International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 04 | Apr 2023 www.irjet.net p-ISSN: 2395-0072

Circuit Approaches for VLSI in Internet-of-Things Applications: A Review

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Abstract - *Very-Large-Scale-Integration (VLSI) Circuit Techniques play a significant role in the development of the Internet of Things (IoT) devices. The IoT is a network of devices that are connected to the internet, enabling them to collect and exchange data. The data collected by these devices can be used to make informed decisions and automate processes. VLSI Circuit Techniques refer to the methods used to design and manufacture integrated circuits (ICs) that can be used in IoT devices. SoC is a technique used to integrate all the components of a system into a single chip. This technique is used in IoT devices to reduce the size of the device, lower power consumption and increase efficiency. IoT devices are often battery-powered, and as such, low power consumption is critical. Low-power design techniques such as voltage scaling, clock gating, and power gating are used to reduce power consumption in IoT devices. RF design is essential in IoT devices that use wireless communication. RF design techniques such as low-noise amplifiers, power amplifiers, and frequency synthesizers are used to design wireless communication circuits for IoT devices. IoT devices often require the integration of analog and digital circuits. Mixed-signal design techniques are used to integrate analog and digital circuits in a single chip. Testing and Verification techniques are used to ensure that IoT devices meet the required specifications. These techniques are used to detect defects and ensure that the device functions correctly. VLSI Circuit Techniques play a significant role in the development of IoT devices. These techniques are used to design and manufacture integrated circuits that can be used in IoT devices. The use of these techniques has enabled the development of smaller, more efficient, and low-power IoT devices.*

Key Words: VLSI, IoT based, Performance, VLSI Circuit, Integratred Circuit.

1. INTRODUCTION

The development of VLSI circuits has been one of the major driving forces behind the growth of the computer industry. The first integrated circuits were developed in the 1950s and 1960s and contained only a few transistors. However, advances in semiconductor technology made it possible to fabricate ICs with thousands, and later millions, of transistors on a single chip. This allowed for the development of microprocessors, which are the heart of modern computers.

The design of VLSI circuits involves a complex set of steps, including design specification, logic synthesis, physical design, and testing. Design specification involves defining the requirements of the circuit, such as its function, performance, and power consumption. Logic synthesis involves converting the design specification into a logic circuit, which can be implemented using a hardware description language (HDL) such as Verilog or VHDL.

Physical design involves mapping the logic circuit onto a specific chip layout, which involves optimizing the layout for performance, area, and power consumption. This step involves a range of techniques such as floor planning, placement, routing, and timing analysis. The final step is testing, which involves verifying the functionality and performance of the fabricated chip using a range of techniques such as functional testing, performance testing, and fault testing.

One of the main challenges in designing VLSI circuits is power consumption. As the number of transistors on a chip increases, so does the power consumption. This can lead to issues such as heat dissipation and reduced battery life in portable devices. To address this, designers use a range of techniques such as low-power circuit design, power gating, and dynamic voltage and frequency scaling (DVFS). These techniques can reduce power consumption without compromising performance or functionality.

Another challenge is design verification, which is the process of ensuring that the design meets the specification and is free of errors. As the complexity of the design increases, so does the complexity of verification. This has led to the development of a range of techniques such as simulation, formal verification, and emulation.

In addition to design challenges, VLSI circuits also face manufacturing challenges. The fabrication of ICs involves a complex set of steps, including lithography, doping, etching, and metallization. These steps must be performed with high precision and accuracy to ensure that the resulting chips are functional and reliable. Manufacturing defects can lead to reduced yield, increased costs, and reduced reliability.

To address these challenges, designers and manufacturers use a range of tools and techniques such as computer-aided design (CAD), process simulation, and process control. These tools and techniques can help to optimize the design and manufacturing process, reduce costs, and improve yield and reliability.

VLSI circuits are used in a wide range of applications, including microprocessors, memory chips, communication devices, and digital signal processors. Microprocessors are used in computers, smartphones, and other electronic devices to perform complex computations and run software applications. Memory chips are used to store data and program code, while communication devices are used to transmit and receive data over networks. Digital signal processors are used in audio and video processing applications.

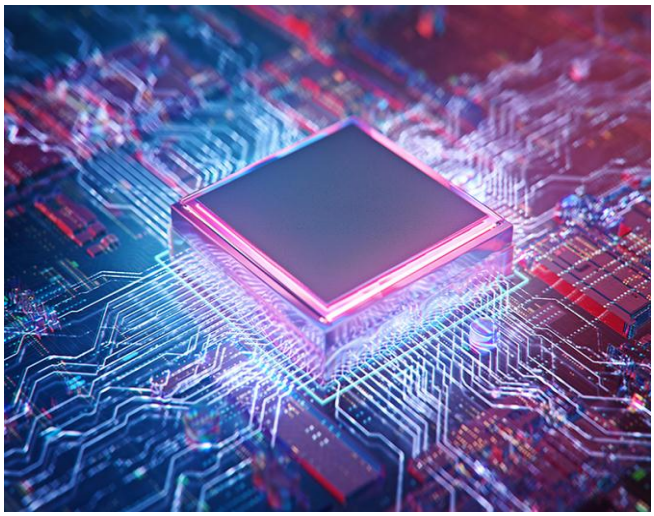

Figure-1: VLSI Circuit

1.1. Principle of VLSI Circuit

The principle of VLSI circuit design involves the following steps:

1. **Specification:** This involves defining the functionality and performance requirements of the circuit.
2. **Architecture:** This step involves selecting the appropriate architecture and system-level design for the circuit based on the specifications.
3. **Logic Design:** This step involves the implementation of the circuit using logic gates and designing the interconnection between the gates.
4. **Circuit Design:** This step involves designing the individual transistors and other components that make up the circuit.
5. **Layout:** This step involves arranging the components on the chip and designing the interconnects between them.
6. **Verification:** This step involves testing the circuit to ensure that it meets the specified performance and functionality requirements.
7. **Manufacturing:** This step involves the fabrication of the circuit on a silicon wafer using various processes such as lithography, etching, and deposition.

The principle of VLSI circuit design is to optimize the circuit for performance, power, and area while minimizing the cost and time-to-market. This requires a deep understanding of the underlying technology and a systematic approach to design and verification.

1.2. Purpose of VLSI Circuit

VLSI circuits are used in a wide range of electronic devices, including computers, smartphones, digital cameras, and many other consumer electronics products. They are also used in industrial and scientific applications, such as automotive systems, aerospace systems, medical devices, and telecommunications equipment.

The primary benefits of VLSI circuits are that they enable the design of more powerful and versatile electronic devices with smaller size and lower power consumption. This has led to the development of many new technologies and products that have transformed the way we live and work, and continue to drive innovation in the electronics industry.

1.3. Advantage and Disadvantage of VLSI Circuit

VLSI (Very Large Scale Integration) circuits are electronic circuits that contain a large number of transistors, diodes, resistors, and other electronic components integrated onto a single chip. VLSI circuits offer several advantages and disadvantages, which are discussed below:

Advantages:

1. **Size:** VLSI circuits are very small in size, which makes them ideal for use in portable electronic devices such as smartphones, tablets, and laptops.
2. **Power Consumption:** VLSI circuits consume very little power, making them ideal for battery-operated devices.
3. **Reliability:** The integration of a large number of components onto a single chip reduces the number of interconnections, which in turn reduces the chances of failure due to a loose or faulty connection.

4. **Performance:** VLSI circuits offer high-speed performance, making them ideal for use in high-speed computing applications such as graphics processing, artificial intelligence, and machine learning.

5. **Cost:** VLSI circuits can be manufactured at a lower cost than discrete electronic components, as the manufacturing process is automated and requires less labor.

Disadvantages:

1. **Complexity:** The design and fabrication of VLSI circuits are complex and require a high level of expertise, making them more expensive to design and develop.

2. **Fabrication Process:** The fabrication process for VLSI circuits is highly specialized and requires expensive equipment and clean room facilities, making it difficult for small companies to enter the market.

3. **Testing:** Testing VLSI circuits is difficult and time-consuming, as the circuits are highly integrated and any failure in one component can affect the entire circuit.

4. **Heat Dissipation:** VLSI circuits generate a lot of heat, which can cause reliability issues and limit their performance.

5. **Vulnerability:** VLSI circuits are vulnerable to electromagnetic interference (EMI) and radiation, which can cause data corruption and affect their performance.

2. FULLY-INTEGRATED POWER MANAGEMENT CIRCUITS

Fully-integrated power management circuits are electronic circuits that are designed to manage the power consumption of a system. These circuits are integrated into the same chip or module as the rest of the system components, such as the microprocessor, memory, and input/output interfaces.

The primary function of power management circuits is to regulate the power supply to the various components of a system, so that they receive the correct amount of voltage and current for proper operation. These circuits can also help to conserve power by shutting down or reducing power to components that are not in use.

Fully-integrated power management circuits can include a wide range of functions, such as voltage regulators, power-on reset circuits, battery chargers, and voltage monitors. Some of the key benefits of these circuits include increased efficiency, reduced power consumption, and improved system reliability.

Overall, fully-integrated power management circuits play a critical role in the design of modern electronic systems, helping to ensure that they operate reliably and efficiently while minimizing power consumption.

3. LITERATURE REVIEW

The purpose of a literature review is to identify gaps in the existing research, highlight the strengths and weaknesses of different studies, and synthesize the information to provide a coherent and well-supported argument. A well-conducted literature review can also help to identify areas where further research is needed.

Yammenavar, Gurunaik: This study aims to present a demonstration of a neural network that is constructed utilizing VLSI technology. This is the objective of the inquiry. The use of analog weights in conjunction with a refresh circuit is one method that may be utilized to achieve stable weight storage. In electronic scales, you'll often find this particular setup. Several neural networks make use of analog multipliers to realize synapses in their architecture. Even though the functions that were learned were analog, the network could be reprogrammed to take digital inputs and deliver digital outputs so that it could learn new functions. This would allow the network to learn new functions even though the functions that it had previously learned were analog. This would make it possible for the network to acquire new skills. Some instances of digital operations that have been effectively achieved via the use of network architecture are "and," "or," and "not."

Madhavi et.al: The rise in leakage power is made worse by the fact that deep-submicron and nanometer technologies need the reduction of device dimensions, supply voltages, and threshold voltages to achieve high performance and low dynamic power dissipation. As a direct consequence of this, overcoming the obstacle of power loss via leakage becomes an extremely tough issue to take on. When LCPMOS is used, there is only one LCT, and how it operates is determined by the output of the circuit itself. This is because LCPMOS is a single-chip technology. In terms of its capabilities to decrease leakage power without sacrificing dynamic power, LCPMOS is superior to other approaches for lowering leakage power, such as LECTOR, sleepy stack, and sleepy keeper, amongst others. This is because LCPMOS can reduce leakage power without compromising dynamic power. This is because LECTOR, sleepy stack and sleepy keeper each give up some of their dynamic power to reduce their overall leaking power. This is made possible by the fact that LCPMOS does not need any additional control and monitor circuitry, and in addition, the approach guarantees that the exact logic state will be preserved. This enables the task to be completed. Because of this, it is now feasible for this to

take place. The LCPMOS technique, when applied to generic logic circuits, has the potential to generate a reduction in leakage that is up to 80-92% lower than that of conventional circuits with equivalent functionality. This is in comparison to the potential reduction in leakage that can be generated by using the PMOS technique. This is accomplished without suffering any loss in the dynamic power's original state. There is a give-and-take connection between the area overhead and the propagation delay in this specific case. One must sacrifice one for the other.

Senthil: The objective of electrical design is to reach a state of balance in which the amount of performance that may be obtained in terms of speed is maximized while the amount of power that is required in the process is minimized as much as possible. Because the designers of VLSI circuits for low-power applications need to adhere to a large number of degrees of freedom to achieve an acceptable amount of power reduction, the design of VLSI circuits for low-power applications is a complex problem that can be approached from several different points of view. This is because to achieve an acceptable amount of power reduction, the designers of VLSI circuits for low-power applications need to adhere to a large number of degrees of freedom. A low power design flow has to find solutions to all problems that are associated with power consumption at every stage of the design process and abstraction level to achieve the maximum possible degree of effectiveness in terms of the amount of power that is used. This is very necessary to achieve the best possible efficiency in the use of electricity. This page provides detailed information on a variety of concepts and approaches that have been investigated, developed, and used in the past to cut down on the amount of leakage and dynamic power. The concepts and methods that are dissected in this body of work have the potential to be of significant assistance to designers who have been faced with the job of building low-power VLSI circuits. Applications that are transportable and of a medical nature are where you will most often come across the use of these circuits.

Indira et.al: The arithmetic and logical unit is an essential component in the design of digital circuits. Using the appropriate design approach is one method for reducing the amount of power that is used by the circuit, which is one way to lower the amount of power that the circuit needs. This piece of research presents a heuristic technique that makes use of a gravitational search algorithm as a way of minimizing the amount of power that is lost as a consequence of leakage in ALU circuits. This method aims to cut down on the amount of power that is wasted in ALU circuits. This method is provided as a means of reducing the quantity of power that is dropped throughout its use. Both 16-bit and 32-bit ALU input test combinations are carefully considered throughout the whole of the design process, after which they are written using the verilog coding language. This is done to develop the MLV to its full potential so that it can be used more effectively. The data make it possible to conclude that the GSA algorithm delivers better ideal test function results while simultaneously minimizing both the amount of leakage power and the number of repetitions that are required. When the statistics are taken into consideration, one may make this conclusion. In conclusion, a comparative analysis was carried out to provide proof that the layout is efficient. It was found that the results achieved by the design were superior to the results obtained by the Genetic Algorithm in comparison to the results obtained by Genetic Algorithm. This was determined by comparing the two sets of results. In the not-too-distant future, the developed method will have the ability to be expanded so that it can work with a 64-bit input vector set to provide the best possible MLV that can be accomplished. This will take place to ensure that the greatest possible results are obtained.

Kundan, Ankit: The mapping technique based on cell reordering that was presented in Chapter 4 demonstrated a large gain in terms of latency when compared to the Domino mapping method, which was mentioned earlier in this chapter. In addition, the area penalty that is applied all during the process of cell re-ordering is restricted to the bare minimum that is practically possible. This is done to avoid any unnecessary complications. In particular, the use of this tactic makes the design usable under conditions that call for high levels of performance. The decomposition-based method that has been presented here results in a lower number of transistors needed as opposed to the static CMOS logic type that has been offered. The study that was referenced elsewhere suggests that hybrid CMOS circuits may be compared to exclusively dynamic and completely static realizations. In addition, we may conclude that mixed CMOS circuits are perfect for high-speed applications that need very little power. Some examples of these applications are mobile phones, portable digital gadgets, and other similar products. The approach for gating the clock based on pattern recognition that was disclosed brought about significant savings in the amount of power that was used. The Domino block's clock signal is given a significant amount of focus in this chapter because of the crucial part it plays in the overall operation of the block. As a consequence of this, the entire design started to take on characteristics that were similar to those of several other low-power approaches that were described in the relevant research. As a result, the likelihood of the concept being used in a range of applications that make use of portable devices has increased. It is possible to further expand the capabilities of the decomposition methods so that they may be used for functions of the Boolean data type that are only partly defined. This revelation does, however, leave a lot of issues unsolved and problems that need to be addressed, which paves the way for this study to be continued and expanded upon in the future. While the raw mapping method was being used, the gates could only be considered to be of a "and" or "or" kind. Such capabilities have the potential to be

accounted for in the preliminary circuit mapping, from which an entirely new set of rules may subsequently be generated to govern combination operations. This would be done to ensure that all possible combinations are taken into consideration. While calculating the delay, it is also feasible to make use of notions such as the average case delay in terms of incompletely stated Boolean functions and the application of logical effort. Both of these concepts may be used in the process of calculating the delay. Also, a broad number of other ways for multi-objective optimization and choosing the best candidate from the Pareto optimal front might be researched. These strategies include: When you use the technique that we have offered, you will be able to optimize the clock gating logic in terms of switching power as well as area. Yet, the logic of the gates has a significant bearing on the amount of delay that the circuit displays. As a direct consequence of this, the performance measure may also be included in the analysis.

Megha et.al: This digital system, which is advantageous in all respects due to the support of optimization technologies, can be used to implement a method of getting things done that is both cost-effective and efficient. Because we prefer things to be done automatically with fewer human interferences as technology continues to advance at a rapid pace, this digital system, which supports optimization technologies, can be used to implement this method. This is because we like for things to be done automatically with as few interruptions from humans as possible. These benefits include a reduced consumption of power, a smaller area, a faster speed, a lower latency, a lowered delay, and enhanced frequency. There are a great many more advantages as well. This digital system has the potential to be used to put into action a method of getting things done that is not just efficient but also cost-effective. There have been serious efforts made, using EDA technology, to test out a variety of distinct approaches to the formulation of an optimization issue to find the optimal solution. For CAD tools to effectively penetrate low-end applications, it is quite probable that extra considerations, such as a more extensive optimization plan that takes into account the life cycle of the product, would be necessary. The significant amount of rivalry that exists in this particular sector of the market would make this a likely scenario. To do this, we are making use of an FPGA programming device that adopts a straightforward strategy for the whole design process. When it comes to the frequency of operation and the size of the device, the digital system designs that are utilized in VLSI technology are already on the approach of hitting saturation. This is because technology is becoming smaller and smaller. Because of this, the industry as a whole has begun to place a larger focus on developments that are based on architecture to combat this problem. The creation of superior digital solutions is now being afforded a window of opportunity that will never close. Technology in all of its many forms, including hardware and software, is in a state of continuous growth, and with this progress comes the introduction of new design trends across a broad variety of component types.

Ranjan et.al: The primary objective of this research is to demonstrate, through the use of pass transistor logic that is based on multiplexers, how one may design a full adder architecture that is distinguished by both high performance and low power consumption. This will be accomplished by demonstrating how one may design a full adder architecture that is based on multiplexers. This project has a secondary purpose that demonstrates how to achieve the primary target of the project. The whole adder notion that is being shown here is realized with the help of several different logics. SERF, PFAL, and ECRL are three of the logics that fall within this category; nevertheless, this list is not exhaustive. This was achieved in the work that is now being shown here in this location. In addition, the execution of the design takes the use of pass transistor logic in combination with other circuits to complete the process. This is necessary to do what has to be done. As compared to the number of transistors that are required to realize the design of a complete adder using CMOS by itself, the number of transistors that are required to realize the design of a full adder utilizing combined CMOS is a much lower quantity. Hence, putting fundamental reasoning into practice while yet clinging to an ideal is not an impossibility. In adiabatic logic design, I discovered that the quantity of energy that was converted was around forty percent lower when compared to the similar static CMOS design. This was a significant improvement. This enables the adiabatic logic architecture to work at a speedier pace when compared to the performance of a standard static CMOS full adder. This is made feasible because this makes it possible. A carry look-ahead adder that takes advantage of adiabatic logic was created in the second section of the thesis. As a result of this, it was possible to carry out a technique that was more effective than the design of the adder as a complete when taken into consideration as a whole.

Dharminder: This article also displays new and forthcoming technologies that are making advancements in the field of VLSI methodology and design, which is predicated on the research of VLSI design. First and foremost, familiarise yourself with the specific concept, which clarifies how the characteristics of certain knowledge systems, methodologies, and substructures influence the extent and rates of diffusion, creation, convergence, knowledge, integration, and displacement. If you want to have a comprehensive comprehension of the Mead-Conway method, the first thing you need to do is educate yourself on the particular concept. The process of designing VLSI is divided into several separate parts, and each of these parts is covered in some detail. This page contains views and studies on fundamental cognitive and social phenomena that occur throughout the theory formulation, testing, and theory revision processes that are involved in the design of design knowledge. These

activities are engaged in the design of design knowledge. The creation of design knowledge is said to entail certain steps, which are stated as being involved. As a direct result of our efforts, we now have the self-assurance and comprehension necessary to delve more deeply into the qualities of knowledge as well as the processes that contribute to its development. This was made possible as a direct result of the fact that our efforts have directly contributed to our success. As a direct result of this, we are analyzing the possibilities for the practical application of findings from computer science and artificial intelligence to the creation and execution of new concepts for knowledge engineering. Integration on a very large scale may be used to the solution of a wide range of issues in the field of electronics. The aforementioned text suggests a potential means by which one's total power level might be decreased. The issue of VLSI research and design technique is discussed in a great number of papers, and VLSI is one of the themes that are discussed in these articles. In addition, a large number of different strategies were used to address the complex issues that were existing inside the computer and electronics systems. The background of very large-scale integration (VLSI) was covered in detail in the book titled "The Layout of the VLSI Design Techniques" written by Lynn Conway. According to the information presented in the book, an investigation and research project entitled electronic circuit designs was initiated by a British scientist by the name of Carver Pear brandy in the early 1970s. Throughout this series, he discussed how large-scale work might be accomplished with the assistance of little chips. During this period, he also established the nMOS design business.

4. CONCLUSION

To increase the performance of a VLSI circuit, here are some general tips that can be followed:

One of the easiest ways to increase the performance of a VLSI circuit is to reduce its size. This can be done by optimizing the design of the circuit and reducing the number of components used. The use of advanced fabrication processes can also significantly improve the performance of VLSI circuits. These processes include technologies such as FinFETs, which provide better control over the flow of electrons through the circuit. Power consumption is a key factor that affects the performance of VLSI circuits. By optimizing the power consumption of the circuit, you can improve its performance. This can be achieved through the use of low-power design techniques such as clock gating, power gating, and voltage scaling. The clock speed of a VLSI circuit is another important factor that affects its performance. By increasing the clock speed of the circuit, you can improve its performance. This can be done by optimizing the design of the clock distribution network and using advanced clock generation techniques. Parallel processing is another technique that can be used to improve the performance of VLSI circuits. By using multiple processing cores, you can increase the processing power of the circuit and improve its performance. Signal propagation delay is another factor that affects the performance of VLSI circuits. By reducing the signal propagation delay through the use of advanced interconnect technologies and optimizing the routing of signals, you can improve the performance of the circuit.

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