

## **LAB 5: SYNCHRONOUS SEQUENTIAL CIRCUITS**

This lab will focus on the implementation and uses of memory elements (in this case, D Flip-Flops) and combinational circuits, and the design of synchronous sequential circuits for a variety of purposes in the context of a sleepy seaside resort town.

On that note, congratulations! You've saved enough for a plane ticket, packed up, and finally got away from your ECE 465 demons. Unfortunately, the town isn't big, and everyone's clocked you out to have been an engineering graduate, so everyone's coming to you to solve their electric engineering problems. They're your family, too, so you can't hit them with the 'I tender my resignation, effective immediately'...so get to it! Mang Tomas' Electronics Shop will give you access to a good number of logic gates (AND, OR, NOT, XOR, XNOR), and D Flip-Flops, as well as digital oscilloscopes that can serve as Clock inputs.

Mang Tomas is great, but he's also really temperamental and eccentric, so *the availability of components will vary from task to task*.

*As in previous labs, use Logisim-evolution when instructed to implement or design a circuit.*

### **Part 1: Tita Josie's Sari-Sari Store**

Your Tita Josie will be gone for the next few weeks, and has thus left the care of her store to your cousin, Kuya Jerome. Unfortunately for you, your Kuya Jerome has been watching a few too many business and technology TikToks and has badgered you into automating the store. Against your better judgment, you finally give in, and decide to show him how to implement a **barcode reader**.

You will have to start with a prototype, that can recognize a barcode for the store's most popular product—a shampoo sachet.

For your input, you will have a scanner that reads from left to right, and returns 1 when a black stripe is detected, and 0 when a black stripe is not detected. After doing some digging, you also find that every barcode for the sachets has at least one black stripe, followed by a blank space, then followed by one black stripe. The output must be able to recognize this sequence and returns 1 when it is detected. Every barcode provides an input sequence of length 5. ***Design and implement a synchronous sequential circuit that achieves this purpose.***

*Unfortunately, the soap opera that Mang Tomas has been watching had a bad ending, and so has decided to shut off much of his shop. You will therefore only have access to NAND gates and D Flip Flops for the implementation.*

## **Part 2: Kuya Kokoy's Traysikol**

Another cousin, Kuya Kokoy, drives a *traysikol* around town, and with money being tight, needs to keep careful track of exactly how much to charge his riders, so as to avoid both losing money for charging too little, and avoid losing trust by charging too much. He can easily do much of the math *but needs a way to track the distance that he is driving for his riders.*

Kuya Kokoy already has access to a Wheel Meter attached to the wheels, which will briefly return a value of 1 whenever he has driven a distance of 1 km—which is important, as he will have to charge riders a certain value per kilometre. (You can assume that there will be no charge for fractions of a kilometre.) The vehicle also has an Old Display, which takes in a binary input, and will display the decimal representation of said binary input (e.g., if its input is 0, it will display “0”, and if its input is 1001, it will display “9”, etc.). ***Design and implement a Rate Calculator circuit to connect these two components, such that the Old Display reads the distance traveled through the trip. Bonus points if you can implement an asynchronous sequential circuit instead of a synchronous one (i.e., remove the need for a Clock input).***

You may also include a “reset” input for Kuya Kokoy, such that when this input is 1, the machine resets and the distance reading is set back to 0.

You have also done some surveying of the neighborhood, and determined that the longest drive Kuya Kokoy can make is 7 kilometres.

*Luckily for you, Mang Tomas has finally hit the jackpot in the semi-legal neighborhood gambling bets. It won him a grand total of 5 pesos, but it's enough glee for him to give you an unusually steep discount on this go round, so for Part 2, you will have access to all of the components in the shop. (In the case of Logisim-evolution, you will have access to all of the components available, as opposed to just the logic gates and D Flip Flops, as stated earlier)*