speed modems such as ADSL, xDSL, etc.

The Reed-Solomon encoder takes a block of digital data and adds extra "redundant" bits. Errors occur during transmission or storage for a number of reasons. The Reed-Solomon decoder processes each block and attempts to

correct errors and recover the original data. The number and type of errors that can be corrected depends on the characteristics of the Reed-Solomon code [2].

1.2 Problem Statement

In digital communication system during the transfer of message, the data might get corrupted due to lots of disturbances in the communication channel. So it is necessary for the decoder tool to also have a function of correcting the error that might occur.

There are many types of correcting code schemes that used in digital communication system in order to have good transmission of data and ability to correct burst error with Reed-Solomon code this issue is done with special decoding algorithm and they differ in their features like computational complexity, implementation environment and error-correction capability. Other factors which influence works of algorithms are number of occurred error, codeword length, redundancy.

1.3 Proposed Solutions

In this project an implementation of error detection and correction system based on Reed Solomon codeis proposed to evaluate the suitable parameters for selecting the encoding and decoding algorithm. Simulation and implementation using DSP starter Kit TMS320C6713 of the encoding and decoding algorithm are done. The study includes general procedure for encoding and decoding Reed Solomon codes.

The block code length in the code has been selected as 255 and the message length is 223, which is known as (255, 223) Reed Solomon codes.

The code rate is 223/255 = 0.875 and this code is defined over GF (2^8), where each symbol is represented by an 8-bit (one byte) to make 255 x 8 = 2040 binary bits transmitted serially. This code is capable of detecting and correcting up to sixteen errors bytes in every block of 255 bytes.

1.4. Aim and Objectives

The aim of this project is to implement the Reed Solomon code in DSP starter kit (TMS320C6713) using berlekamp iterative algorithm to analyze the error probability that is occurring during transmission. This aim includes the following objectives:

1. Study of mathematical background which concern mainly Galois Fields, polynomial arithmetic, Reed-Solomon encoding and decoding theory.
2. Study the digital signal processing processor especially the starter kit TMS320C6713.
3. Select the suitable RS algorithm based on the available DSP kit.
4. Implement of algorithm on the DSP starter kit(TMS320C6713).

1.5 Methodology

To achieve the objectives of this project, first module is Reed-Solomon encoding and decoding theory of RS(255,223), second module DSP processors and TMS320C6713 DSP starter kit is selected, third module is simulation, code composer studio is used to implement C code in DSP starter kit, and the code is tested firstly in simulator mode, basic mathematical functions which include arithmetic of Galois field, arithmetic of polynomials, functions needed for encoding and decoding are

implemented using berlekamp iterative algorithm the more efficient use of hardware resources[1], fourth module is implementation, the algorithm is implemented in dsk mode.

1.6 Research Outlines

Chapter one: Introduction, problem statement, proposed Solutions, objective, Methodology and Research Outlines.

Chapter two: Literature review which contains background, history of RS code, Reed-Solomon theory.

Chapter three: Reed-Solomon encoding and decoding which contains Reed-Solomon encoding, Reed-Solomon decoding.

Chapter four: Methodology which contains implementation of RS code, Software implementation, hardware implementation.

Chapter five: Result and discussion which contains result of encoding and decoding in simulator mode and dsk mode.

Chapter six: Conclusion and Recommendation.