CONSTRUCT OF A LOW VOLTAGE SCHMITT TRIGGER

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"I declare that this thesis entitled "*Construct of A Low Voltage Schmitt Trigger*" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree".

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"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering (Telecommunication)"

Signature : …….

Supervisor : Mr. Faiz Arith

Date :……..

This work I dedicated to my family;

For my beloved father, Drahim Bin Kamis and mother, Aishah Binti Harun

Every journey begins with single steps and here your daughter become

and

To my supervisor's;

Good to know you,

"A single conversation with a wise person is better than ten years of study"

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ABSTRAC

This project presents the effect of load capacitance and source voltage on the performance of Schmitt trigger designed circuit. A Schmitt Trigger circuit is a circuit with the combination of six transistors. It used in microchip processor to improve speed for data processing. It is a comparator circuit with hysteresis which is implemented by applying positive feedback to the non-inverting input of a comparator or differential amplifier. Schmitt Trigger is widely used in analogue and digital circuit to solve the noise problem and speed up the data processing. The project is to design a low voltage Schmitt trigger circuit using 0.18μm CMOS technology using Cadence simulation software. The circuit was designed to operate at low voltage to minimize energy consumption and to reduce the supply voltage of the circuit. The method of this design circuit is based on Conventional Schmitt Trigger by manipulating the arrangement of transistors and the width-length ratio. This method is applied to produce the best performance circuit by solving noise problems in microprocessor. The Cadence simulator software was successfully implemented in this project. The design is successfully constructed by Cadence simulation software. This CMOS Schmitt Trigger was able to operate at low voltage as low as 0.8 V to 1.5 V.

ABSTRAK

Projek ini membentangkan kesan kemuatan beban dan sumber voltan kepada prestasi Schmitt pencetus direka litar. Satu litar Penggera Schmitt adalah satu litar dengan kombinasi enam transistor. Ia digunakan dalam pemproses mikrocip untuk meningkatkan kelajuan pemprosesan data. Ia adalah litar pembanding dengan histerisis yang dilaksanakan dengan menggunakan maklum balas positif kepada input yang komparator tidak menyongsang atau penguat beza. Litar Penggera Schmitt digunakan secara meluas dalam litar analog dan digital untuk menyelesaikan masalah bunyi bising dan mempercepatkan pemprosesan data. Projek ini adalah untuk mereka bentuk voltan rendah Schmitt mencetuskan litar menggunakan teknologi CMOS 0.18µm menggunakan perisian simulasi CADENCE. Litar ini telah direka bentuk untuk beroperasi pada voltan rendah untuk mengurangkan penggunaan tenaga dan untuk mengurangkan voltan bekalan litar. Kaedah litar reka bentuk ini adalah berdasarkan kepada Schmitt Trigger Konvensional dengan memanipulasi susunan transistor dan nisbah lebar-panjang. Kaedah ini digunakan untuk menghasilkan litar prestasi terbaik dengan menyelesaikan masalah bunyi bising di dalam mikropemproses. Perisian simulasi CADENCE telah berjaya dilaksanakan dalam projek ini. Reka bentuk litar ini telah berjaya dibina dalam perisian simulasi CADENCE. Litar Penggera Schmitt dapat beroperasi pada voltan rendah serendah 0.8 V kepada 1.5 V.

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LIST OF ABBREVIATIONS

PMOS	-	Positive channel MOS
NMOS	-	Negative channel MOS
CMOS	-	Complementary Metal Oxide Semiconductor
VIH	-	Voltage Input High
VIL	-	Voltage Input Low

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CHAPTER I

INTRODUCTION

1.1 Background of the project

This project presents the effect of load capacitance and source voltage on the performance of Schmitt trigger designed circuit. The circuit was designed to operate at low voltage, based on Conventional Schmitt Trigger by manipulating the arrangement of transistors and the width-length ratio [1]. This method is applied to produce the best performance circuit by solving noise problems in microprocessor depending on demand nowadays. The design is carried out in 0.18μm CMOS technology using Cadence simulation software. This CMOS Schmitt Trigger was able to operate at low voltage of 0.8 V to 1.5 V.

1.2 Introduction

A Schmitt Trigger is a circuit that used in the microprocessor in electronics device such as computer, mobile phone and all other electronics devices that use a microprocessor. It was built in a combination of a few transistors [2][3]. A Schmitt Trigger main role inside microprocessor is used to reduce noise signal, so the device can perform faster in processing data [4][5]. It is a comparator circuit with hysteresis [6] which is implemented by applying positive feedback to the non-inverting input of a comparator or differential amplifier [3]. A Schmitt Trigger is widely used in analogue and digital circuit. Schmitt triggers are widely used in different circuits to increase noise immunity [7] by using only single input threshold, so the noisy input signal close to the threshold might source the output to switch swiftly back and forth from noise itself [8][9]. Schmitt trigger's noisy input signal near to threshold can grounds only one switch in output value after which it would have to move away from the other threshold in order to switch another [10]. A common disadvantage of

the taking place single ended Schmitt triggers is that the hysteresis is set by process parameters, device dimensions, supply voltage and differs with process situations [11]. Tuneable hysteresis is extremely required to overcome this insufficiency. These are analytically needed in applications where disturbances and noise level combined to the triggering signals [12].

This low voltage digital circuit is an active research area that tailors portable applications. Such applications include wearable electronics, intelligent remote sensors, implantable medical devices, and energy-harvesting systems [4]. Two major goals of such systems are minimized energy consumption and improved compatibility with low-voltage power supplies and analogue components [13]. The immediate solution to achieve these goals is to reduce the supply voltage, but doing so raises the issue of operability [11]. At low supply voltages, the integrity of digital signals degrades dramatically due to the indifference between active and leakage currents [14]. In addition, the system timing becomes more unpredictable as the impact of process, voltage and temperature variations being more significant at lower voltages.

Schmitt triggers are electronic comparators that are widely used to enhance the immunity of circuits to noise [15][16] and disturbances and are inherent components of various emerging applications. Commonly used in the field of communication and signal processing techniques for improving on and off control, reducing the noise effects in triggering devices, analogue to digital and a number of other emerging applications including frequency doublers, retinal focal-plane sensors, sub-threshold SRAM, image sensors, pulse width modulation circuits, wireless transponders, FPGA based system and sensors [17]. Conventional Schmitt triggers, composed of operational amplifiers, suffer from some inevitable drawbacks which are not prominent in CMOS Schmitt triggers.

There are two types configuration of Schmitt Trigger which is non-inverting and inverting configuration [18]. Non-inverting Schmitt Trigger is the standard circuit that used in most devices [19]. There are basically two symbols for the Schmitt Trigger which is non-inverting and inverting Schmitt Trigger. The symbol is a triangle with an input and an output and inside there is the hysteresis symbol. The

hysteresis curve sign differs depending on the type of Schmitt Trigger, inverting or non-inverting. The symbol of Schmitt Trigger is shown in Figure 1.

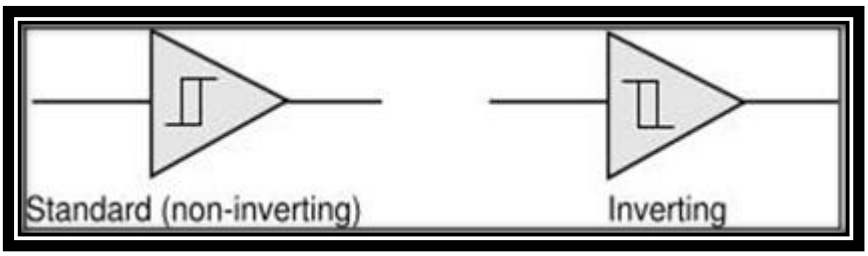

Figure 1: Symbol of Schmitt Trigger[4]

To operate the Schmitt trigger, the comparator [20] must need to have a positive and a negative power supply. Figure 2 and Figure 3 represents the basic circuit diagrams of a standard and an inverting Schmitt Trigger circuit respectively.

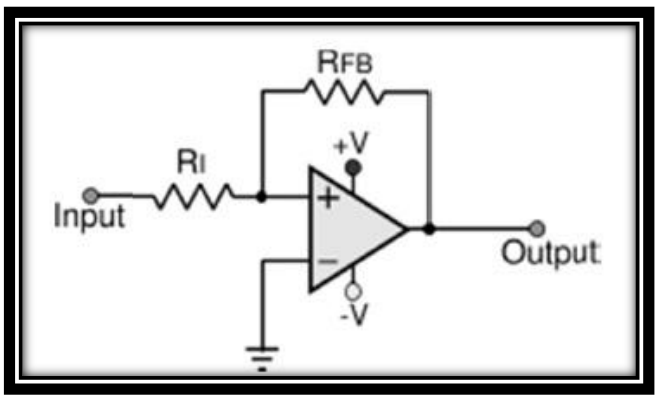

Figure 2: A standard non-inverting Schmitt trigger circuit[4]

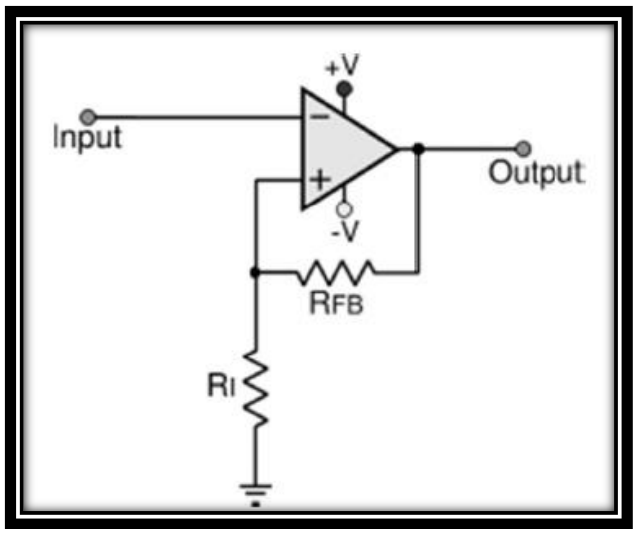

Figure 3: An inverting Schmitt trigger circuit[4]

1.3 Project working operation

A Schmitt Trigger is an active circuit which converts an analogue input signal to a digital output signal. The term used of "trigger" [21] is because of the output retains its value until the input changes [22] at a certain value which is the value that have been set in the circuit to trigger a change. From the picture Figure 2 below, the high and low output voltages are actually represented of the positive and negative power supply voltages of the comparator [23]. To operate a Schmitt Trigger normally, the comparator needs to have a positive and negative power supply. The following drawing shows the behaviour of a Schmitt Trigger against an alternating voltage.

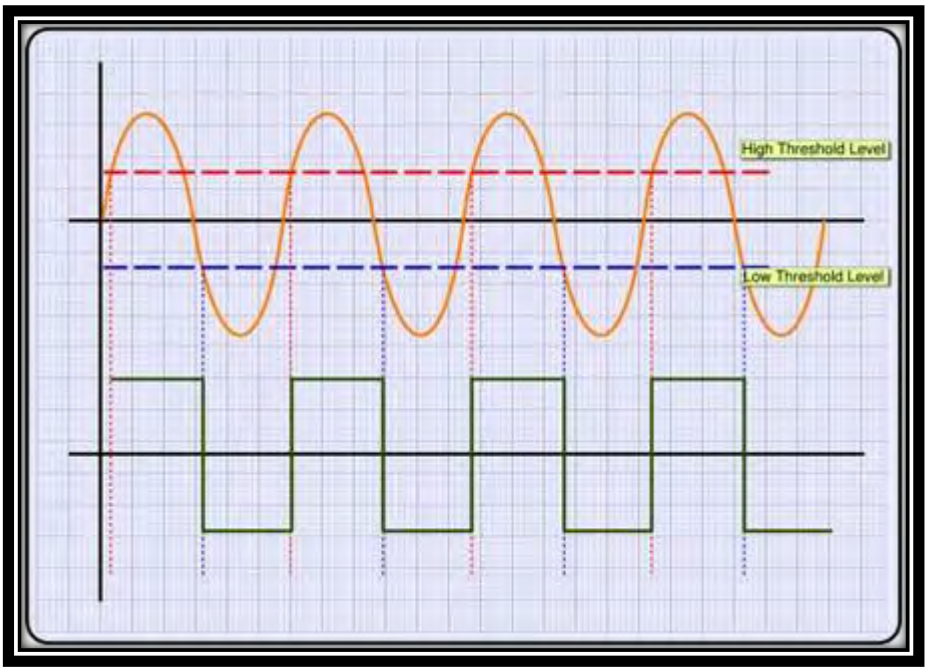

Figure 4: Waveform of Schmitt Trigger [4]

The AC input is the orange line. The horizontal red line indicates the High Threshold Level, the blue horizontal line indicates the Low Threshold Level and the green line is indicates the output of the Schmitt Trigger.

In the non-inverting Schmitt Trigger, whenever the input signal enters the circuit, the signal goes higher than a High Threshold Level, the output is high [19]. Whereas, in inverting Schmitt Trigger, the output is low [24]. When the input signal enters is below a Voltage Threshold Level, the output is low for non-inverting, while the output is high for inverting Schmitt Trigger. Well, if the input is in between of the two levels, the output retains at its value. This concept is the basis operation of a

Schmitt Trigger. This dual threshold action is called “hysteresis” and this is because of the Schmitt trigger possesses memory and can act as a bistable circuit of latch or flip-flop which is a Schmitt trigger can be converted into a latch and a latch can be converted into a Schmitt trigger [25]. Schmitt triggers are bistable networks that are widely used to enhance the immunity of a circuit to noise and disturbances. It is good as a noise rejecter. Schmitt trigger makes use of waves, therefore it is widely used for converting analogue signals into digital ones and to reshape sloppy, or distorted rectangular pulses [24]. The hysteresis of the trigger eliminates noise making a cleaner and more reliable signal [26]. The output of a Schmitt trigger changes state when a positive going input passes the upper trigger point (UTP) voltage and when negative going input passes the lower trigger point voltage. The conventional Schmitt trigger has fixed hysteresis width.

Hysteresis refers to the difference in voltage levels. The difference in voltage levels is in between of the detection of a transition from a logic low level to a logic high level, and also the transition from a logic high level to a logic low level [27].

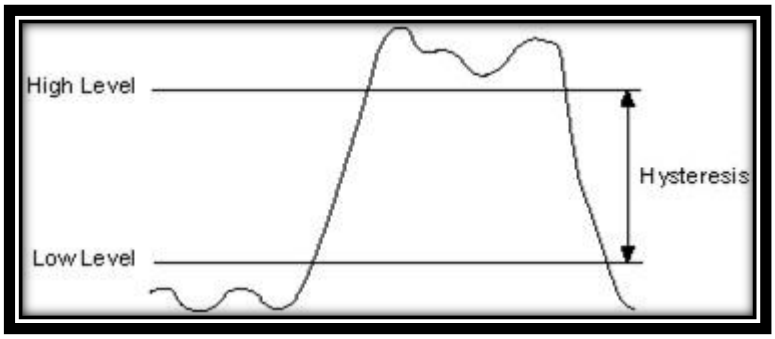

Figure 5: Hysteresis of Schmitt Trigger[4]

The level of hysteresis depends on the different types of digital logic devices on their digital inputs. At the input rising edge of the digital signal, the device detects a transition from a logic low to a logic high. Otherwise, the device detects a transition from a logic high to a logic low when the voltage at the input of the device crosses at low level voltage. In digital devices, hysteresis is very useful because it provides some amount of natural immunity [5] to high-frequency noise in a digital system. The reflections from the high edge rates of logic level transitions are the cause of noise. It also could make false transition detections by the digital device if only a single voltage threshold determined a change in logic state. The figure below explains the flow of phenomena.

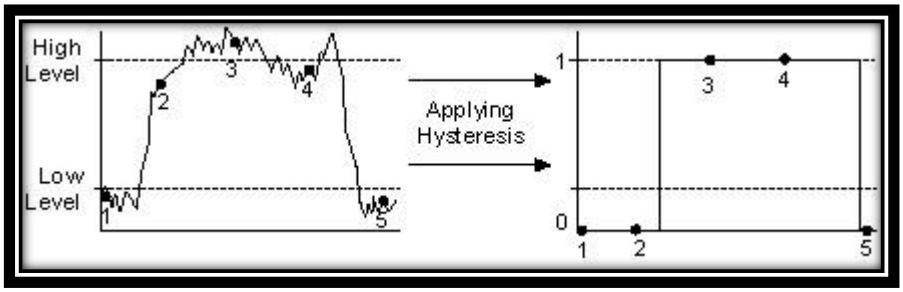

Figure 6: Output curve of Schmitt Trigger[4]

After applying the hysteresis, a logic low level is acquired the first sample [28]. Then, following by the second sample also is a logic low level. This is because of the signal remain in between, not yet crossed the logic high level threshold [29]. While the third and the forth samples are representative of a logic high level and a logic low level respectively.

Referring to the figure below, the hysteresis is located in between the switching path on the rising [30] edge of higher point (VT+) and on the falling [30] edge of lower point (VT–), where the point of switching threshold can be adjusted [26]. In setting the voltage threshold of Schmitt Trigger, there are a few specs that have been set for limitation [27]. All diversification limits which are related to Schmitt Trigger input are important for different reasons. Refer to the figure below (VT+ max) represent as Vih and (VT– min) represent as Vil. The input level of Vih and Vil must be larger than (VT+max) and smaller than (VT– min) in order for the input part to switch. The input signal which enters in between of (VT+min) and (VT+max) will switch as rising edge, while for the falling edge the signal will switch in between of (VT–max) and (VT–min). The input signal will not switch in between of (VT+min) and (VT-max) [3]. Thus, the noise that enters this area will be rejected in Schmitt Trigger.

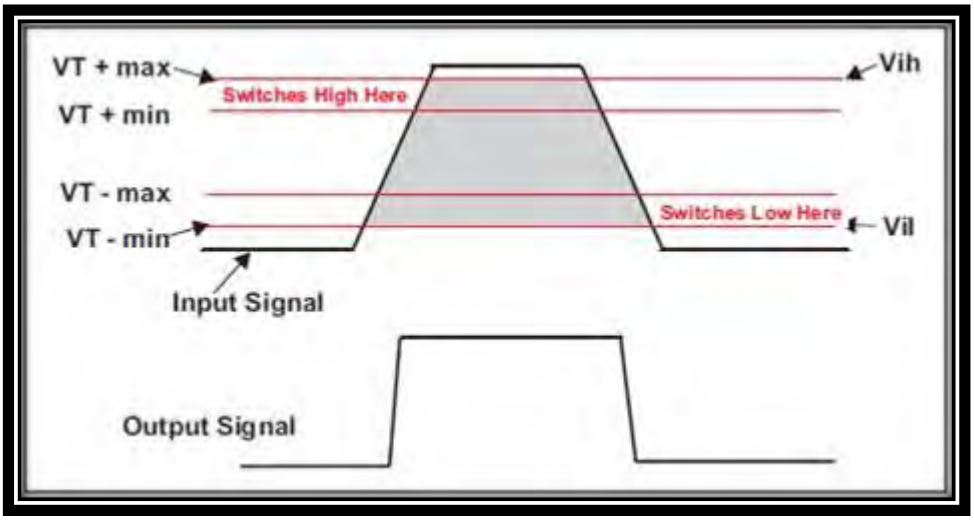

Figure 7: Output signal of Schmitt Trigger[3]

In a standard non-inverting Schmitt Trigger circuit, the switching of the input signal is switched to the same point of rising and falling edge. The signal will switch at the threshold with sufficient current received from the Vcc [31]. Then, when the current is forced from Vcc, the Vcc level will drop and cause the threshold to shift [32]. The excessive current is happens when the current is excess when the signal is shifts across the input and this is causing the signal to switch again, this process will repeat continuously and making oscillation. So that, the way chosen to solve this problem is by using a Schmitt Trigger which is meeting all the specification required in switching process of input rise and falling edge for use in the device.

The threshold's dual function in Schmitt trigger is called hysteresis and shows that the Schmitt trigger has some memory as well [33]. Actually it is a bistable multivibrator circuit which converts a varying voltage into an unvarying logical voltage signal (zero or one). Numerous design and implementation of Schmitt trigger circuits for different applications and advantages has been proposed in literatures by many researchers.

Since its invention, the Schmitt trigger circuit has relied on changing the voltage or current threshold levels by means of positive feedback in the analogue loop. Schmitt trigger is one kind of regenerative circuit, mainly worthwhile in digital systems.

1.4 Problem statement

The main drawback implementation of the new design circuit is to reduce a few problems facing in electronics devices and also to meet the customer needs in market. Nowadays, there are many types of Schmitt Trigger have been invented. However, they're still facing problems in term the noise problem in the output signal of the Schmitt Trigger. The problem is having a large static power and high dynamic power dissipation, operate at high voltage which is do not able to operate at low voltage and this will cause in the use of high power consumption and also having low speed in data processing. Hence the idea comes out in implementing the new design circuit of Schmitt Trigger to overcome these problems. A low voltage Schmitt Trigger is required in the industry, especially in electronics which is getting demanding nowadays.

1.5 Objectives of project

The main objective of this project is to design the new Schmitt Trigger circuit that capable to function at low voltage. The low voltage is optimized for 0.8V to 1.5V. Furthermore, is to determine the performance of the constructed circuit in term of functionality and also to reduce noise of the Schmitt Trigger circuit. The simulation result must be in square form for both input voltage and output voltage. Hence, design a layout circuit in 2D graphic which is the final design for circuit to be implemented.

1.6 Scope of project

The scopes of project are research articles about Schmitt Trigger circuit. For the researcher, to know about theory working principle of Schmitt Trigger, hysteresis, schematic circuit design procedure, simulation and final design circuit layout. The first step is to understanding the working operation of Schmitt Trigger. The parameter characteristic of an antenna is important so that the simulator will run successfully.

Next, is to design a Schmitt Trigger circuit. The design is carried out in 0.18µm CMOS technology using Cadence simulation software. The design circuit will then be simulated in the Cadence simulator application. A few voltage values have been tested in this circuit. The optimized value of voltage for this project is

0.8 V to 1.5 V. Hence, design a layout circuit, which is the 2D graphic circuit. The layout is confirmed for final design and exactly suitable and ready used for manufactured in the industry.

Finally, comparison between Cadence simulation software and Mentor Graphic simulation software was tabulated in result data. The result of noise from every each of circuit is observed to analyze the characteristics of the arrangement of transistors and the width-length ratio of the circuit.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

This chapter will explain the theory and concept of the Schmitt Trigger circuit. Then, discuss among the five circuit design and briefly explain the propose circuit design. Hence, determine the design parameter and the characteristic of the Schmitt Trigger circuit.

2.2 Description of the circuit design

2.2.1 Introduction

There are six designs of circuit being discussed in this literature review. These circuits will be analysed by its characteristic of the design. Then, come out with the best design for this project. There are five difference circuit for use of low voltage application will be analysed which are Conventional Schmitt Trigger [18], Low voltage CMOS Schmitt trigger circuits [21], A Low-Voltage Low-Power Current-Mode Differential Adjustable Schmitt Trigger, Low-voltage high-speed Schmitt trigger and compact window comparator [22] and a Low voltage CMOS Schmitt Trigger in 0.18μm technology [1]. For introduction of Schmitt Trigger circuit, the Conventional Schmitt Trigger circuit will be briefly explained in this chapter. The construction and operation will be clearly discussed. Then, followed by another circuit design for comparison of the circuit, hence the best design among the circuits will be defined.