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DESIGN OF A COUNTER USING T-FLIP-FLOPS IN VERILOG

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Abstract. This paper presents the design and implementation of a 4-bit counter using T-type flip-flops (TFFs) in Verilog. The system utilizes four T flip-flops to generate a custom sequence of outputs, controlled by combinational logic that governs the input to each flip-flop. The flip-flops toggle on the rising edge of the clock signal, and their state is reset when the reset signal (rst) is asserted. The counter operates based on the logic that defines the input to each flip-flop, including conditional toggle behaviors. The core of the design relies on a modular approach, where each flip-flop is instantiated and connected according to the desired functionality. The output of the counter is a 3-bit sequence derived from the 4-bit register of flip-flops, providing insights into the operation and behavior of the counter logic. This design is suitable for use in systems requiring counters or state machines based on binary sequences.

I.INTRODUCTION

A counter is essentially a variable used to keep track of how many times something happens or how many iterations have occurred in a program. It is commonly used in loops, recursion, or event-driven programming to count specific occurrences or to track the number of iterations through a series of operations. In simpler terms, a counter is a way to store and update a number that represents something being counted

The counter in our sugar kit must track sugar levels or portions dispensed. Let's assume that the counter counts from 0 to a predefined limit.

A sugar kit is a device designed to measure and dispense a specific quantity of sugar. Without using a counter or T flip-flop, we can still design a functional sugar kit using basic electronic components such as logic gates, sensors, micro controllers, or mechanical systems. Below is a simple approach using an alternative method.

Diabetes Mellifluous is a major health concern in the society today both locally and worldwide According to National Diabetes Institute Malaysia, 3.6 million Malaysians suffer from diabetes in 2019. This is the highest rate of incidence in Asia and one of the highest in the world. Diabetes has been linked with other health problems, including heart disease and stroke, kidney disease, nerve damage and vision loss due to fluctuating blood sugar levels. Such complications can result in nephropathy leading to blindness, can lead to amputation of feet and legs, nephropathy (nerve disorder), cardiovascular diseases or even worst; death. Diabetes Mellifluous can be categorized into two major types.

Type 1 and Type 2. Type 1 occurs when insulin cannot be produced in the body to control the level of blood glucose. Type 2 which is common, occurs when not enough insulin is produced or when the insulin in the body is not working efficiently . Pre-diabetes is a health condition where patients have a higher level of blood glucose than normal but not high enough to be classified as diabetes.

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II EXISTING SYSTEM

The existing glucose monitoring systems or sugar test kits are essential diagnostic tools for diabetes management. These kits help measure blood glucose levels using electro chemical biosensors, signal processing circuits, and micro controllers. The conventional systems are designed to be portable, accurate, and power-efficient, but they have certain limitations in terms of speed, precision, and integration with modern technologies like AI and IOT.The existing glucose meters work using the following steps:

Early glucometers were basic devices that measured blood glucose levels without features like dose counters or test strip usage counters. The user would insert a test strip into the device, apply a blood sample, and get a result.

There were no automated counters to track the number of times the meter had been used or how many strips were left, so the person using the glucometer would need to keep track manually or remember when they last changed a strip or performed a test**.**

Blood Sample Collection: A small drop of blood is placed on a test strip that contains an enzyme (glucose oxidase or glucose dehydrogenase).

Chemical Reaction: The glucose in the blood reacts with the enzyme, producing an electrical signal proportional to the glucose concentration.

Signal Processing: The electrical signal is processed using an Analog-to-Digital Converter (ADC) and a counter circuit to measure glucose levels.

Data Display: The final glucose reading is displayed on the LCD screen of the glucose meter.

II. PROPOSED METHOD AND ITS METHODOLOGY

A **flip-flop** is a basic digital memory circuit that can store one bit of data. There are different types of flip-flops, but we'll use the **T flip-flop** (toggle flip-flop) in this example, which changes state (toggles) on each clock pulse. A 2-bit counter will count from 00 (0) to 11 (3) in binary. Since we have two bits, we need **two T flip-flops**

T Flip-Flop Behavior:

- When the T input is high (T=1), the flip-flop toggles its state with each clock pulse.
- When T=0, the flip-flop holds its current state.

The Two T Flip-Flops:

- **Q1** and **Q2** represent the outputs of the first and second T flip-flops, respectively.
- The first flip-flop (Q1) will toggle with every clock pulse.
- The second flip-flop (Q2) will toggle when Q1 goes from 1 to 0 (i.e., when Q1 completes a cycle).

A Counter is a device which stores (and sometimes displays) the number of times a particular event or process has occurred, often in relationship to a clock signal. Counters are used in digital electronics for counting purpose, they can count specific event happening in the circuit. For example, in UP counter a counter increases count for every rising edge of clock. Not only counting, a counter can follow the certain sequence based on our design like any random sequence 0,1,3,2…. They can also be designed with the help of flip flops. They are used as frequency dividers where the frequency of given pulse waveform is divided. Counters are sequential circuit that count the number of pulses can be either in binary code or BCD form. The main properties of a counter are timing, sequencing, and counting

1. start the procedure
2. The default value store in the display is zero
3. Next Add stripand the in the strip is compare to the circuit value

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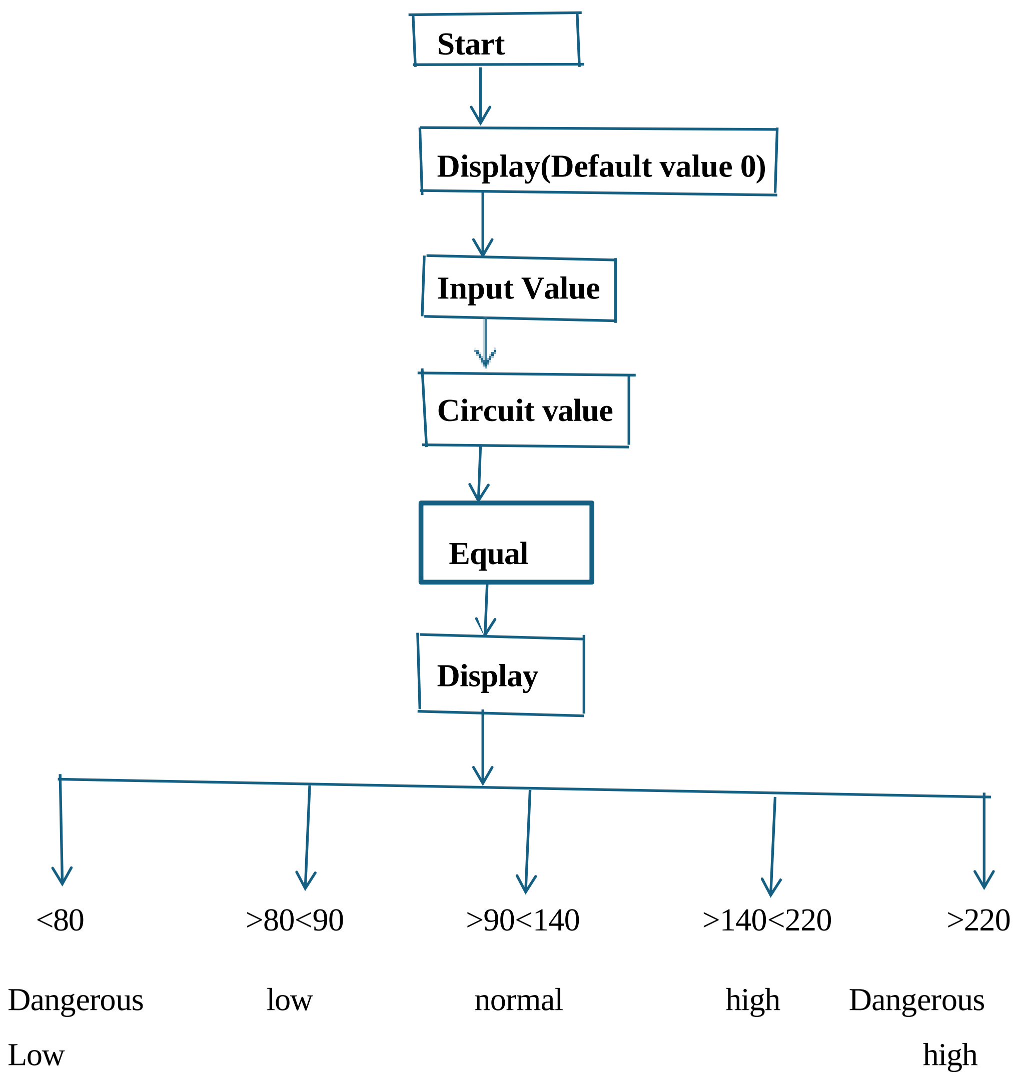
4. Then display the stage of the level.
5. If <80 it displays dangerous low
6. If >80<90 it displays low
7. If >90<140 it displays normal
8. If >140<220 it displays high
9. If >220 it displays dangerous high

Flow Chart:



Flowchat 1 working of counter in diabetic kit

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It is evident from timing diagram that Q0 is changing as soon as the rising edge of clock pulse is encountered, Q1 is changing when rising edge of Q0 is encountered (because Q0 is like clock pulse for second flip flop) and so on. In this way ripples are generated through Q0, Q1,Q2,Q3 hence it is also called **RIPPLE counter and serial counter.** A ripple counter is a cascaded arrangement of flip flops where the output of one flip flop drives the clock input of the following flip flop.

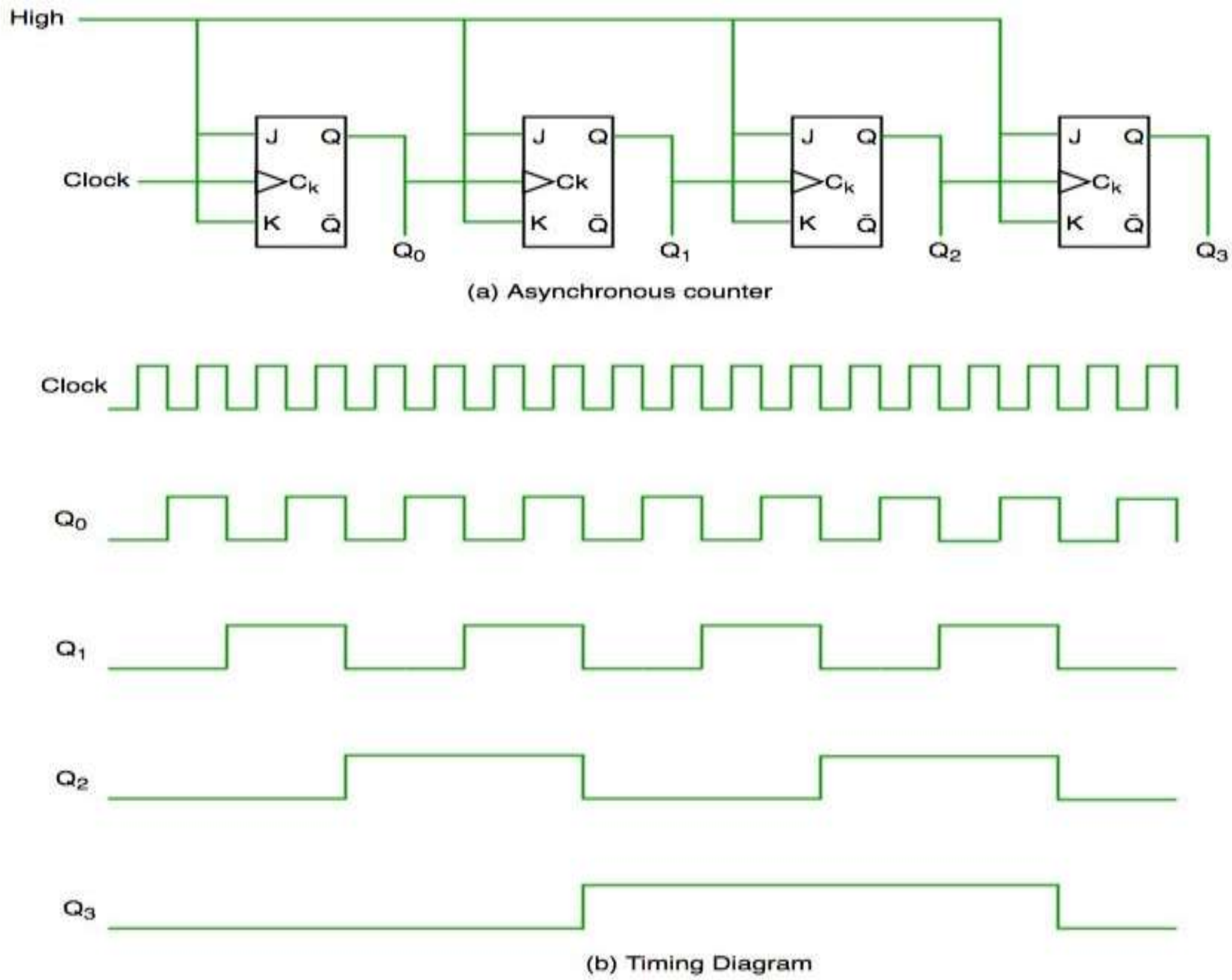

Fig 2: counter

A Synchronous counter is a type of digital counter where all flip-flops (FFs) are triggered simultaneously by the same clock signal. Unlike asynchronous counters, where flip-flops trigger sequentially causing delays, in synchronous counters, all flip-flops receive the clock pulse simultaneously. This design eliminates propagation delays, making synchronous counters faster and more efficient.

Synchronous counter may suffer from the problem of lock-out, which means they may not be self-starting. A self-starting counter is a type of synchronous counter that will enter to its proper sequence of states regardless of its initial state. We can make a counter self-starting by designing it so that it enters to a particular state whenever it goes to an invalid state.

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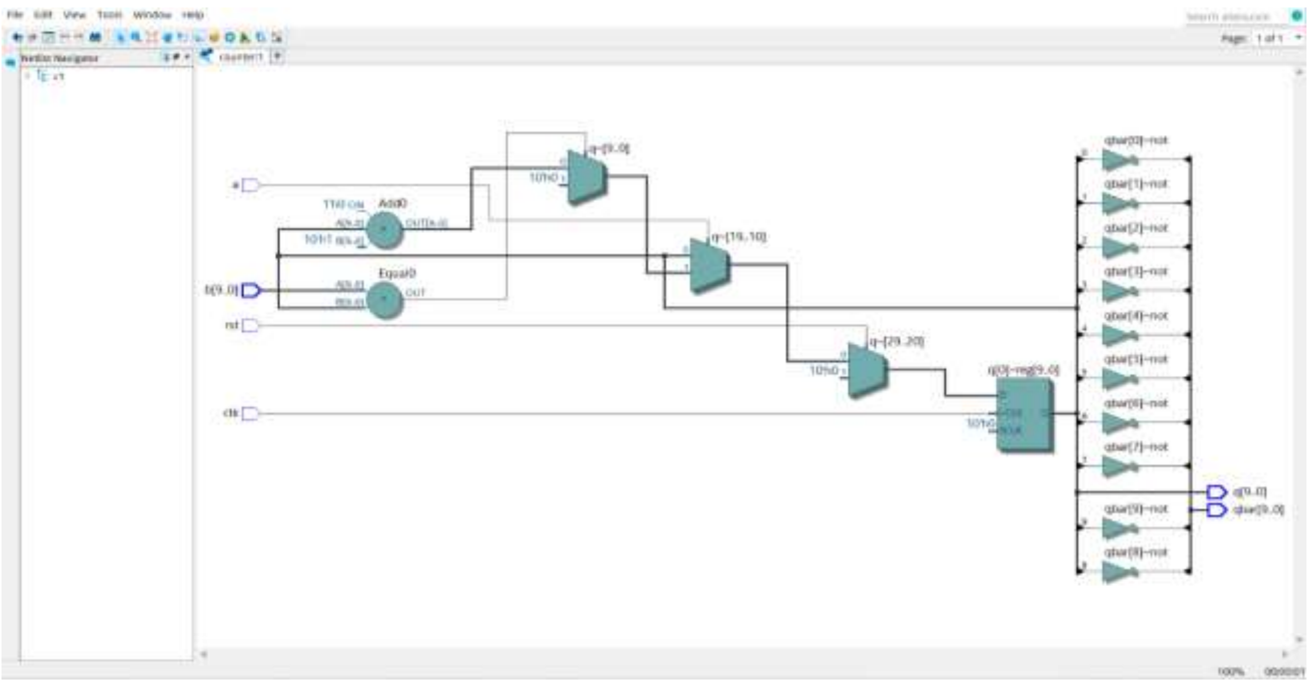
The operation of a Synchronous counter relies on flip-flops (typically JK or D flip-flops) and additional logic gates that ensure all flip-flops are triggered simultaneously. When the clock pulse is applied, the state of the flip-flop's changes based on the counting direction (up or down) and the logic implemented

IV. RESULTS

Schematic diagram



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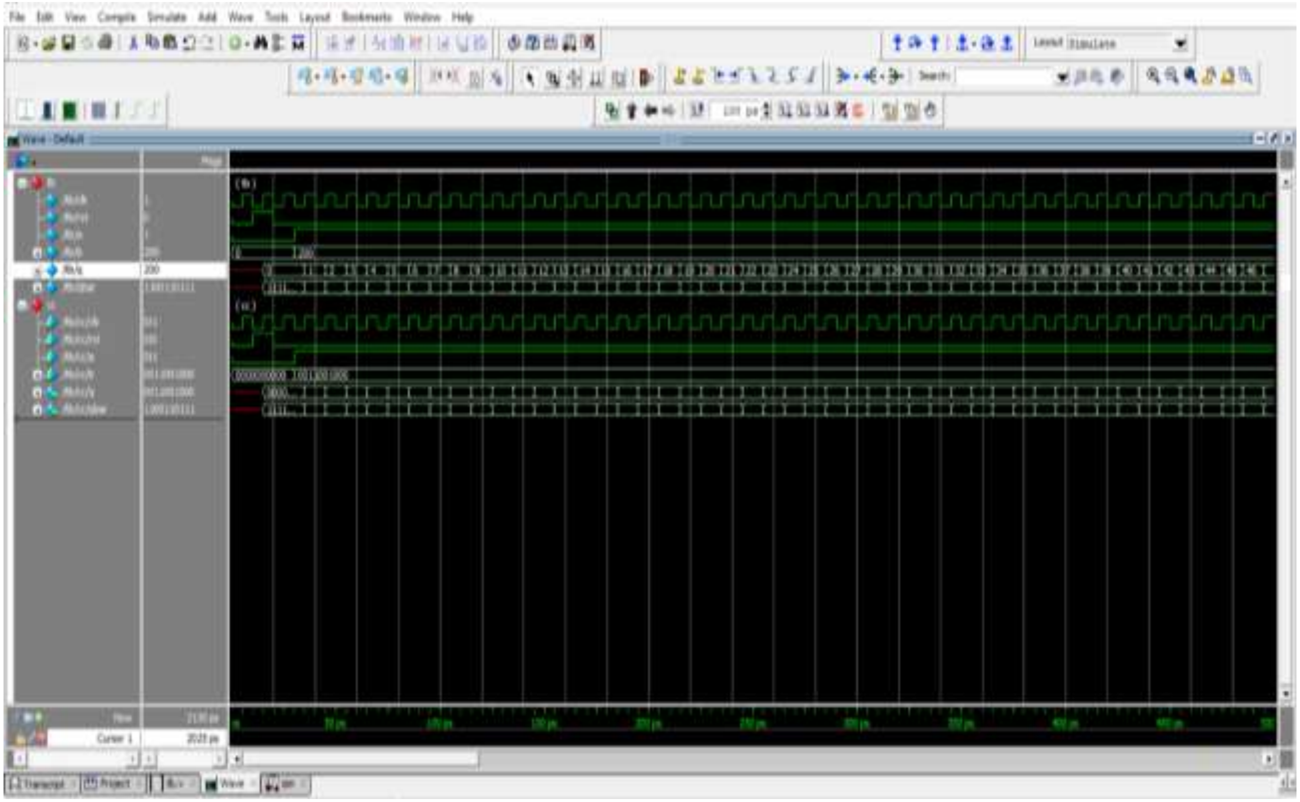
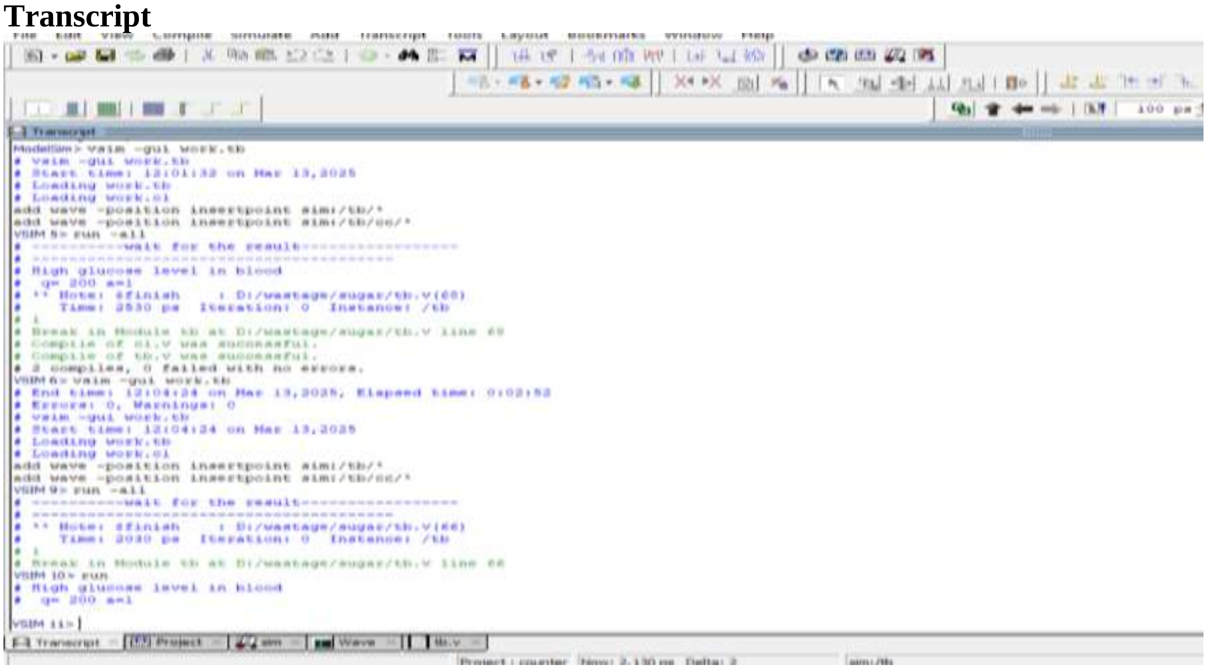
waveform



Transcript



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V CONCLUSION

We conclude that, the project belongs to diabetic kit with a counter can be designed to track the number of insulin doses taken, blood sugar measurements, or carbohydrate intakes. The counter ensures that a diabetic patient maintains an accurate log of their health metrics. Implementing this counter using a T flip-flop simplifies the design, as the T flip-flop toggles its state with each clock pulse, effectively counting events. By cascading multiple T flip-flops, a binary counter can be created to track and display the required counts on an LED or LCD screen. In conclusion, using a T flip-flop-based counter in a diabetic kit enhances monitoring accuracy, reduces human error, and ensures proper diabetes management

VI REFERENCES

1. **Digital Design by M. Morris Mano**
   Description: This is one of the most well-known textbooks on digital design. It covers flip-flops in detail, including T flip-flops, and how they can be used to build counters and other sequential circuits. The book has clear explanations of counter designs, state machines, and practical applications of flip-flops.
2. **Digital Fundamentals by Thomas L. Floyd**
   Description: This book provides an easy-to-understand approach to digital electronics and logic design, with chapters dedicated to flip-flops, sequential circuits, and counters. It includes practical examples of counter design using T flip-flops.
3. **Digital Logic and Computer Design" by M. Morris Mano**
   Description: This book provides an introduction to digital logic circuits, including sequential circuits and flip-flops. It includes practical methods for designing counters, including those using T flip-flops.
4. **Digital Logic Design by Brian Holdsworth and Clive Woods**
   Description: This book provides a solid foundation in digital logic design and includes specific examples of flip-flops and counters. It discusses T flip-flops and how they can be used in the construction of counters.
5. **Logic and Computer Design Fundamentals by M. Morris Mano and Charles R. Kime**
   Description: This book is another excellent resource for learning about digital circuits, including T flip-flops. It covers the design of sequential circuits and counters in depth.
6. **Contemporary Logic Design by Randy H. Katz and Gaetano G. Borriello**
   Description: This book covers modern digital logic design and includes detailed explanations of counters, flip-flops, and sequential circuits. It is well-suited for those learning both theoretical and practical aspects of digital systems.