Duke University
Department of Physics

Physics 271 Spring Term 2017

WUN2K FOR LECTURE 21

These are notes summarizing the main concepts you need to understand and be able to apply.

- *Digital circuits:* analog signals can have any voltage level; in digital circuits, we make use of only two meaningful voltage levels, "high" and "low", defined as above and below predefined thresholds. These correspond to two binary states, "true" and "false", or "0" and "1". Digital signal processing is useful for defeating noise (which typically won't exceed thresholds), and is also used for *computation*.
  - Binary logic levels can be implemented using transistor switches, which can be turned on (into conducting mode) and off according to base voltage levels.
  - A *bit* corresponds to a single on-or-off element. A group of four bits is a called a nibble, a group of eight bits is called a *byte*, and groups of 16, 32, or 64 bits are called *words*. The "most significant bit" is conventionally the leftmost, the the "least significant bit" is conventionally the rightmost.
  - Numbers are encoded in *binary* in a base-2 system (other popular systems are *octal*, which is base-8 and *hexadecimal* which is base-16). A group of N bits can encode a number from 0 to $2^N - 1$. Negative numbers can be indicated by reserving the leftmost bit ("signed magnitude" convention) to indicate if negative. A more common implementation of negative-number encoding is the *two's complement* method: change all 0's to 1's and vice versa, then add 1 to get the negative of a number.
  - *Boolean algebra* defines logical operations between binary states. The basic operations are, for states A and B:

* Logical AND: $Q = A \cdot B = AB$. Q is true if and only if both A and B are true.
* Logical OR: $Q = A + B$. Q is true if either A or B (or both) are true.
* Logical NOT: $Q = \overline{A}$: if A is false, Q is true; if A is true, Q is false.

One can also create a NAND operation, $Q = \overline{AB}$, and a NOR operation: $= \overline{A + B}$. These operations can be implemented in a digital circuit using *logic gates*.

– *De Morgan's Theorem* is a very useful theorem from Boolean algebra: it states that $\overline{(A \cdot B)} = \overline{A} + \overline{B}$, or $\overline{(A + B)} = \overline{A} \cdot \overline{B}$.