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PROPOSED SRAM CELL USING LOW POWER SCHMITT TRIGGER IN SUB-THRESHOLD REGION WHICH ADAPTS ITS OWN THRESHOLD

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ABSTRACT

In 1950, an American biophysicist and polymath Otto Schmitt coined the term 'Biomimetics' (imitation of nature element, systems, models for the purpose of solving complex problems of the human). Proceeding on the same concept, finally he developed the Schmitt Trigger by studying the nerves in squid, attempting to engineer a device that replicated the nerve propagation's biological system during his doctoral research. Many researchers proposed the numerous designs, advantages and implementation of Schmitt Trigger for different applications.

This paper reveals a detail review of each circuit illustrated in literature for last two decades in terms of their merits and demerits. Section 1 gives brief illustration of history, properties and advancement of Schmitt Trigge,. Section2 comprises merits, demerits and application of Schmitt Trigger. Section 3 gives detailed review about threshold adaption by Schmitt trigger and Section 4 ends with the summary of the review.

KEYWORDS: Schmitt Trigger, Threshold, Hysteresis, SRAM Cell.

INTRODUCTION

WORKING PRINCIPAL OF TRADITIONAL SCHMITT TRIGGER

In their textbook, Millman and Halkias discussed how the voltage or current threshold levels are changed by means of resistive voltage dividers. Schmitt Trigger is usually composed of a comparator which has two different threshold voltages. A Comparator must have a positive and negative power supply to operate the Schmitt Trigger.
In an inverting Schmitt Trigger, output will be low if the input voltage level will be higher than the threshold level and if the input voltage is lower than threshold level than the output level will be high. Traditional Schmitt Trigger suffers from the disadvantage of dependency of reference voltage on the output voltage. Also, in high speed applications, speed of analogue switch in the feedback loop becomes critical. These sorts of Schmitt Trigger are not suitable for CMOS Technology because of correctness restriction of resistors and op-amp design tasks e.g. low offset and high DC gain necessities.

USE OF SCHMITT TRIGGER FOR LOW SLEW RATE INPUT

An ideal input Signal is an instantaneous transition from logic low to logic high or vice versa. However, inherent parasitic Capacitance, resistance and inductance in the input path and input buffer cause an input signal to have a finite amount of rise or fall time. This time is referred to as Slew rate and is commonly defined to be the propagation delay between 10% and 90% of the signal's voltage swing.

One way to eliminate problems with low slew rate is with external Schmitt Triggers. A Schmitt Trigger is a buffer used to convert a slow or noisy signal into a clean one before passing it to the FPGA.Schmitt Trigger buffers have a transfer function with hysteresis. If we apply the hysteresis theory to the noisy signal, one will notice that an almost perfect output is recovered from a slow and very noisy input. Schmitt Trigger utilizes the hysteresis phenomena with two voltage thresholds. An upper threshold is used to generate an output transistors as the input switches from low to high, and a lower threshold is used to generate an output transition as the input switches from high to low. Such a trigger scheme is highly resistant to noise as long as the peak to peak amplitude of the noise is less than the difference between threshold voltages. Similarly, a low slew rate signal turns into a sharp, high slew rate signal after passing through a Schmitt trigger.

MERITS & DEMERITS OF SCHMITT TRIGGER

Schmitt Trigger has the advantage of noise immunity. They are utilized in many circuits by using only single input threshold, the noisy input signal close the threshold might source the output to switch swiftly back and forth from noise itself.

Schmitt Trigger noisy input signal near to threshold can ground only one switch in output value after which it would have to be move away from the other threshold in order to switch another. A major demerit inherited by the single ended Schmitt Trigger is that Hysteresis is set by supply voltage, device dimensions, process parameters and differs with process situation. To overcome this insufficiency, Tunable Hysteresis is extremely required. They are needed in application where noise level and disturbances combined to the triggering signals.

PROPERTY THAT MAKES SCHMITT TRIGGER UNIQUE:- "SCHMITT TRIGGER ADAPTS ITS OWN THRESHOLD":

The details of a comparator circuit that converted a slowly varying input signal into an abrupt change in output voltage was published in 1938 in the journal of Scientific instruments. American Scientist 0.H. Schmitt developed the circuit based on cross coupled thermionic valves. Since then Signal processing circuits utilizes Schmitt Trigger as the building block.

Schmitt Trigger inherits Hysteresis-i.e. the difference between the upper and lower thresholds. The circuit rejects the noise contained in the input signal provided the input signal crosses both thresholds and we get rectangular signal as output at the same frequency as the input.

Quantity of required hysteresis and threshold voltages need to be known whether you implement a Schmitt Trigger using Transistors, OP-amps or Comparators. Knowing the input signal's amplitude and the noise level it is likely to contain, the process become simple. However, setting the threshold to produce reliable triggering could be tricky if these parameters are variable or largely unknown. Input signal not able to cross one or both thresholds if hysteresis is too much and large noise gets added in the input signal and we get false triggering if hysteresis is low. It solves these problems by implementing a circuit.

Acc. to the suitability of input signal's amplitude, this circuit automatically adjusts the trigger thresholds. Positive Peak detector is formed by Comparator IC1A together with analog switch IC2B and capacitor C1.The comparator output goes high causing IC2B to switch into the position shown in the Schematic when the input Signal rises above the voltage stored on C1 at Comparator's inverting input. Now the input Signal is sampled by detector. The Detector also tops up the charge stored on C1.The Switch changes state such that the voltage Vu stored on C1 is a DC level corresponding to the upper peak value of the input Signal when the input Signal drops below the voltage on C1.

Negative peak detector is formed by Comparator IC1B, analog Switch IC2C and Capacitor C2.It works in the same way as the positive peak detector described above. Only difference is that sampling on the negative peak of the signal such that the voltage Vl stored on C2 is a DC level corresponding to the lower trough value of input signal is not provided by this.

Instead it provides the discharge path for the charge stored on the Sampling Capacitors formed by Resistor network created by R1, R2 & R3.For the final comparator IC4A,it sets the upper and lower threshold voltages. Values of resistor are chosen such that Vtl is just slightly greater than Vl&Vtu is just slightly less than Vu.

If R1 equal to R3 then we can write the voltage difference in percentage terms as Voltage difference={[R1]/[2R1+R2]}*100% Vtl is 5% greater than Vl and Vtu is 5% less than Vu with the values shown in the figure. The input signal amplitude and DC level is tracked by constantly adjusting the thresholds. For example to produce thresholds of Vtu=2.45V and Vtl=1.55V,1V peak-peak signal riding on a DC level of 2V is provided.

It can be observed that the hysteresis voltage Vh given by Vh=Vtu-Vtl is always just slightly less than the peak=peak amplitude of input signal(Vh=Vtu-Vtl),in this example it is 0.9V.Before being fed to analog Switch IC2A,the threshold voltages are buffered by IC3A&IC3B.

Assume that IC2A is in the state shown in the figure such that the threshold voltage Vtu is fed to the comparator's inverting input and the input signal at the Comparator's non-inverting input is rising up from tis negative peak to understand the working of the final part of the Circuit. Vout, the digital output signal is presently at its low level.

The Comparator output immediately goes high causing IC2A to change state and feed Vtl to the comparators inverting input at the moment when the input signal just crosses Vtu'.Typical of Schmitt Trigger behavior, this positive feedback ensures rapid, clean switching of the digital output Signal.

To prevent stray capacitance around IC4A's inverting input from introducing aberrations into Vtu and Vtl when IC2A changes state, buffers IC3A and IC3B are necessary (particularly at high frequencies).

APPLICATIONS OF SCHMITT TRIGGER

Schmitt Trigger or regenerative comparator is used in the field of Signal processing techniques and communication for reducing the noise effect in triggering devices, improving on-off control, analog to digital conversion and a number of emerging applications including Wireless Transponders, Pulse Width Modulation Circuits, Sine to Square wave comparator ,Amplitude Comparator, Squaring Circuit, in Flip Flops, Calculator, image sensors, Sub-threshold SRAM, frequency doublers, retinal focal plane sensors, FPGA based systems and sensors etc.

A. PSEUDO-BJT BASED RETINAL FOCAL PLANE SENSING SYSTEM:

In the 21st century Pseudo -BJT based retinal focal plane Sensing system utilized the concept of adaptive Schmitt Trigger to improve its efficiency and to remove the existing technical drawbacks. This modified system provides instant image processing, front end processing and high dynamic range. It is aptly applied to mimic parts of the cell in the outer plexiform layer of real retina.

This system also performs well in Character readers, bar code, robot vision and image tracing by utilizing the concept of Silicon retinal structure. With the latest technology in electronics system Human Visual System functions or its partial functions can be attained to enhance the capability of instant image processing System. Secondly highly accurate motion sensing chip can be designed by Silicon retinal structure. This structure replaces electrical Resistance by MOSFET to save the occupied area. Pseudo-BJT Technique is also useful for the manufacturing of CMOS. Adaptive Current Schmitt Trigger enhances the noise immunity of the circuit. This proposed Pseudo-BJT focal plane Sensor works in the Sub-Threshold region. Compared with BJT based retinal Sensor Circuit devoid of adaptive Schmitt Trigger, the power consumption of this invention is far less.

B. APPLICATION OF SCHMITT TRIGGER IN SRAM CELLS

Due to migration of Computer workstations to hand-held devices that need real time performance within the budget for physical size and energy dissipation, the demand for low power devices has increased tremendously in recent years. Due to this battery operated portable applications such as PDAs, Cell phones, laptops and other hand-held devices are growing fast. So for digital Circuits and applications, power reduction is becoming an important design issue.Schmitt Trigger based SRAM Cells has been proposed to reduce the power consumption of SRAMs operating at low voltages.

PROPOSED SRAM CELL USING LOW POWER SCHMITT TRIGGER IN SUB-THRESHOLD REGION

6T SRAM has the advantage of very less area. But it suffers from instability problem during read and Write operations. Compared to the 6T Cell architecture, the proposed SRAM Cell requires no architecture change. Only difference is that the proposed Schmitt Trigger pair replaces the cross coupled inverter pair as shown in the figure1.

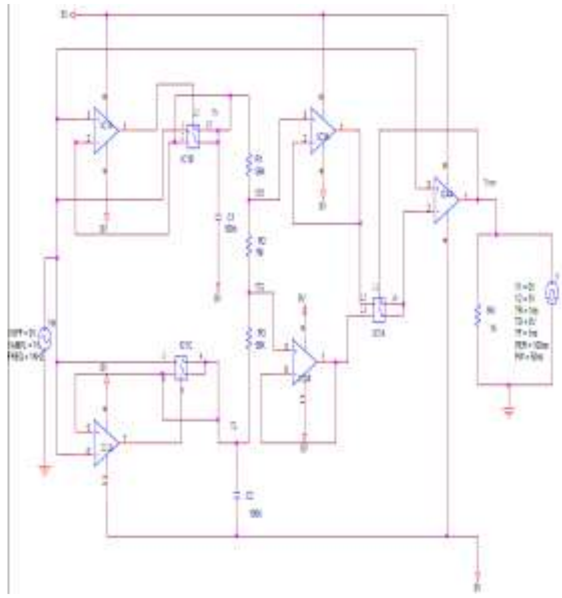

Fig 1. Circuit Diagram of SRAM Cell using low power Schmitt Trigger

It can be used as the drop in replacement for 6T Cell. The modified Schmitt Trigger based SRAM Cell consumes less power.

CIRCUIT SIMULATION ANALYSIS & RESULTS

Fig 2 shows the response of circuit to the very small input Signals. In this, the source signal is a 100 Khz sine wave riding on a DC level of 400mv at around 30Mv P-P. Some jitter in the output signal is resulted due to the presence of switching spikes in the input Signal if implemented on less than perfect breadboard.

It is to be noted that the Circuit can handle different signal amplitudes that vary by as much as two orders of magnitude provided the input signal remains with the common mode range of the comparators and the buffer(in this case, around 0 to 4V).

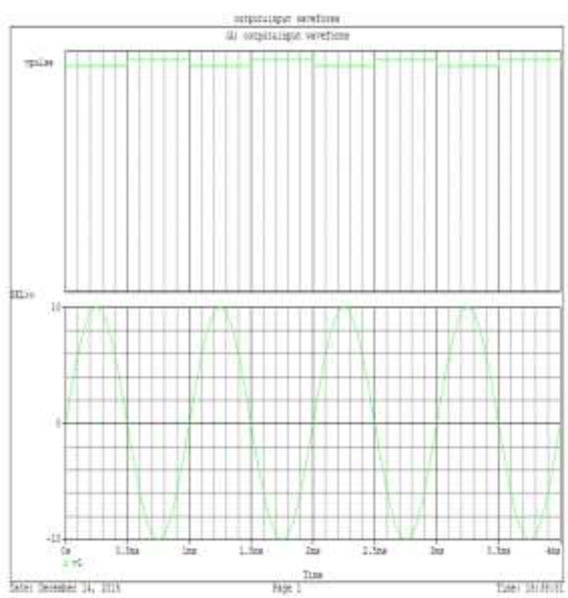

Fig 2. Simulation Result

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If the Signal's DC Level is outside the input Common Mode range then only the AC Coupling is required. According to the suitability of anticipated frequency rang C1 & C2 are to be chosen. For frequencies above 300hz or so, the values of around 100nF are suitable.

Below this level, to prevent excessive delay ripple appearing on Vu & Vl, the sampling capacitance should be increased.

The TTL3702 comparators work well up-to 100Khz, but you may need faster devices beyond this level. It is to be noted that the Capacitor C1 take a gulp of charge from the input when the positive peak detector samples the input signal only the On-resistance of IC2B limits the associated current that flows from the input.

On the negative peaks with C2 and C2 the same process occurs on the negative peaks. These current pulses can produce spikes in the input signal which can lead to erratic triggering, if the input source impedance is significant. Therefore, to avoid these problems, it may be necessary to buffer the input signal.

CONCLUSION

The circuit should prove useful for the cases when the fixed thresholds of the conventional Schmitt Trigger are not suitable but it is not a panacea for all Triggering applications. The circuit is simulated and analysed using Pspice software. Using Schmitt Trigger, buffer generates a fast, noise free input signal to the FPGA. Addition of Current Hysteresis in the retinal Sensor system eliminate noise disturbance.

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