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Signature	:	....
Name of supervisor	:	Dr. A.B..M Shafiul Azam
Date	:	March 2005

DESIGN OF A SATURATION BURST GENERATOR FOR PULSE PROGRAMMER

KENIDY BIN MALOI

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Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
Kolej Universiti Teknikal Kebangsaan Malaysia

March 2005

" I agree that this report is my own work except the quotation and summary, each that I mentioned the source "

Signature	:	....
Author's name	:	Kenidy Bin Maloi
Date	:	1 April 2005

To my Beloved family.
Especially Mum and Dad.

ACKNOWLEDGEMENT

I would like to thank and express my deepest gratitude especially to my supervisor, Dr. A.B.M Shafiul Azam upon the invaluable support and wise counsel throughout the completion of this project. Hopefully, through the ideas, and information given, it can provide the useful needs in successfully in my project.

I also like to extend my appreciation to my family and all my friends for their help and support. Thank you.

ABSTRACT

A digital pulse programmer producing the standard pulse sequence required for pulsed nuclear magnetic resonance spectroscopy is described easily modified to produce more specialized pulse sequences. Pulse programmer provided the two-pulse sequences for 90^0– 90° and 180° - 90°. The saturation burst generator produces a sequence of pulses to provide a pseudo-90° pulse useful for the measurement of long relaxation times in solids. This sequence consists of few different pulses of equal separation time. In the simulation part, the input pulse is generated from the pulse sources. The pulse input is supplied to the circuit. During this sequence the input to the decade scaler will be interrupted, and the time base is reset on the last pulse in the sequence. In this way, all delayed pulses following the pseudo-90° pulse will occur at times measured from the beginning of the final pulse in the saturation burst. The input frequency will be divided by a counter and a decoder. In the hardware method, a switch would be used to determine the frequency division by resetting the counter when the desired divisor is achieved. The wiper of switch will provide the pulses for the **90°** saturation burst pulses.

ABSTRAK

'Digital Pulse Programmer' bertindak sebagai penjana gelombang denyut yang digunakan dalam 'Nuclear magnetic resonance Spectroscopy' dan mempunyai ciri ubahsuai yang mudah bagi menjana rangkaian-rangkaian gelombang denyut. 'Pulse Programmer' dapat menghasilkan 2 jenis rangkaian denyut iaitu untuk 90°- 90° dan 180°- 90°. Penjana Pemecah Ketepuan (Saturation burst Generator) mengeluarkan rangkaian gelombang denyut yang membekalkan denyut palsu 90° yang diperlukan dalam menggukuran gelombang tepu yang panjang dan berterusan. Rangkaian ini mengandungi beberapa denyut yang berbeza bergantung kepada pembahagian masa. Dalam bahagian simulasi projek ini, masukkan denyut diambil daripada sumber denyut dan di bekalkan kepada litar. Rangkaian denyut yang dibekalkan akan terganggu ketika memasuki bahagian skala dekad dan pengkalan masa akan terulang pada denyut yang terakhir dalam rangkaian tersebut. Dalam keadaan ini, semua denyut tertunda mengikut denyut palsu 90° akan berlaku pada ketika pengukuran yang bermula dari denyut yang terakhir pada ' Saturation Burst'. Masukkan frekuensi akan dibahagikan oleh litar pengira (counter) dan pengkod. Pada perkakasan 'Saturation Burst' , suis di gunakan untuk mengenalpasti frekuensi dengan menggulang kiraan apabila semua pembahagi diterima. Wiper yang terdapat pada suis akan menghasilkan denyut 90° kepada 'Saturation Burst".

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CHAPTER I

INTRODUCTION

1.1 Background

A microprocessor-based pulse programmer for pulsed NMR applications employing digital integrated circuit and microprocessor techniques is described. The pulse programmer was designed to be completely general with the capability to quickly and easily program any desired pulse sequence. Pulse sequencing and timing information is entered through any standard ASCII terminal using a programming language developed specifically for NMR. A resident text editor provides for easy pulse sequence modifications as well as a program library feature. A language translator and run-time monitor transform this general hardware system into a smart pulse programmer capable of extended programming functions.

A digital pulse programmer is use to producing the standard pulse sequences required for pulsed nuclear magnetic resonance spectroscopy is described. In addition, a Saturation Burst Generator useful in the measurement of long relaxation time in solids, is provides. Both positive and negative 4V trigger pulses are produced that are fully synchronous with a crystal-controlled time base, and the pulse programmer may be phase - locked with a maximum pulse jitter of 3 ns to the oscillator of a coherent pulse spectrometer. Medium speed TTL integrated circuit is used throughout.

1.2 Objective

The objective of this final project is to develop and make the Saturation Burst Generator function. The Circuit of Saturation Burst is used in Pulse Programmer for Nuclear Magnetic Resonance Spectroscopy.

The main objectives of the Saturation Burst Generator project is to produce a sequence of pulse to provide a pseudo-90^{o} pulse useful for the measurement of long relaxation times.

1.3 Problem Statement

In the measurement of long relaxation time for pulse, the sequence probably consists of few different pulses of equal separation t such that $T_2<t<<T_1$. Its may be consist of 1-9 pulse. During this sequence the input to the decade scaler is interrupted. The time base is also reset on the last pulse in the sequence. Its will be produce an error measurement for the pulse. So this project is construction to solve the problem.

1.4 Methodology

In order to achieved the objective of this final project , the following is going to be carried out:

1. Recognize all components involved in the project. Learning about the components function and operation.

2. Design and analysis of the circuit

   a.) Software.

   - Using the suitable software.
     For this project, Multisim electronic workbench software was used
     The software was used to make a simulation for circuit operation.

   b) Hardware.

   - Construct circuit on the breadboard.
   - Construct circuit on the strip board.

3. Test the circuit operation.

1.5 Report Organization

This report is divided into several sections. They are:

1) Introduction
2) Literature Review
3) Project Methodology
4) Microcontroller Circuit Development
5) Design And Description Of Circuit
6) Conclusion

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

The current progress of this project is at the end of literature study concerning the technology of pulse programmer for pulsed nuclear resonance spectroscopy and the saturation burst generator. The purposes of this study are to:-

i. Study about function of pulse programmer for nuclear magnetic resonance.
ii. Study the causes of pulse programmer and saturation burst generator.

2.2 Research Related :

A description of the sequence of events and the decisions leading to the design of a versatile pulse programmer for pulsed NMR are presented. Background and application information is discussed in order that the reader might better understand the role of the pulse programmer in a NMR spectrometer. Various other design approaches are presented *as a basis for comparison. Specifications for this design are proposed, the hardware implementation of the specifications is discussed, and the software operating system is presented*

(Ames Lab., IA (USA) Pages: 89, 1979 May 01 Adduci, D.J.)

We use nuclear magnetic resonance (NMR) spectroscopy, measurement of circular dichroism, fluorescence spectroscopy, and structural bioinformatics as major tools for the determination of the 3-dimensional structure, dynamic properties, and interplay of biomolecules. In addition, we perform all molecular biology work in our department, so that we are able to work on all aspects of bioengineering in our laboratories.

(Lehrstuhl für Biopolymere, Universität Bayreuth, Universitätsstr. 30, 95447 Bayreuth, Germany)

2.3 Study of NMR

Nuclear magnetic resonance, or NMR as it is abbreviated by scientists, is a phenomenon which occurs when the nuclei of certain atoms are immersed in a static magnetic field and exposed to a second oscillating magnetic field. Some nuclei experience this phenomenon, and others do not, dependent upon whether they possess a property called spin.

Most of the matter can examine with NMR is composed of molecules. Molecules are composed of atoms. Here are a few water molecules. Each water molecule has one oxygen and two hydrogen atoms. If we zoom into one of the hydrogen past the electron cloud we see a nucleus composed of a single proton. The proton possesses a property called spin which:

1. can be thought of as a small magnetic field, and
2. will cause the nucleus to produce an NMR signal.

2.3.1 Spectroscopy

Spectroscopy is the study of the interaction of electromagnetic radiation with matter. Nuclear magnetic resonance spectroscopy is the use of the NMR phenomenon to study physical, chemical, and biological properties of matter. As a consequence, NMR spectroscopy finds applications in several areas of science. NMR spectroscopy is routinely used by chemists to study chemical structure using simple one-dimensional techniques. Two-dimensional techniques are used to determine the structure of more complicated molecules. These techniques are replacing x-ray crystallography for the determination of protein structure. Time domain NMR spectroscopic techniques are used to probe molecular dynamics in solutions. Solid state NMR spectroscopy is used to determine the molecular structure of solids. Other scientists have developed NMR methods of measuring diffusion coefficients.

The versatility of NMR makes it pervasive in the sciences. Scientists and students are discovering that knowledge of the science and technology of NMR is essential for applying, as well as developing, new applications for it. Unfortunately many of the dynamic concepts of NMR spectroscopy are difficult for the novice to understand when static diagrams in hard copy texts are used. The chapters in this hypertext book on NMR are designed in such a way to incorporate both static and dynamic figures with hypertext. This book presents a comprehensive picture of the basic principles necessary to begin using NMR spectroscopy, and it will provide you with an understanding of the principles of NMR from the microscopic, macroscopic, and system perspectives.

2.3.2 Units Review

NMR scientists use a set of units when describing temperature, energy, frequency, etc. Units of time are seconds (s). Angles are reported in degrees (°) and in radians (rad). There are 2π radians in 360°.

The absolute temperature scale in Kelvin (K) is used in NMR. The Kelvin temperature scale is equal to the Celsius scale reading plus 273.15. 0 K is characterized by the absence of molecular motion. There are no degrees in the Kelvin temperature unit. Magnetic field strength (B) is measured in Tesla (T). The earth's magnetic field in Rochester, New York is approximately 5×10^{-5} T.

The unit of energy (E) is the Joule (J). In NMR one often depicts the relative energy of a particle using an energy level diagram. The frequency of electromagnetic radiation may be reported in cycles per second or radians per second. Frequency in cycles per second (Hz) have units of inverse seconds (s^{-1}) and are given the symbols ν or f. Frequencies represented in radians per second (rad/s) are given the symbol ω. Radians tend to be used more to describe periodic circular motions. The conversion between Hz and rad/s is easy to remember. There are 2π radians in a circle or cycle, therefore

$$\mathbf{2\pi\ rad/s = 1\ Hz = 1\ s^{-1}.}$$

Power is the energy consumed per time and has units of Watts (W).

Finally, it is common in science to use prefixes before units to indicate a power of ten. For example, 0.005 seconds can be written as 5×10^{-3} s or as 5 ms. The m implies 10^{-3}.

2.4 Pulse programmer for nuclear magnetic resonance.

The pulse programmer is programmed and controlled using a printer (parallel) port. Pulse programmers are essential components of spectroscopy of magnetic resonance. Using hardware description language (HDL) and the memory-based state machine paradigm [1], a high performance pulse/pattern generator has been designed and implemented using two complex programmable logic devices (CPLD). The design [2] features a 20 ns resolution, a 200 ns to 90 minutes timing range, and a 20 bit output word. It can be used in high-performance stationary systems as well as in small desktop or even portable spectrometers. Using the HDL design strategy, the design can be modified to accommodate different specifications. Resolution, longest pulse duration, output width, maximum program length , and even the op-codes can be changed to meet new design requirements. The inherent reprogramming capability may be essential for the development of the future applications of Nuclear Magnetic Resonance.

[1] E.A. Wachter, E.Y. Sidky, and T.C. Farrar, Rev. Sci. Instrum. ***59,*** *2285-2289 (1988).*

[2] M. L. Buszko, M.J. Fiyak, and M.A. Lynch, Development of a Versatile Pulse

The block diagram of the programmer is shown as in figure 1.

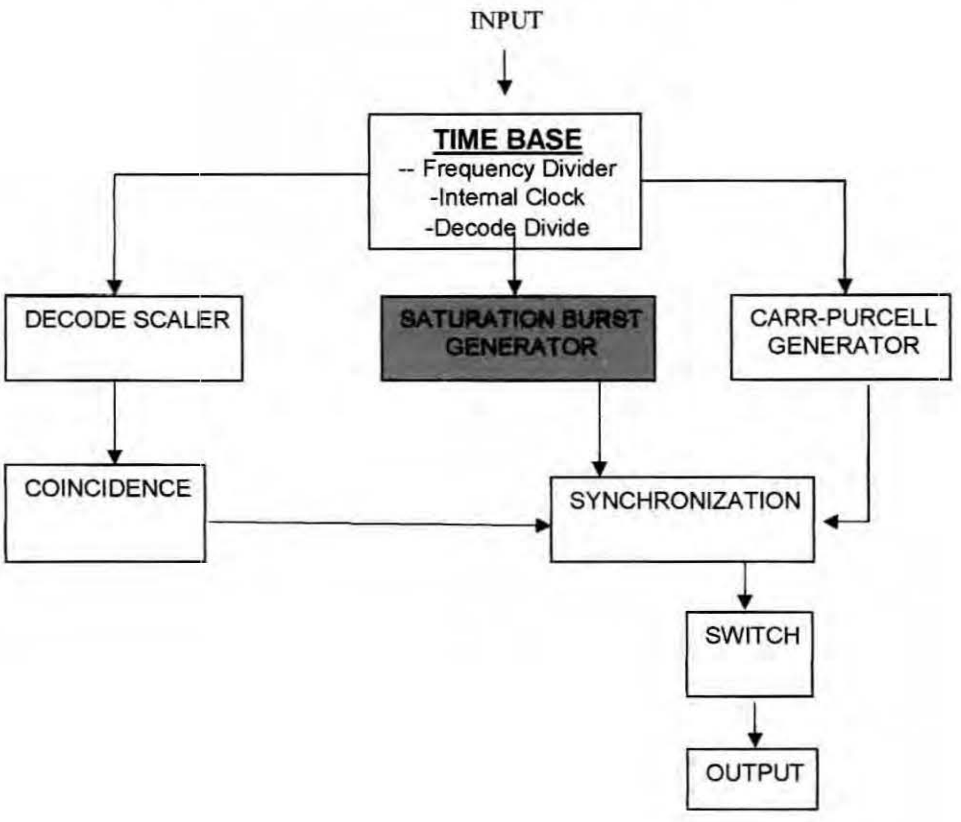

Figure 2.1 : The Block diagram of pulse programmer.

2.5 Description of the circuit

A block diagram of the programmer is shown in figure 1. The prototype in our laboratory was constructed on the printed circuit cards following approximately this division to provide compact and accessible packaging. The layout, however, is not critical, and no particular construction precautions should be necessary.

The circuitry of the pulse programmer will be discussed in four segment:

1. Time base
2. Four-digit decade scaler
3. Burst Generator for special pulse sequences
    a) Saturation Burst Generator
    b) Carr-Purcell Generator.
4. Coincidence and Synchronization circuit

2.5.1 Time Base.

The time base consist of a frequency standard and a decade divider. The frequency standard may be taken as some appropriate division of the oscillator frequency of a coherent spectrometer to provide phase-locking to the pulse programmer, or an internal clock may be use.

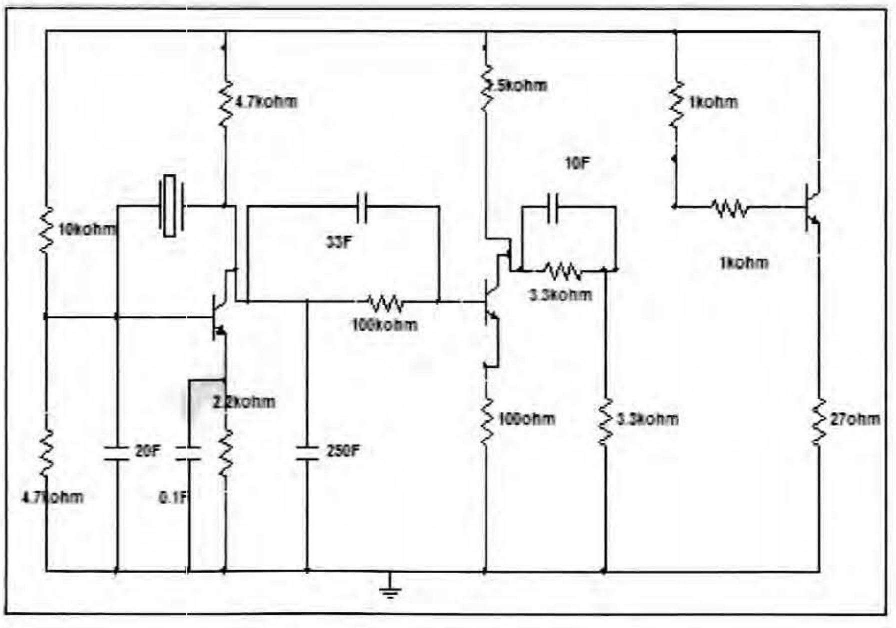

Figure 2.2 : Internal Clock Circuit

The internal clock circuit shown in figure 2 contains a 1 MHz crystal oscillator and a Schmidt trigger with coupling and divider resistor selected to produce a symmetric square wave. An emitter follower output provides impedance matching to the remaining circuitry.

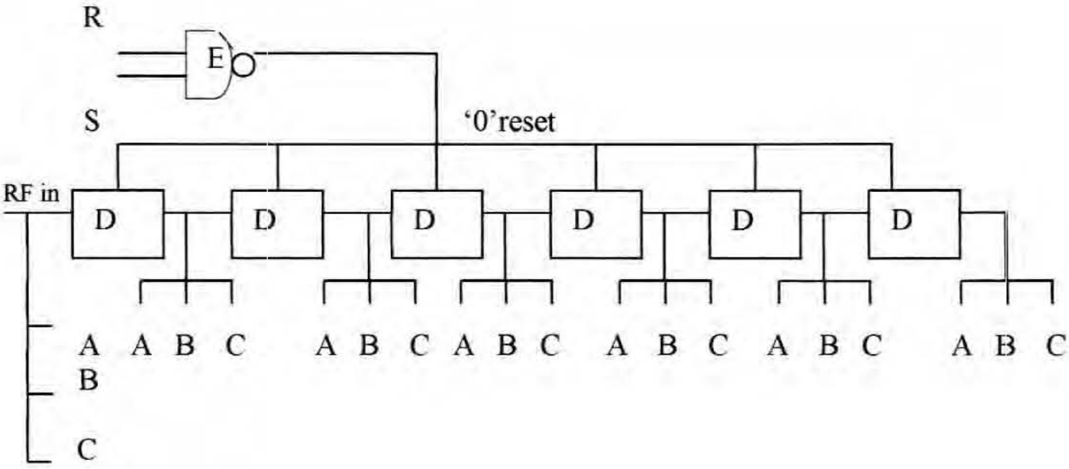

Figure 2.3 : Block diagram of the decade divider

E, ½ SN7440 ; D, SN7490N ; A,B & C, selected switch

Figure 3 shows the decade divider portion of the time base. Six SN7490N decade counter wired as symmetric divide-by-ten counter and three independent switched outputs labeled, "time base channel A, B and C " , provide frequencies at decade at decade intervals from 1 MHz to 1 Hz, inclusive. The decade divider is automatically reset to zero by a coincidence circuit set to provide the desired repetition rate for the pulse sequence (input R) and by the saturation burst generator (input S) following a series of 90° pulses.

2.5.2 Decade Scale

The decade scaler contains four of the synchronous decade counter wired as a binary coded decimal (BCD) counter is decoded to decimal output by an SN7442N four-line to 10-line decoder. Visual display is provided by a Burroughs B5540 display tube driven by an SN7441N decoder/driver. The carry out of each decade counter is synchronized with its count input to minimize accumulated delays and to allow independent resetting (input R) of the counter.

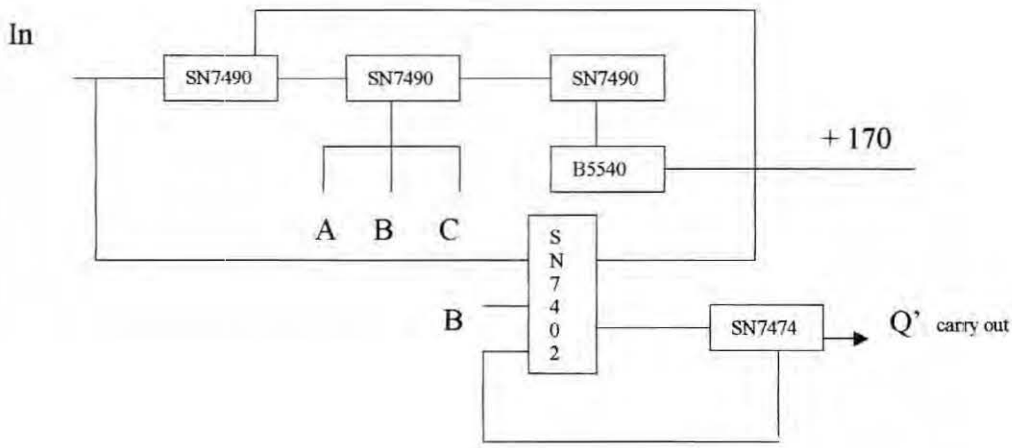

Figure 2.4 : Block diagram of decade counter
A,B & C : Coincidence Channel

The leading edge of a negative-going output from the BCD-decade decoder coincides with a trailing edge of the count input, as shown in figure 5 (c) . The '9' output is inverted (figure 5(d)) and applied to the D-input of an SN 7474N edge-triggered flip-flop. This flip-flop is clocked by the inverted count input (figure 5(b) to produce a carry pulse (figure 5(e)) whose negative leading edge is synchronous with the trailing edge of the count input.

Independently adjustable delayed pulses are produced when coincidence occurs between the switch selected decimal output of each decade counter.
Three such coincidence channels provide pulses for: