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Implementation of FinFET based 14T SRAM Memory Cell using Modified Lector Technique & Dual Threshold

Ramesh Gullapally[1], Dr. N. Siva Sankara Reddy[2], Dr. P. Chandra Sekhar[3]

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Abstract: Static Random Access Memory (SRAM) can't become any smaller because to the sorts of materials and leakage testing used in today's large-scale silicon MOSFETs. This study uses a double edge and modified LECTOR method to create new tradeoffs in 14-semiconductor SRAM cells. Because of their outstanding transportation capabilities and the possibility for usage on large-scale processing and production, FinFETs are great replacements replacing outdated CMOS electronics. This test especially investigates a double edge value-based SRAM cell design. There are 14 semiconductor materials used in the design. According to the simulation's findings, FinFET-based circuits are more energy-efficient and reliable than scaled circuits. They are more susceptible to variances and flaws nevertheless. These findings suggest that in terms of power efficiency, FinFETs are far superior to CMOS.

Keywords: *CMOS, Dual Threshold, FinFET, SRAM*.

I. INTRODUCTION

The shrinking of semiconductor devices has been shown to be the most effective method for accomplishing electronic development in terms of speed, cost, power dissipation, and semiconductor utilisation. Gordon Moore, an individual Intel supporter, made the earliest prediction of the renowned Moore's Law in 1965. He said that the quantity of semiconductors on a chip would double every 2 years. The semiconductor sector has seen significant transformation recently. By shrinking the separate components, more semiconductors may now fit on a single chip. Due to Moore's Law's reduction in semiconductor size, Metal Oxide Semiconductor Field Effect Transistors (MOSFETs) is an necessary component of the technology utilised in Very Large Scale Integration (VLSI). The MOSFET's size decreased during the previous 20 years, falling from a few microns to 32 nanometers. There are certain issues that start to impact how effectively MOSFET devices function as the pieces grow smaller. These issues include voltage loss in the capacity, channel-induced resistance decrease, and short channel effects. The quantity of undesired current grows more quickly as the doorway coating's thickness decreases, requiring more power and slowing down operation. There are certain flaws in some components that are not exactly the same as MOSFETs in the smaller-scale realm of nanotechnology. Scientists have been researching novel nanotechnology devices including FinFETs, Silicon on Insulator (SOI) MOSFETs, Carbon Nanotube Field Effect Transistors (CNTFETs)[1], & Graphene Nanoribbon Field Effect Transistors (GNRFETs) in the recent years to learn more about these issues [2,3].

Additionally, semiconductor memories are regarded as the fundamental microelectronic components of electronic reasoning structure plans, such as PC-based applications. All modernised systems require the storage of large amounts of cutting-edge information, which semiconductor memory displays are excellent at handling. Limit work requires a greater quantity of semiconductors than logic exercises and other uses, while the proportion of memory required in a given structure depends on the type of usage. The constant increase in need for large limits has pushed memory and production advancements towards larger data accumulating densities. The single chip read/write memory limit for commercially accessible VLSI circuits has showed up at 1 GB, and on-chip memory groups have become widely used subsystems. The semiconductor memory is often organised according to the kind of data access and storing[4-5]. Data bits put aside in the memory show should be distinguishable, as well as their interest in restoration, in examine/create memory or Random access Memory (RAM). The reserved data is inconsistent. SRAM's fast speed and low power consumption make it ideal for holding chip memory, worker PC connections, workstation architecture, and controlled device management. Memory cell manufacturing uses semiconductors. Moore's law predicts that as time goes on, a single chip will use an increasing number of semiconductors. Even if they have

[1]*Research Scholar, Department of Electronics and Communication Engineering, University College of Engineering, Hyderabad, ramesh.gullapally@gmail.com.*
[2]*Associate Professor, Department of Electronics and Communication Engineering, Vasavi College of Engineering, n.sivasankarreddy@staff.vce.ac.in.*
[3]*Professor, Department of Electronics and Communication Engineering, University College of Engineering, Hyderabad, sekharpaidimarry@gmail.com*

less leakage, faster mobility, and fewer semiconductors, they lose their usefulness when the area shrinks below 32nm. general progress Information on recent developments and examples is provided through the roadmap for semiconductors (ITRS)[6-7].

To address execution concerns, a state-of-the-art method for storing electronic data on chip is required because tip top VLSI chips are present. The ideal choice for this type of operation is SRAMs. A vital component of many different kinds of microelectronic devices is SRAMS. The desire for smaller memory-storing devices comes from consumer demand[8–10]. Scaling growth advances introduce new problems related to the use of sub-10nm MOSFETs in VLSI CKT designs, including the incapacity to handle variation and the rise in semiconductor spillage. Scaling has emerged at a basic apogee, where the overflowing streams have become a notable regression. These findings need the development of a universal FET. These needs were practically addressed when graphene was discovered[11–12].

Silicon-on-insulator MOSFET, SiGe MOSFET, Double Gate, MOSFET carbon nanotube FET, low-temperature, even quantum dot device & CMOS are some of the new device topologies for next-generation technologies that have been presented [13]. Issues with lithography and performance gain are the focus of these designs. Because of their ideal device features under the electrical connection of the 2gates and their compatibility with conventional CMOS technology, SOI & DG are the most intriguing of them all [14].

II. 12T SRAM Cell

By eliminating the charge dispute caused by the input configuration of an SRAM cell, the proposed 12T piece cell in [29] greatly improves the compose edge. Its inherent structure obstructs the force supply path, allowing for solid action during composition. Since there is no charge dispute, there is no need for measurement; pull-up gadgets can be measured many times more than draw-down gadgets for adjusting the VTC (Voltage Transfer Curve) of consecutive inverters. Additionally, since the proposed structure has no measuring limitations, any gadget can be estimated by a specific presentation necessity. The VTC of the suggested cell in WSNM (write static noise margin) is nearly identical to the ideal bending recommended in Section 1 due to the criticism of free building during compose. The 12T cell is more resilient than the conventional 6T and 8T cells & is comparable to the 10T cell in three different interpretations of compose edge, such as WSNM. Furthermore, the suggested 12T cell provides more power stability than the 6T, 8T, and 10T cells. In this way, the proposed cell obtains a bigger WSNM without compromising RSNM (read static noise margin). The recommended 12T cell could be utilised for very low force applications that require low voltage operations and a slightly low limit because the memory block's space is suitably tiny. Furthermore, a WSNM logical model for the 12T cell is proposed. Although the super-limit model fits within 8.7% of errors, the subthreshold model fits within 14.2% of errors. When β percentage ranges from 1 to 5, the subthreshold model fits within 15.42% errors, while the super-edge model fits within 6.17% errors[30].

In the paper [28], creators propose two fourfold cross-coupled hook based SRAM bit-cells for profoundly solid earthly applications. Contrasted and the greater part of the thought about SRAM cells, the proposed FINFET 10T and 12T have practically identical or better delicate blunder resilience, RSNMs, and HSNMs at ostensible inventory voltage. As to the strength, the FINFET 10T and 12T are about 2× and 3.4× the base basic charge of the customary 6T separately. Notwithstanding, the FINFET 10T highlights a high compose blunder rate in close to edge voltage area, which implies it can't be utilized in low voltage applications despite the fact that it has high understood dependability. What's more, the FINFET 10T has equivalent or lower region overhead contrasted and the majority of the considered cutting edge delicate mistake lenient to SRAM bit-cells. Thus, the FINFET 10T is a decent decision for profoundly dependable high-thickness earthly applications at ostensible stockpile voltage. FINFET 12T displays about 56% region and half spillage power punishments over the customary 6T. Among the large variety of other cells that nearly have no compose disappointment around there, the FINFET 12T has, without a doubt, the best understood edge (aside from the 8T) in terms of the μ/σ proportion in the close to limit voltage district. Moreover, it saves more than half the read admission time in comparison to most reference cells, including the 6T. The proposed FINFET 12T is a promising candidate for future exceptionally solid earthbound low-voltage applications when the 3 challenges of applying close/subthreshold voltage in SRAM plans—diminished read steadiness, expanded compose blunder rate, and expanded postponement—are taken into consideration. Furthermore, the FINFET structure could be used to plan delicate mistake lenient hooks, back & forth, or registers, just like DICE & Quatro.

The authors report a new, highly reliable 12T cell with decoupled read & write ports in the publication [27]. The suggested has been demonstrated to have ordinary capacities and delicate error resistance in the recreation outcomes. The suggested 12T has the largest RSNM when compared to the vast range of other bitcells, & it also generally saves 85.4% read admission time. Furthermore,

it has a 42.2% leakage power penalty above the standard 6T. Taking these results into consideration, the suggested twin port 12T makes sense for quick and incredibly dependable applications.

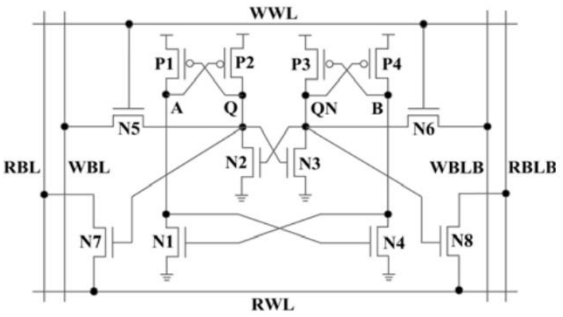

Fig. 1 12T SRAM cell

A tale RHPD (Relative Hybrid Placement Device)-12T memory cell with excellent constant quality and speed was recently proposed by IN [34–35]. In addition to performing better in circuits at high repetition and low force supply voltage, the recommended RHPD-12T cell can endure any single-hub upset when compared to other radiation-solidified memory cells. Given its superior hold and composition edge over a range of other cells, RHPD-12T is a good option for SRAM schemes that require speed and high consistency. Furthermore, it has the ability to reduce access times for all referential cells—including the DICE cell—by more than 40%. Its good composition capacity may be maintained even in close-limit voltage regions. Because it is anything but a fair balance between radiation power & CKT execution, the suggested RHPD-12T cell shown in Fig. 1 may be considered a decent design for aeroplane applications. The circuit level solidifying approach is introduced to offer a 12T SRAM cell that is delicately mistake-forgiving. The proposed design can recover at any sensitive hub from "0" to "1" as well as "1" to "0" mistakes. The proposed engineering is more robust against small faults than the current radiation hardening memory cells since it reduces the total number of sensitive hubs from four to two. Because of the decrease in the absolute sensitive region, the recommended cell is the best choice for SRAM cells to be utilised in the radiation climate.

GENERAL LECTOR APPROACH

Narender Hanchate et al. presented a revolutionary technology named LECTOR (Shown in Fig. 2) for lowering leakage power in CMOS circuits, which is the generic Lector approach. He added a PMOS & a NMOS leakage control transistor (LCT) to the logic gate. Each LCT's gate terminal is governed by the source of the other LCT. For each input combination, one of the LCTs in this configuration is always close to its cutoff voltage. Leakage currents are significantly reduced as a result of the route from Vdd to ground having more resistance. This method reduces leakage more efficiently and is effective in both the active and inactive stages of the circuit. For MCNC "91benchmark circuits, the experimental findings show an average leakage reduction of 79.4%.

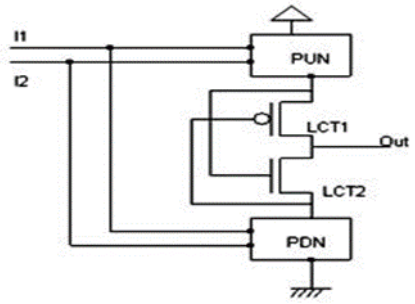

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Fig. 2 LECTOR technique

III. PROPOSED 14T SRAM CELL

Lastly, the common 6T SRAM cell is used in CMOS enhancement as a core storage element & a fundamental part of PC design and development. Read/make fight, half-select unsettling impact, & read upset are seen, despite the fact that the immediate construction of 6T SRAM with a massive breaking point limit has accomplished its expected function [14]. Standard Si-CMOS SRAM cells' poor stock voltage dependability is actually inconvenient since it completely deteriorates under the impact of supply voltage scaling.

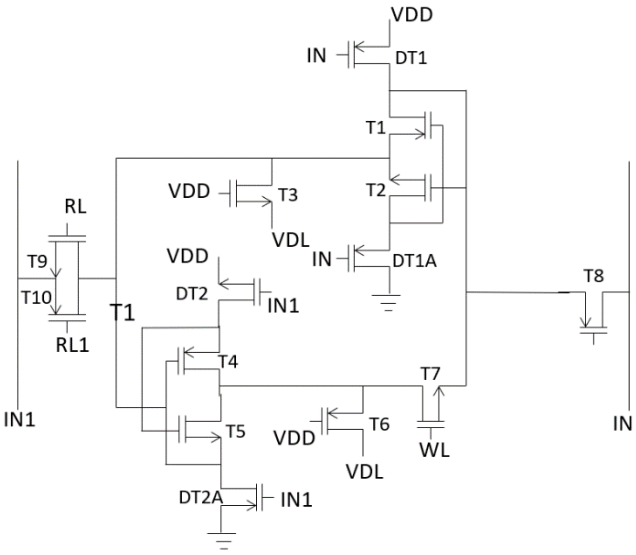


Fig. 3 Modified Lector Approach and dual Threshold with 14T SRAM cell

due to Vmin's requirements [15]. Lastly, the common 6T SRAM cell is used in CMOS innovation as a primary storage component & a crucial part of PC topologies and architectures. While 6T SRAM's immediate arrangement and high breaking point limit serve a useful purpose, they can also lead to read/make conflicts, half-select issues, and

read upsets [14]. Because supply voltage scaling and its show impact are caused by VMIN requirements, standard Si-CMOS SRAM cells are essentially unstable at low stock voltages [15]. Working on the bravery and execution of low force SRAM plans at low store voltage has been recommended by a number of specialists [15–18]. Read security in different SRAM cells can be enhanced by utilising read maintains, which basically update the read stream and render the completed read SNM (Static Noise Margin) identical to hold SNM [16–18].Refreshing the strength of pull down to pass entryway & surrender entrance to pull freely is used in the SRAM cell investigation and structure support frameworks with isolating with covered digit line, negative-VSS & word-line-under-drive for boosting read tasks & negative-cycle line, word-line-over-drive & transient-voltage-breakdown for boosting work out [19–21]. The read security of a proportional SRAM cell is achieved by strengthening pull-down with a single read port, hence reducing read upset [22]. Even yet, read disturbance is reduced by the information system, which also provides a fundamental boost in consistency by keeping the phone from drawing attention from the read bitline. Gliding focal point storage is triggered by NMOS semiconductors, and this can lead to delicate mess and other cell instabilities. It also impacts spilled current in the subthreshold region [23]. By utilising the piece interleaving plan with error check and modification, the distinct cells upset may be limited [24]. The chosen wordline (WL) conduct pseudo read development that is dependent on Noise margin makes the conventional 6T SRAM cell invalid for digit interleaving structures [24–25]. Cross-point make planning on both line-based and segment-based wordline (WL) structures can be used to reduce the effect of make half-select upset, which degrades writeability. This research proposes a revolutionary single-finished marvel-free 14T SRAM cell with a finFET base that runs near the limit voltage zone at a low stock voltage. By employing cross-point access, read cushion for increased read reliability, single bitline for thickness increase, and power savings, the proposed cell resolves the create half-select issue.

A twofold limit voltage approach is helpful in a functioning strategy for activities because it decreases power consumption and spillage current in the inactive condition. The SNM of the cell with the low voltage limit (LVT) gadgets is higher than that of the cell with the high voltage edge (HVT) gadgets. This is how a typical SRAM cell organises its voltage decision-making process quickly [26–27]. The low limit voltage cell can withstand greater disruptive blows than the cell with high edge voltage. In low spillage FinFET development, it is essential to determine the device's stock voltage under 0.5V, 16 nm, in order to increase the force utilisation in the proposed SRAM architecture. The low leakage FinFET-based SRAM design, based on 16 nm technology, simplifies the 325 mV stock voltage.

T10 semiconductor is mostly used to reduce the CKTs conveyance-way problem because it drives with manufacture line. T10 will turn on exactly when the make line is ready. This means that for this test, I have to focus on two things. To begin with, I have to use T10, which is reliable for standard 6T and 8T SRAM cells. The second to employ a two-edged structure. The appearance and strength of the common 6T SRAM are deteriorated by the read/make struggle. In order to isolate the make bitline from the read bitline and decrease read upset, an additional read line (WL) is needed in an 8T SRAM cell. The structural line (WL) affects the half-select problem when interleaving regions and taking charge directly from bitline into the internal focus of the 8T SRAM cell. The number of memory cells in the bitline increased, making the half-select problem more difficult to solve. An helpful procedure for considerably lowering the force distribution in the SRAM memory cell is a particular finishing technique. It also greatly minimises leakage current and chip plan region. This one-sided approach may reduce the one component of the amazing dynamic. It taints the SRAM cell's acquaintance with the level of production delays and inspection at low stock voltage, nevertheless. To overcome these obstacles, it was advised to use unmistakable analyse and build assistance approaches such examination unequal read/structure support ,read/make support,cross-point information caution, double edge voltage, and force support. In this work, we present a novel FinFET-based single-finished 14T SRAM cell. The schematic CKT diagram of a typical single-finished, clash-free 14T SRAM cell design is shown in Fig. 3. To store focus Q and Qn data, the proposed cell has 2 cross-coupled inverters, inv1 (T2 &T1) & inv2 (T4 & T5). A different read/structure port (T5-T9) might enhance the demonstration of the 9T SRAM cell. When comparing the new 14T SRAM cell to an 8T SRAM cell with minimal area overhead taking bound read port (T7, T8, and T9), there are 2.8 more identified miracle impediments. To maximise the SRAM cell's strength and facilitate further development, the structure port's semiconductor assessment degree (T5/T9) has been raised to 1.8. The goal of the piece interleaving technique is to handle the delicate confusion while lowering coupling complaints. The line section pick line, which uses a huge number of cells on piece line, is used to boost bunch capacity and decrease region overhead.

Static Random Access Memory is known as SRAM. It has uses in router buffers, hard disc buffers, workstations, routers, CPU cache, and routers. SRAM has the benefit over DRAM in that it does not need to be refreshed on a regular basis. It is also volatile, meaning that once the

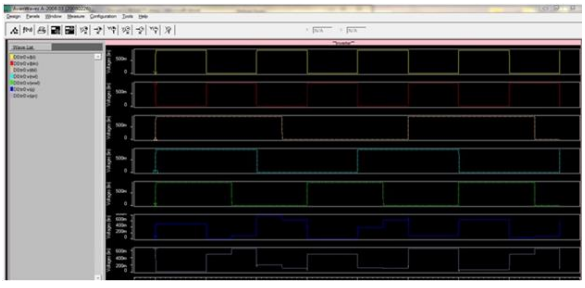
power is switched off, the data is gone. 2 PMOS & 4 NMOS transistors are used to construct a 6T SRAM cell. The circuit design of a 6T SRAM cell is understandable from fig. 3. The read, write, & hold states allow us to classify SRAM activity. Bit lines BL' & BL are raised to Vdd or the appropriate levels during write operations, and WL's voltage is increased. The updated bit line value takes precedence over the previous one. When the WL voltage is raised during read operations, the memory cell discharges either BL' or BL, b Every bit in a SRAM is keep on 2 cross-coupled transistors; these transistors form a storage cell with 2 stable states, which act as symbols for 0 & 1. 2 additional access transistors regulate access to the storage cell during read & write operations. Vdd, or left floating, while the voltage in WL is maintained low during the hold state.

IV. RESULTS

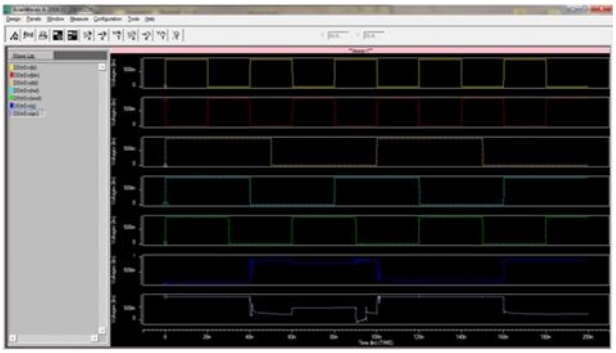
HSpice has been used to simulate the suggested design. FinFET and CMOS have both been used to emulate the dual threshold concept. A comparison of the FinFET and CMOS SRAM cell is shown in Table 1, using the FinFET demonstrating a significantly lower power consumption than the CMOS. The waveforms for CMOS and FinFET, respectively, are displayed in Figure 4. The overall technical parameters are displayed in Table 2.

Table 1: FinFET & CMOS Comparison with 14T 1- bit SRAM Cell

S.No.	nm	CMOS Power in mW	FinFET Power in mW
i	22	6.080	3.570
ii	14	5.320	3.280
iii	10	5.760	2.670
iv	7	5.680	2.530



(a)



(b)

Fig. 4 (a) In Hspice show FinFET Waveforms (b) In Hspice show CMOS Waveforms

Table 2: Parameters of Technology

S.No.	Parameter	VALUE
1	Avg-power	3.5702E-05 from= 0.0000E+00 to= 2.0000E-07
2	Avg-pwr	3.5989E-05 from= 5.0000E-09 to= 2.0000E-07
3	q_rise_delay	1.6266E-11
4	trig	4.4786E-11
5	q_fall_delay	3.8400E-11
6	tpd	2.7406E-11
7	targ	7.2486E-11
8	Supply-current	1.5602E-05 from= 0.0000E+00 to= 1.0000E-08
9	Static- power	-7.8011E-06
10	High to low total energy	3.8728E-14
11	Low to high total energy	3.9283E-14
12	Dynamic-energy	7.8011E-14
13	Avg dynamic energy	3.9005E-14
14	SNM	6.3845 E-01

V. CONCLUSION

By performing this research we have analyzed FinFET characteristics properties, manufacturing complexity and behavior in various VLSI circuits and to prove how FinFET is a better solution to replace existing MOSFET and CMOS technologies in terms of area, power, delay, voltage, device process variations and leakage current. In comparison to CMOS, the power has been reduced by up to 60%.

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