Chapter_1 Intro (A)

The Electronic Aspect of Digital Design

Digital vs. Analog

Digital systems are capable of greater accuracy and reliability than analog systems. Because of this, many tasks which used to be performed by analog systems are now being performed by digital systems. The world we live in today is covered with digital systems. Every day, more examples of these systems are added to our lives. We have **microprocessors, digital computers along with all the things that go with them, communication systems, entertainment systems such as TV's, DVD's, and CD's, instrumentation (especially hospital equipment), control systems, etc**.

A digital system manipulates data that is composed of a finite number of discrete elements. The results, or output, of the system is also made up of a finite number of discrete elements. The normal voltages represented in a digital system are **0 volts (logic 0)** and **+5 volts (logic 1).** Each voltage level represents an element of data.

On the other hand, an **analog system manipulates data that is represented in a continuous or infinite form**. Voltages, currents, and other physical relationships in real circuits take on values which are infinite in nature. Since real values are continuously variable, we could use this physical quality to represent real numbers. For instance, we could represent pi (π) to 14 decimal digits of precision, theoretically that is.

However, in the real world stability and accuracy in physical quantities are difficult to obtain in real life circuits. They are affected by power supply voltages, temperature, factory tolerances, cosmic rays, solar flares, noise from other electronic equipment, and many other things. If we were to model π with an analog circuit, its value may vary by as much as 10%!

It is also impossible to perform many things with analog circuits. Think about how hard (if possible at all) it would be to build a 50 input, 50 output, circuit; with the outputs identical to the inputs but sorted. This can be done digitally quite easily **(Wakerly).**

Accuracy

As mentioned earlier, **compared to analog systems, digital systems are more accurate and reliable**. In many cases, for a given input, the output is exactly correct

(Roth.) For example, if we were to multiply two 6-digit numbers using a digital multiplier, the 12-digit product will be correct in all 12-digits. Analog systems on the other hand have a built-in error of up to several percentage points due to the accuracy of the components which make up the multiplier. In addition, if we wanted to double the number of digits, all we would have to do in a digital system is to add more bits to the input and processing capability. We couldn't do the same thing with an analog system due to the limitations on the accuracy of the analog components. Therefore, digital systems are replacing analog systems wherever possible.

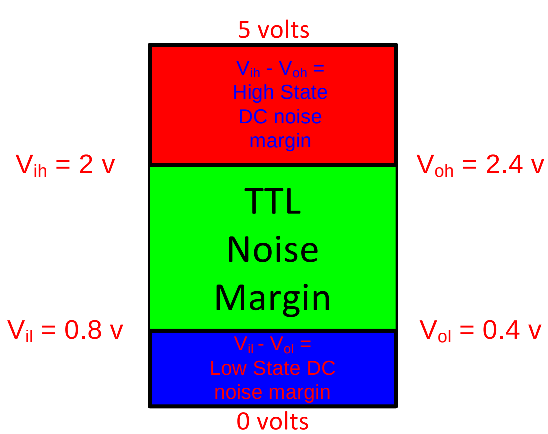
Digital system Disadvantages

Digital systems do have a major disadvantage. **No matter what the advertisements says, we live in an analog world, not a digital one.** The information must first be converted to digital. In the process of this conversion, some information in the signal is lost. Take the 35-mm camera versus the digital camera. The best digital camera will never be as good as the best 35-mm camera. But it's probably going to be good enough. Most news organizations today use digital cameras because they are good enough to get the job done. A second disadvantage is that quite often in order to be useful the digital output must 1st be converted back to an analog signal. This process adds expense and causes bandwidth loss.

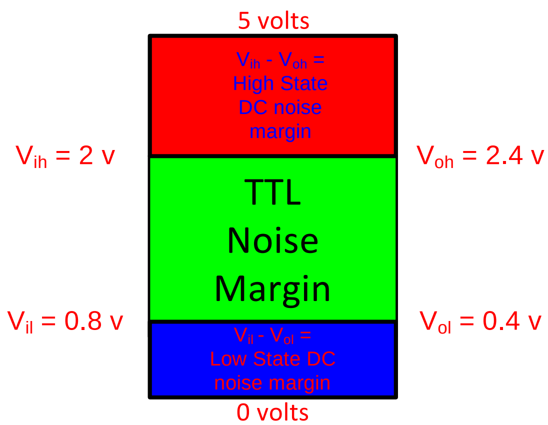
Digital Logic levels and Noise Margin

While the circuits we will be working on this semester are called "**Digital**", they don't really operate with **1**'s and **0**'s. While this digital abstraction is useful, in reality they are dealing with analog voltages and currents, and these values can vary fairly widely. Hopefully, you already knew that.

What we quite often forget is that a **logic '0' doesn't necessarily mean 0 volts and a logic '1' doesn't have to mean 5 volts.** There is an area known as the "**noise margin**" in which a gates low output might be somewhere in the vicinity of **0v** but not **0v**. The same is true of **5 volts**. The gates output might be as low as **2.4 volts** instead of **5 volts (TTL)**.



Between these two regions, there is a no-man's land of invalid voltages which are classified as neither; a '**1**' or a '**0**'. This is called the "**Noise Margin**". As long as your digital device is operating at the appropriate temperatures and voltages, all devices will react to the margins specified in the specs.



V_{oh} (output High voltage)	➔	**minimum** voltage at which the circuit delivers a logic 1
V_{ol} (output Low voltage)	➔	**maximum** voltage at which the circuit can produce a logic 0
V_{ih} (input High voltage)	➔	**minimum** voltage at which the circuit can detect a logic 1
V_{il} (input Low voltage)	➔	**maximum** voltage at which the circuit can detect a logic 0

Low Power Digital

Along with the **"noise margin"** issues, the advent of the **low power** uses of microprocessors has necessitated the development of low voltage logic chips where the logic '**1**' might represent **3 volts** vice **5 volts**. It is the task of the electronic circuit designer to ensure that the logic gates produce and recognize the appropriate signals in the appropriate ranges. This course will focus on **5** volt Boolean Logic. This should not be an issue since once the logic **1**'s and **0**'s replace the high and low level voltage levels, the actual voltages are not important for the **LOGIC** of the system.

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