Lecture 6: Latches and Flip-Flops

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Introduction — 3.1 in Text

Every circuit has so far been purely combinational in ECE 271. At any given the outputs are only determined by the current inputs. This chapter explores the design and construction of state machines. Counters, stoplights, and stepper motor drivers are all examples of these state machines.

Sequential Circuits — 3.1 in Text

Sequential circuits depend on both the current inputs and the current state of the circuit. This means if there are 2 inputs and 3 state bits that the combinational logic has 5 inputs, a 5 input karnaugh map would be needed to minimize this logic. The outputs could turn on LEDs or control motors. There would also be 3 outputs to the memory to control what the next state would be. This whole process is pictured in figure 1.

![General structure for a sequential circuit](image)

**Figure 1:** General structure for a sequential circuit
Latches — 3.2 in Text

Latches are the fundamental storage unit of memory. There are 3 basic latches below in figure 2, 3, and 4.

Figure 2: Active high SR latch

Figure 3: Active low SR latch

Figure 4: Active high SR latch with an enable input
Figure 5: When Enable is high the DataInput is copied to Q in a D Latch

LD is a transparent data latch. The data output (Q) of the latch reflects the data (D) input while the gate enable (G) input is High. The data on the D input during the High-to-Low gate transition is stored in the latch. The data on the Q output remains unchanged as long as G remains Low.

The latch is asynchronously cleared, output Low, when power is applied.

Figure 6: Xilinx Information Sheet on the D Latch

**Flip-Flops — 3.2 in Text**

Flip-flops are the most commonly used storage unit in digital logic. They are more usable than latches, because they only change at a transition of the clock, either rising or falling edge. There are three different types of flip flops shown in figures 7, 9, 8.

Figure 7: On the rising edge, D is copied to Q in a D Flip Flop.

Figure 8: A T Flip Flop toggles the output whenever T is high.
Figure 9: A JK Flip Flop can set, reset, toggle, or not toggle the outputs, based off of the JK inputs.