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Power analyzer of linear feedback shift register techniques using built in self test

Kannadhasan Suriyan[1], Nagarajan Ramalingam[2], Kanagaraj Venusamy[3], Sathish Sivaraman[4], Kiruthiga Balasubramaniyan[5], Manjunathan Alagarsamy[5]
[1]Department of Electronics and Communication Engineering, Cheran College of Engineering, Anna University, Tamilnadu, India
[2]Department of Electrical and Electronics Engineering, Gnanamani College of Technology, Tamilnadu, India
[3]Control Systems Instructor, Department of Engineering, University of Technology and Applied Sciences-AI Mussanah, AI Muladdha, Oman
[4]Department of Computer Science Engineering, Sri Ranganathar Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India
[5]Department of Electronics and Communication Engineering, K.Ramakrishnan College of Technology, Trichy, Tamilnadu, India

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ABSTRACT

Wasteful patterns that don't lead to fault dropping squander a tone of energy in the linear-feedback shift register and circuit under examination in a random research region. Random switching actions in the CUT and scan pathways between applications with two consecutive vectors are another significant cause of energy loss. This study proposes a unique built-in self-test (BIST) technique for scan-based circuits that might help save energy. Only the available vectors are produced in a fixed series thanks to a mapping logic that alters the LFSR's state transitions. As a consequence, and without reducing fault coverage, the time it takes to execute trials has decreased. Experiments on circuits demonstrated that during random testing, the linear feedback shift register saves a significant amount of power.

Corresponding Author:

Kannadhasan Suriyan
Department of Electronics and Communication Engineering, Cheran College of Engineering
Anna University
Tamilnadu, India
Kannadhasan.ece@gmail.com

1. INTRODUCTION

The built-in self-test technology is used to monitor VLSI circuits, removing the requirement for extra research facilities. This technique allows several circuits to be tested online at the same time. The purpose of the proposed project is to build a logic module that stores input test vectors in static random-access memory SRAM cells and reduces switching operations, resulting in faster testing and lower concurrent test latency. The stated approach may be used with any kind of integrated circuit. Instead of requiring the circuit to be turned off, the input vector monitoring concurrent built-in self-test system monitors it while it is running. As a consequence, they may have difficulties similar to offline built-in self-test methodologies, such as longer testing periods and higher power consumption. The assessment criteria include the time it takes for the exam to complete in regular mode, as well as the hardware overhead and contextual teaching and learning. A concurrent built-in self-test (BIST) design for online research looked at the use of a static random-access memory SRAM-cell-like architecture for data storage, independent of whether or not an input vector emerged during regular circuit operation. For testing extremely large-scale integration VLSI loops, the suggested method surpasses the present system of concurrent built-in self-test techniques [1]-[5].

Every integrated circuit in the world follows Moore's law. Moore's law claims that every 1.5 years, the number of transistors in an integrated circuit doubles. Despite the fact that, thanks to recent technological developments, device sizes are reducing to the nanoscale, IC density and complexity are rising. This might result in a cascade of industrial failures and equipment failures. The device function size is lowered to allow a greater number of transistors. The amount of development flaws grows as feature sizes decrease, making fault identification more challenging. VLSI testing is getting more required and sophisticated as more devices are integrated on a large scale in order to confirm that they are running correctly. The prior ATE-based testing method can no longer keep up with the growing number of test difficulties. A number of scan-based systems use the logic built-in self-test as a testing approach. Because both automated test equipment and logic BIST may be used to review designs, both can be utilised to evaluate designs. Taking into account the dynamic thermal and electrical stress profiles of microprocessor systems when running real-world devices, a method for properly measuring microprocessor lifetime based on each wear out mechanism has been established.

This study also demonstrates how to link device-level wear out models, electrical stress profiles, temperature profiles, and the performance of both logic and memory blocks in the system. The influence of line ends on time-dependent gate oxide breakdown (BTDDB) was investigated and found to be important. Because these strange geometries may impair chip lifespan, they must be isolated separately and used in the durability simulator. The study identified the first component of a device that is more prone to failure, accounting for a variety of use scenarios such as the percentage of time the system is in use, the percentage of time it is in standby, and the percentage of time it is turned off. This gives information about memory endurance in real-life situations. Backend wear out processes are a major source of contemporary microprocessor durability issues [6]-[10]. Using a framework that integrates BTDDB and special immigrant visas SIV modules, this study investigates circuit design geometries and interconnects in order to accurately predict state-of-the-art microprocessor lifespan due to each mechanism. Electrical stress, temperature, line width, and cross-sectional areas of each connection are all taken into account by our system inside the central processing unit CPU.We look at a variety of designs using typical benchmarks to highlight life-limiting wear out processes as well as microprocessor functional units that are critical for dependability. This study presents a method for evaluating current microprocessor performance using simulation. When using conventional benchmarks, a technique for accurately forecasting microprocessor lifetime based on backend wear out processes is presented, which takes into account the microprocessor systems' complex thermal and electrical stress profiles [11]-[15].

The topologies that were created utilising the 32-nanometer laws were compared. Layouts are developed and documented in a systematic manner, taking into account transistor scaling and connector implementation. Simulations show how each design performs in terms of space, power consumption, read/write latency, and other factors. At 32 nm, a variety of 6T static random-access memory SRAM cell structure layouts and associated 16-bit arrays were designed and tested for size, power consumption, and read/write latency. In every instance, the thin cell structure was the best option. Although the ultrathin cell is lithographically superior than the thin cell, it comes at a significant cost in terms of space and power/delay efficiency, resulting in overall performance that falls short of typical systems. Despite having no effect on the SRAM design, global and local fluctuations, Negative-bias temperature instability (NBTI) have a significant influence on the 6T static random-access memory core cell [16]-[20]. This is because negative-bias temperature instability only affects the two pMOS pull-up transistors (NBTI). Furthermore, during the memory's hold state, the two triggers overlap, reducing the read stability of the cell. Cell losses were more than 30% at 100 mV NBTI and PBTI, resulting in threshold voltage drift on pull-up and pull-down transistors. An inadvertent write during a read cycle has the most devastating result of data loss. When a lengthy hold is followed by a read time and annealing isn't an option, BTI characteristics like distribution and annealing become crucial [21]-[25].

2. RELATED WORK

A linear feedback shift register sequence is a pseudo-random number sequence created often in the hardware form of the shift register. When a linear-feedback shift register (LFSR) is implemented in hardware, the previous stage's performance is utilised to evaluate the following stage, resulting in a recursive LFSR sequence. A hardware implementation of a LFSR is shown in Figure 1. The current state of each state cell is sent to the mod 2 adder in this L-length LFSR, which is implemented in hardware using an exclusive-or function. Because this is a move register, the status of the -state cell changes after each repetition (in this case, to the right). For each repetition, the output of the state cell preceding it is utilised to construct the next word in the sequence. A LFSR sequence for this piece of hardware might be designed using a mathematical model of a LFSR. Three pieces of information are required to complete this series. The main, secondary, and

primary algorithms are used to discover the next name in the list. The relationships between the state cells and the mod 2 adder govern how the outputs of the state cells are utilised as inputs to the mod 2 adder in the hardware implementation. The main also controls whether the LFSR series' previous words may be utilised to calculate the next word in the sequence. Even though the reference polynomial normally refuses, the key may be expressed as a vector C=[C_1, C_2,C_3...,C_L].

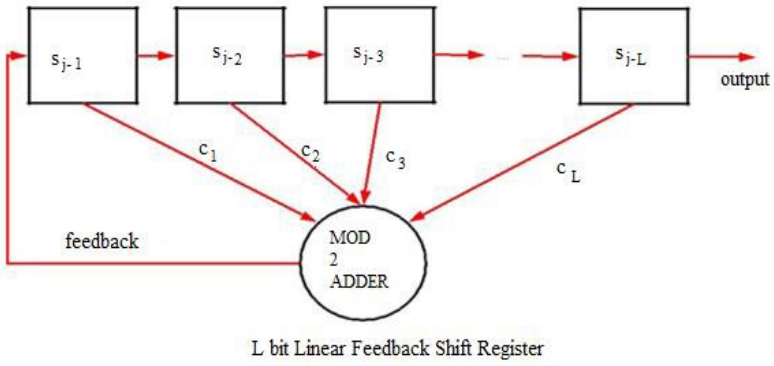

Figure 1. Bit LFSR diagram

$$C(x)=1+ C_1 x_1 + C_2 x_2 +C_3x_3 \dots + C_L. x_L \quad (1)$$

$$S_j=C_iS_j-i \bmod 2 \quad (2)$$

The coefficients (sometimes called ci's) are the most important. In Figure 1, the coefficients reveal which cells were utilised as modulo 2 adder inputs. The degree of the polynomial also determines the number of cells (or bits) required to produce the LFSR series with the shortest linear feedback shift register feasible. S0, S1, S2, S3... are the contents of the L stages in Figure 1. The initial contents of the L stages displayed in Figure 1 are SL1. According to Massey, the initial ll is a list of state cell start values. In the binary example, the recursion link removes the necessity for the LFSR sequence.

3. PROPOSED SYSTEM

As mobile computing and networking applications have risen in prominence, low-power VLSI devices have become a hot issue in circuit synthesis. In complementary metal oxide semiconductor (CMOS) circuits, the total amount of switching activity (SA) at various circuit nodes accounts for a large fraction of the energy needed during transmission. The capacitance of the circuit node, which is dependent on its fan-out and transistor implementation, multiplies the total number of 0 1 and 1 0 changes caused by the logic signals. The energy consumption of an IC during testing may be much higher than during regular system operation, causing excessive heating and circuit functionality loss. The battery life of a smartphone with average power optimization will be longer. Full power, whether continuous or abrupt, will result in excessive warmth or an unfavourable mood swing. Traditional BIST systems with surprising patterns use an excessive amount of energy due to the length of the research and the unpredictability of the following test vectors. Scanning operations will also use a substantial amount of resources. Built-in-self-test is a simple and cost-effective method of evaluating integrated circuit outputs. A chip feature examines all or half of the internal features of the chip. Customers may be able to benefit in certain instances. For example, the BIST framework is used to test the functioning of certain field bus networks.

Assume that the architecture self-tests using the BIST test-per-scan method. A modulo-m bit counter is used to count the number of scan movements, where m is the length of the longest scan thread. The LFSR wastes a lot of energy cycling through these meaningless patterns, even if they are stopped at the CUT inputs, since the number of advantageous patterns is known to be a minuscule percentage of all possible patterns. Changing test vectors in a pseudorandom study is similarly tricky. To save energy, the BIST design introduced in this paper prevents the LFSR from rotating through states that produce useless patterns and reorders the important test patterns into a desirable sequence.

The following are the stages in the suggested procedure: a LFSR provides a pseudorandom test series and forward and reverse fault simulation to find the single stuck-at fault coverage in the CUT; let S be

the test sequence up to the final essential vector beyond which fault coverage does not rise noticeably. Determine the number of unsuccessful S trends that do not result in fault removal. For all ordered pairs of test vectors in the limited range S_r=0, evaluate the swapping technique in the scan direction and the CUT. In Sr, rearrange the vectors to get the best possible outcome. As a result, it's feasible to save energy. Construct a new series S using the state table of the LFSR. Create a low-cost mapping logic to supplement the state transitions of the LFSR; the state transitions of the LFSR are modified under certain conditions for two reasons: to keep it from rotating between states and generating pointless patterns, and to reorder Sr to S; the LFSR behaves as expected under all other conditions. Figure 2 depicts a rudimentary MUX-based design that may be employed in this instance. Previously, LFSR states were overcome via a series of deterministic tests.

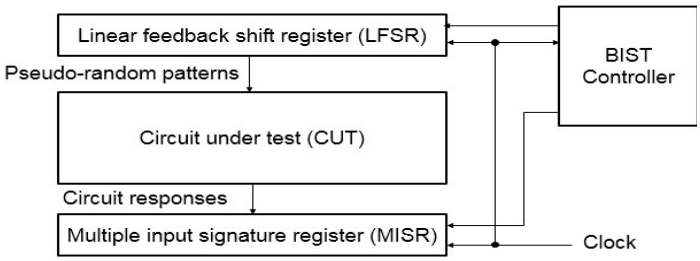

Figure 2. BIST design

The TPG below depicts the states kipping process. The test sequence S is constructed by serially shifting the LFSR's least significant bit LSB onto the scan path. Except for the components of SA, which stay consistent from one test session to the next, everything else is subjective. As a consequence, SA may be seen in Each node in Figure 3 represents a test vector, with the directed edge (e_{ij}) showing how the ordered test pair is implemented (t_i, t_j). The vector component of SA associated with the ordered pair of measurements is denoted by the weight w(e_{ij}) on the edge e_{ij} (t_i, t_j). The edge weights are given as an asymmetric cost matrix since the variable component of SA is substantially reliant on the ordering of test pairs in Figure 3. The switching operation's vector component for the test series S (t_1 t_2 t_3 t_4 t_5,t_6) is as follows: If it is discovered that T_3 and other event edges are unsuccessful test patterns, they may be deleted. A min-cost Hamiltonian route is an energy-efficient optimum ordering of test vectors that costs S. (t_1 t_2 t_3 t_4 t_5,t_6)

As a result, no action is necessary for the ordered pair (t_1 t_2) in the new sequence S, since the LFSR constructs t_2 as a natural successor of t_1. As a result, we set the Y-outputs of the mapping logic to don't matter (d) for s_9, and the control line C to 0. (the t_1 final state) It's critical to transition from $s_1$4 (t_2 end-state) to s_8 (t_5 start-state) and from s_{11} (t_5 end-state) to s_6 (start-state of t_4). The Y outputs are defined by the suitable start states for these combinations, and C is set to 1 for these combinations. Residual fluctuations are not taken into consideration in any of the results. These transitions provide acceptable test patterns in a predetermined order, preventing the LFSR from cycling between unproductive states (in this example, test t_3) is shown in Figure 3(a). The modulo-m bit counter's performance M assumes 1 when the scan route (of length m) is full, i.e. at the end-states of the test vectors. As a result, in order to construct the sequence, we must leap to the start state of the required next test pattern rather than the customary next state of LFSR. Figure 3 depicts these state-skipping transitions as dotted lines. The following is a summary of the mapping rationale: The original LFSR test sequence is S=t'$_1$, t'$_2$,t'$_3$... t'$_i$, t'$_i$ +1,..., whereas S=t'$_1$, t'$_2$,t'$_3$... t'$_i$, t'$_i$ +1is the best-organized shorter test sequence consisting just of functional vectors, given a seed is shown in Figure 3(b).

Let Y_i signify the LFSR's i-th flip-flop through a MUX, and Y_i denote the LFSR's i-th flip-production flops via a MUX (see Figure 2). The ML has k inputs (y_0, y_1,y_2,...,y_{k-1}) and k+1 outputs (Y_0, Y_1, Y_2,...,Y_{k-1}, C), with k being the LFSR length and C representing the control output. Each t'iin s indicator has its own row in the truth table. If the successive test pair (t'$_i$, t'$_i$ +1) of S appears in the same order in the original sequence S, case I applies; otherwise, case (ii) applies. When either C=0 or M=0, the LFSR's next-state corresponds to the transition diagram of the original LFSR, which is determined by the mapping logic outputs. Because these extra alterations only appear at the end of test patterns, the M show, as well as when C=1, will detect them. To prevent the SA from occuring in ML at each scan shift phase, an active signal E controlled by M is utilised. As a result, only when M is 1 can ML access the y-inputs. When S's final acceptable pattern reaches its end-state, the test session ends. The NP-hard travelling salesman problem (TSP), which may be solved using heuristic approaches, can be used to find the best test pattern reordering.

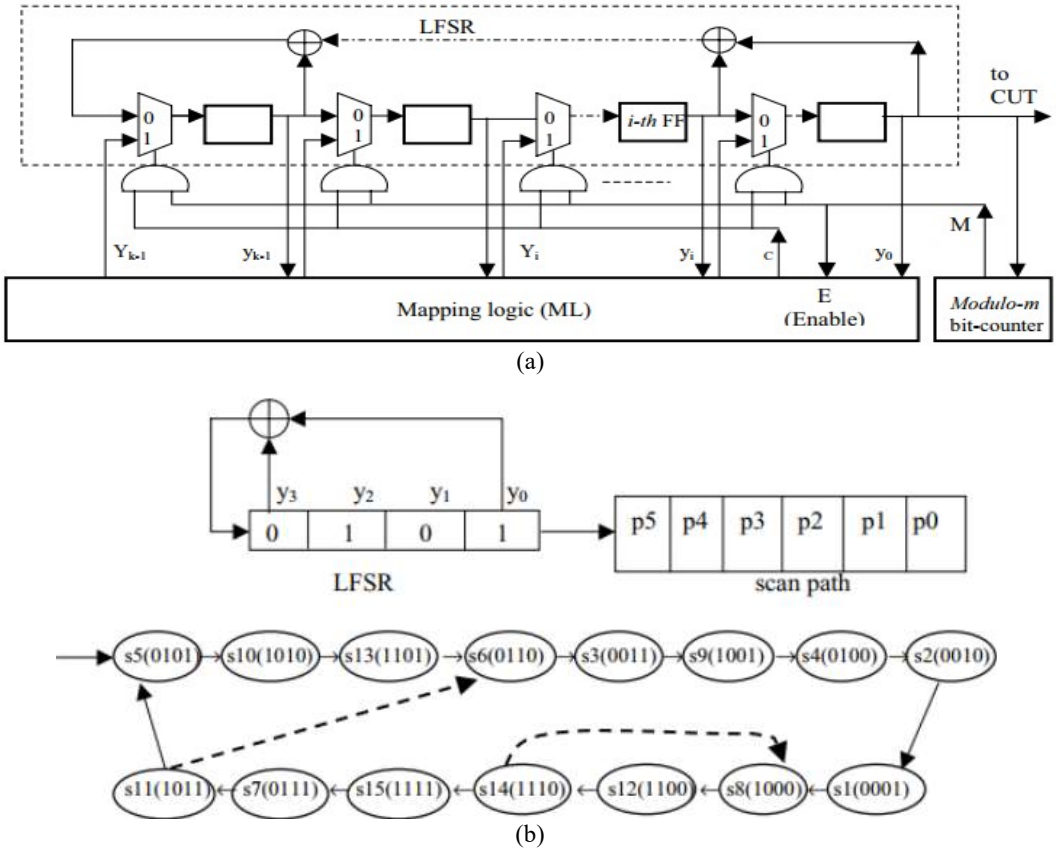

Figure 3. LFSR technique (a) modification to the LFSR and (b) an example LFSR and its state diagram

The test session finishes when S's last acceptable pattern reaches its end-state. To determine the optimal test pattern reordering, utilise the NP-hard TSP, which may be addressed using heuristic techniques. When serial inputs are received, a signature register can only evaluate logic for one output. In that it may be created in the same way as a serial-input signature register, a multiple-input signature register is equal to a serial-input signature register. To build a MISR, you may mix the inputs of both kinds of LFSRs (type 1 and type 2) in a variety of ways. The multiple representations are comparable as long as the add result is the same since the XOR action is linear and associative, (A * B) * C = A * (B * C). If the MISR is n bits long, we may build a signature for up to n inputs, as illustrated in Figure 4. We don't need the additional XOR gates in the MISR's final n–m places if we employ m n inputs.

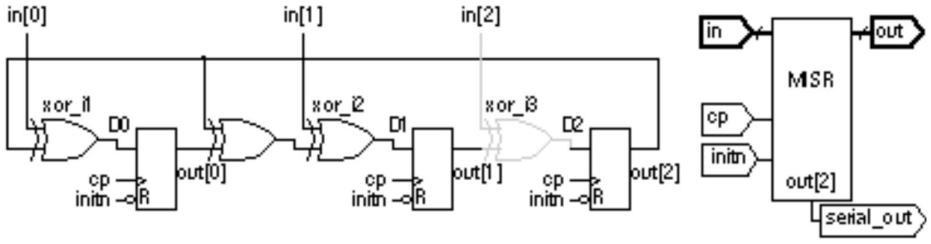

Figure 4. Bit MISR circuit diagram

4. RESULTS AND DISCUSSION

The MISR-based BIST architecture is available in a variety of configurations. We may convert a MISR to a LFSR or a signature register by adding further logic; this is referred to as a built-in logic block observer. We may create circular BIST schemes by inserting the logic we wish to test in the MISR's input

direction. The cyclic self-test course is one such example. Figure 5 demonstrates how to use a LFSR generator and a MISR to test produced blocks such random-access memory RAM, read-only memory ROM, and data route components. We may tweak the LFSR feedback route to force entry and departure from the all-zero state to create all 2 n address values for a random-access memory RAM or read-only memory ROM. Figure 6 demonstrates how to use a LFSR generator and a MISR to test random-access memory RAM, read-only memory ROM, and data route components. To force entry and departure from the all-zero state, we may alter the LFSR feedback pathway to create all 2 n address values for a RAM or ROM. For precision measurement, an 8-bit by 8-bit multiplier takes 65.536 vectors, but a 32-bit by 32-bit multiplier requires 1.8 or 10 19 vectorsIf A and B are both four-bit wide, SA and SAE may be used without any specific test patterns. The SA and SAE assessment sequences include walking 1s and 0s (S_1 and S_1B), walking pairs (S2 and S_2B), and triplets (SA and SAE) (S_3, S_3B). The series was generalised for larger inputs, thus S^2 for an 8-bit signal is a sequence of seven vectors, and so on. As illustrated in Figure 5, S_X and S_XB are intermediate sequences formed by concatenating S_1, S_2, and S_3, as well as S_1B, S_2B, and S_3B. These sequences were created in order to maximise the multiplier's add-and-carry powers.

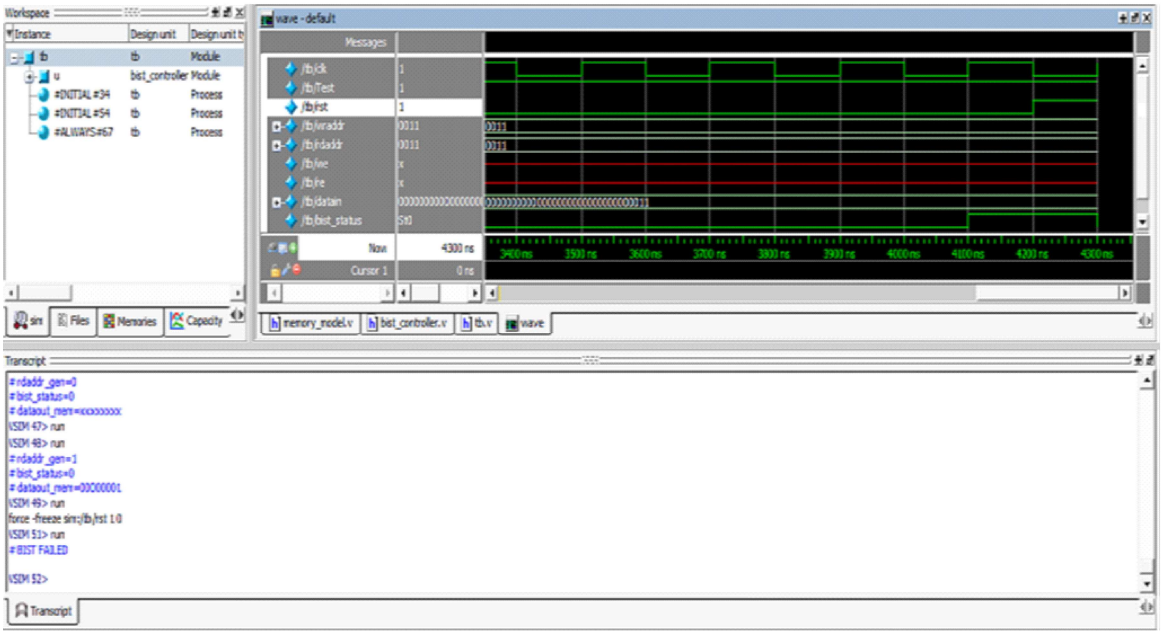

Figure 5. LFSR output

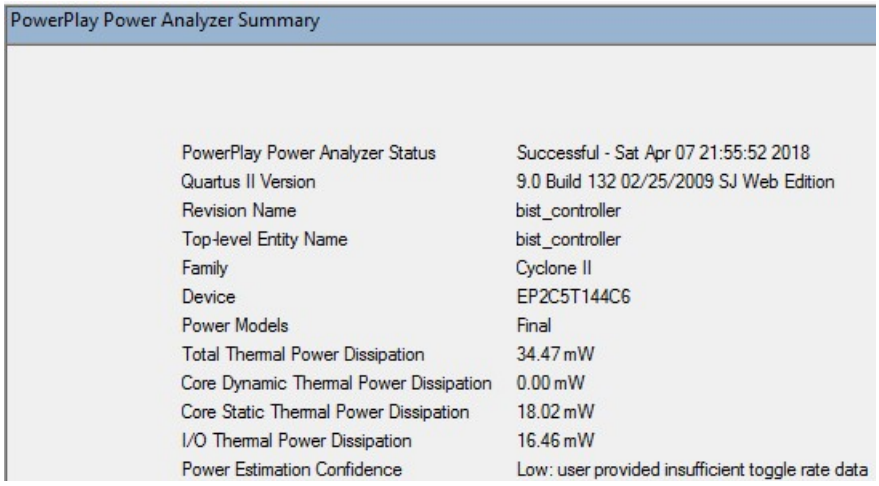

Figure 6. Power analyzer summary

5. CONCLUSION

The BIST design is created in Verilog and tested on a wide range of defective circuits. Modelsim was employed to replicate the concept after it was synthesised on failure. In order to conserve energy, both the LFSR and the CUT include a revolutionary BIST design in a random testing zone. When given a test set, a considerable component of the SA is inherent in design and cannot be reduced by vector reordering. Reorganize the scan route structure or choose a new set of eligible test vectors from the random collection to address. Timing circuitry is another source of power consumption that was not included in this study. Another exciting topic to investigate is the reusability of mapping logic and BIST hardware for many cores of a central processor unit CPU. In this work, we show how to employ Verilog's BIST logic. The LFSR technology is used to produce pseudorandom sequences. The circuit's integrity is checked via signature review. A defective circuit's signature varies from the reference signature. The signature of a poor circuit, on the other hand, has a very little chance of matching that of a good circuit. Signature analysis has a high defect coverage since longer sequences are used.

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BIOGRAPHIES OF AUTHORS

Kannadhasan Suriyan is working as an Assistant Professor in the department of Electronics and Communication Engineering in Cheran College of Engineering, karur, Tamilnadu, India. He is currently doing research in the field of Smart Antenna for Anna University. He is ten years of teaching and research experience. He obtained his B.E in ECE from Sethu Institute of Technology, Kariapatti in 2009 and M.E in Communication Systems from Velammal College of Engineering and Technology, Madurai in 2013. He obtained his M.B.A in Human Resources Management from Tamilnadu Open University, Chennai. He obtained his PGVLSI in Post Graduate diploma in VLSI design from Annamalai University, Chidambaram in 2011 and PGDCA in Post Graduate diploma in Computer Applications from Tamil University in 2014. He obtained his PGDRD in Post Graduate diploma in Rural Development from Indira Gandhi National Open University in 2016. He has published around 18 papers in the reputed indexed international journals and more than 125 papers presented/published in national, international journal and conferences. Besides he has contributed a book chapter also. He also serves as a board member, reviewer, speaker, session chair, advisory and technical committee of various colleges and conferences. He is also to attend the various workshop, seminar, conferences, faculty development programme, STTP and online courses. His areas of interest are smart antennas, digital signal processing, wireless communication, wireless networks, embedded system, network security, optical communication, microwave antennas, electromagnetic compatability and interference, wireless sensor networks, digital image processing, satellite communication, cognitive radio design and soft computing techniques. He is Member of IEEE, ISTE, IEI, IETE, CSI, IAENG, SEEE, IEAE, INSC, IARDO, ISRPM, IACSIT, ICSES, SPG, SDIWC, IJSPR and EAI Community. He can be contacted at: kannadhasan.ece@gmail.com, and has website at: https://sites.google.com/view/kannadhasansuriyan-ece/

Dr. Nagarajan Ramalingam received his B.E. in Electrical and Electronics Engineering from Madurai Kamarajar University, Madurai, India, in 1997. He received his M.E. in Power Electronics and Drives from Anna University, Chennai, India, in 2008. He received his Ph.D in Electrical Engineering from Anna University, Chennai, India, in 2014. He has worked in the industry as an Electrical Engineer. He is currently working as Professor of Electrical and Electronics Engineering at Gnanamani College of Technology, Namakkal, Tamilnadu, India. He has published more than 70 papers in International Journals and Conferences. His research interest includes power electronics, power system, communication engineering, network security, soft computing techniques, cloud computing, big data analysis and renewable energy sources. He can be contacted at: krrajan71@gmail.com.

Mr. Kanagaraj Venusamy obtained his MBA degree in Production Management from ManonmaniumSundaranar University, Tamilnadu, India in 2011 and B.E (Electronics and Communication Engineering) in 2005 from Anna University, M.E in Mechatronics Engineering, India in 2019 from Anna university affiliated college. Presently pursuing Doctorate in Management studies at Bharathidasan University, Tamilnadu, India. His main interests of research are control systems, industrial automation, artificial intelligence, robotics, drone, IoT, entrepreneurship and human resource management. He had 12 years of teaching experience in reputed institution in India and Oman and two year of industrial experience at Saudi Arabia. He has technically assisted various short term course for students, faculty development program and International Robotics Competition. He has acted as co principle investigator in sultanate of Oman government funded research projects. Currently working asa Control Systems Instructor in University of Technology and Applied Sciences-Al Mussanah. He can be contacted at: kanagaraj@act.edu.om and rajkanagaraj1983@gmail.com.

Sathish Sivaraman currently working as an Assistant Professor in the department of CSE at Sri Ranganathar Institute of Engineering and Technology, Coimbatore. I am currently doing my research work in the field of "Software Defined Wireless Sensor Networks" under Anna University. I received my Master's Degree in the field of Software Engineering from Anna University in the year of 2014. I had more than 6 years'experience in teaching. I published papers in reputed international journals and also presented papers at more than 10 National/International conferences. He can be contacted at email: sathesapcse@gmail.com

Kiruthiga Balasubramaniyan received the bachelor of Engineering degree in the field of Electronics and Communication from Madras Institute of Technology, Anna University in 2015. She has completed her post graduate degree in Communication and Networking from Madras Institute of Technology, Anna University in 2018. He is currently working as a Assistant Professot in the Department of Electronics and communication Engineering at K.Ramakrishnan College of Technology, Trichy, India. Her area of interests includes communication systems, image processing, networking. She has published 5 articles in peer reviewed international journals and presented 2 papers in international conferences. She can be contacted at email**:** kiruthigabalu94@gmail.com.

Manjunathan Alagarsamy received the Engineer degree in Electronics and Comunication Engineering from Dr. Navalar Nedunchezhiyan College of Engineering in 2010.He received the Master degree in Embedded System Technologies from Raja College of Engineering and Technology, Madurai, Tamilnadu, India in 2013. He is currently working as an Assistant Professor in the Department of Electronics and Communication Engineering at K.Ramakrishnan College of Technology, Trichy, India. His area of interests includes embedded systems, image processing, sensors and interfacing networks and internet of things. He has published 13 articles in peer reviewed international journals and presented 6 papers in international conferences. He can be contacted at email: manjunathankrct@gmail.com.