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Chapter 2 Summary

Chapter two essentially covers the basics of digital logic, the basics of what computers are built on. It covers voltage, current, transistors, logic gates, Boolean functions, TTL (transistor-transistor logic), combinatorial circuits, flip flops, binary counters, clocks, sequences, demultiplexer (demux), the concept of feedback, iteration, replication, power distribution, heat dissipation, actual physical size, and the different layers of abstraction. All of these topics help the reader to understand exactly what computers are.

The transistor is the most basic part of a computer, it has three paths, one path controls the flow, and the other two paths allow for flow to passthrough the transistor. Transistors make up logic gates, they are the physcial version of boolean functions. Specifically, the nor gate uses 6 transistors, 5 resistors, and 3 diodes. For a not gate, you only need a transistor and a resistor. Rather than the engineer or user have to build gates from transistors everytime they need one, companies manufacture small logic gates thatcan be connected to circuits. One such example is the 7400 family, each number stands for a different type of gate component. The 7400 has 4 nand gates, the 7402 has 4 nor gates, and the 7404 has 6 inverters. These are combinatorial circuits.

Engineers need more than combinatorial circuits to solve more complex problems. Combinatorial circuits are for changing the input that the user puts in, sometimes this is not required. This is where clocks, binary counters, and more sophisticated circuits come into play. The flip flop is an electronic part that can maintain it's state. The flip flop once activated for the first time will become boolean 1 and turn on, the second time the input is received it will turn off. The flip flop is basically a computer on/off button. A good visual representation of a flip flop is shown in a transition diagram. In a transition diagram the leading edge of an input change is where an output change occurs, the falling edge shows when input changes from one to zero.

Binary counters are similar to flip flops, however, binary counters accumulate total rather than just turn on and off. Clocks are very helpful tools that work by alternating values of 0 and 1 at a regular rate measured in Hertz(Hz). A demultiplexor (demux) is a single integrated circuit that uses a binary value and a set of outputs. The demux will be given an i^th value to run, and it will turn all other values off. One way these three tools are used is by running a clock, feeding the clock's output to a binary counter, and then feeding the output of the binary counter to the demux to run whatever task.

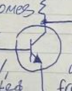
In coding software, replication is an improper way to do things, and iteration is used to avoid errors. However, in physical hardware, replication over iteration as it is more efficient and the hardware is much simpler when replicating.

Building circuits requires the engineer to think critically about how to correctly assemble everything, as well as consider some issues like power distribution, clock skew, and heat dissipation.

*Physical notes

Volts amperes/amps measurements

CS 230 Chap 2 Summary Notes
Fundamentals of Digital Logic
2.1: This chap. covers the basics of digital logic Fundamentals from which cps. are built. BASICS
2.2: Voltage and current
Voltage between 2 points represents potential force, and the current represents flow of electrons along a path (wire)
voltage is like water pressure, current is how much water
★Voltage can only be measured between 2 points★
Assume one point is ground (Ø volts)
2.3 Transistor: ~~the~~ tool to control flow of electrical current semiconductor device
All digital systems use these. Like mini switches, 3 connections
-1 controls flow and 2 allow for flow to pass through
2.4 Logic Gates - boolean funcs. can be converted into physical hardware: And, Or, Not → A transistor and a resistor can make a boolean NOT.
UNDERSTAND: if 5V represents Bool 1, and Ø represents Bool Ø
when ØV is put on the input, the output becomes 5V and vice-versa. The transistor when on connects the output to ØV and when off, ~~connects the output to~~ disconnects the ØV, and the output registers 5V. Gates are not constructed from individual transistors, manufacturers sell integrated circuits



Fewer transistors provide the inverse of Boolean funcs.
2.5 Symbols Used for Gates NAND NOR Inverter/NOT

Also called Boolean Circuits

2.6 Construction of Gates from Transistors
Nor gate needs 6 transistors, 5 resistors, 3 diodes, now that we're [illegible] understand them [illegible]
2.7 Example Interconnection of Gates - The electronic parts that implement gates are classified as transistor-transistor Logic TTL because output transistors in each gate connect to the input of other gates
2.8 Multiple Gates Per Integrated Circuit
Some logic gates can be manufactured on a single cheap electronic component

2.8 cont... Logic Gate family 7400, rectangular package 1.5 in. long with 14 copper wires (pins) to connect to a circuit. Part num. 7400 = 4 nand gates, 7402: 4 nor gates, 7404: 6 inverters.
2.9 The need for more than combinatorial circuits
combinatorial: Output is Boolean combination of input vals
Aren't sufficient, need to perform actions without requiring change of input. Sophisticated Circuits and Clocks!
2.10 Circuits that maintain state
Flip flop: power switch on computer: first input becomes 1 - computer turns on, second time, computer off
2.11 Transition Diagrams
Output transition occurs on the leading edge of input change, when input changes from 1 to Ø, that is on the falling edge
2.12 Binary Counters
counter accumulates a numeric total, like a "FF", a counter output changes whenever the input goes from 0 to 1, unlike FF, a counter has output that represents the total transition count in binary, counters also have a reset input, overflow output, and a max value
2.13 Clocks and Sequences
Clocks ~~continuously~~ alternate 0 and 1 values at a regular rate, speed measured in Hertz (Hz), num of times per second the clock cycles through a 1 followed by a Ø
Many computers operate at 100 MHz or several GHz
Simple Clocked Circuit: say a comp needs to run a sequence of tasks. Use a clock, binary counter, demultiplexor (demux): single integrated circuit that maps between a binary value and a set of outputs.
The demux selects the i^{th} input and runs only that, all others are off. → Circuit can execute steps by taking the output of a clock, inputting it to a binary counter then using that output as input to the demux. ⟶

2.14 The important concept of feedback
Need ability to start and stop operation
Use final output F to stop ~~counter~~ clock from reaching the counter.
insert logic gates that only allow counter pulses to continue when F has value Ø → Bool Clock and (not F)
2.15 Starting a Sequence
Just add a button connected to counter reset.
This can cause issues if button is pushed at times when it shouldn't be
2.16 Iteration in Software vs. Replication in Hardware
ex: a for loop ← easy in software → Hardware iteration is clumsy, so replication is used. engineer creates multiple copies of underlying gates and allows each copy to act on one item. Ex: say we need to compute a Boolean operation on a set of 32 Bool values, ideal hardware is replicating a gate 32 times and allowing each instance to operate on one of the 32 items. To compute Bool Not of 32 values, a solution would be to use 32 inverters. Replication is much much much better than iteration in HARDWARE
2.17 Gate and Chip Minimication
Simplify hardware used
2.18 Using Spare Gates
Consider a 7400, 4 nand gates, if you only need one, think of ways to use the other ones: ex: 1 nand X → is same as not X.
2.19 Power distribution and heat dissipation
Engineer must calculate total power required, construct power supplies, and plan additional wiring that carries power to each chip. holes, fans, and in big cases refrigeration system with liquid coolant must be used.
2.20 Timing: Gates do not act instantly, clock skew: a signal takes one nanosecond to propagate accross a foot of wire → Several clocks are used to combat this

2.21 Physical Size and Process Technologies Integrated Circuits
digital circuits are usually built from IC's,
N-Type Sillicon and P-Type Sillicon form transistors
2.22 Circuit Boards and Layers
most circuit boards are printed and consist of fiber glass board with thin metal strips, → these form wiring
2.23 Levels of Abstraction
lowest level: transistor created from sillicon → extra components: resistors, diodes → multiple gates, flip flops
2.24 Summary