Seeing Is NOT Always Believing

Our lives are filled with electronic signs that display time, temperature, or a game score; however, what we see is not always what is really happening.

Most displays cycle through individual display segments so that only one display is on at a time.

The cycle speed is so fast that the human eye perceives all segments are on all at once.

LWO

Multiplexers and Demultiplexers can be used to control this.

2's Complement Arithmetic

Binary Addition

carry

Single Bit addition:

$$\begin{array}{r} 0 \\ +0 \\ \hline 0 \end{array} \quad \begin{array}{r} 0 \\ +1 \\ \hline 1 \end{array} \quad \begin{array}{r} 1 \\ +0 \\ \hline 1 \end{array} \quad \begin{array}{r} {\scriptstyle 1}1 \\ +1 \\ \hline 10 \end{array}$$

Multiple Bit addition:

$$\begin{array}{r} 6 \\ +3 \\ \hline 9 \end{array} \quad \begin{array}{r} {\scriptstyle 11}\ \\ 0110 \\ +0011 \\ \hline 1001 \end{array}$$

Negative Numbers?

Digital Electronics requires frequent addition and subtraction of numbers.

A subtracter is not needed with the 2's complement system.

The 2's Complement system allows you to convert a positive number into its negative counterpart.

Since subtracting one number from another is the same as adding one number negative and adding, a subtracter is no longer required.

How to create a negative number?

In Digital Electronics you cannot simply put a negative sign in front of a number to make it negative.

You must represent a negative number in a fixed-length binary number system. All signed arithmetic must be performed in a fixed-length system.

A physical fixed-length data (usually memory) contains a fixed number of bits (usually 4-bits, 8-bits, 16-bits) to hold the number.

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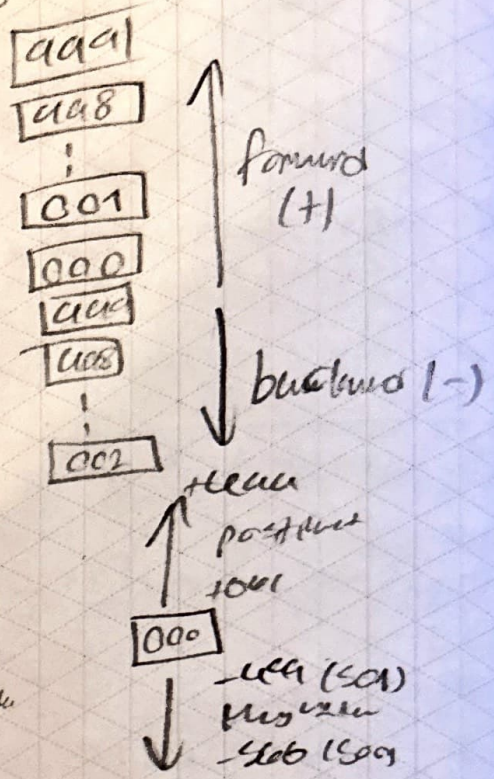
3-Digit Decimal Number System

A bicycle odometer with only three digits is an example of a fixed-length system

The problem is without a negative sign.

You cannot tell the difference between a +998 from a -2

Note: Car odometers do not work this way



Negative Decimal

Cut the number system in half

Use 001-499 to represent positive numbers

Use 500-999 to represent negative numbers

"Odometer" math examples

$\begin{array}{r} 3 \\ +\ 2 \\ \hline 5 \end{array}$ $\begin{array}{r} 003 \\ +002 \\ \hline 005 \end{array}$ $\begin{array}{r} 6 \\ +(-3) \\ \hline 3 \end{array}$ $\begin{array}{r} 006 \\ +\ 997 \\ \hline 1003 \end{array}$ $\begin{array}{r} -5 \\ +\ 2 \\ \hline (-3) \end{array}$ $\begin{array}{r} 995 \\ +\ 002 \\ \hline 997 \end{array}$

Complex Problems

How do we easily convert a number into it's negative counterpart.

Counting backwards is not too easy for large numbers.

10's Complement System

Uses base-10 (decimal) numbers

Complement all of the digits in a number

- A digit's complement is the number you add to the digit to make it equal the largest digit in the base.

Add 1.

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10's Example 1

-003

↓↓↓

996

+ 1

997

Example 2

-214

↓↓↓

785

+ 1

786

2's Example 1

S=00000101

↓↓↓↓↓↓↓↓

11111010

+1

-S= 11111011

8-Bit Binary System

Apply to binary numbers.

Use 00000001 - 01111111 for positive numbers

Use 10000000 - 11111111 for negative numbers

Sign Bit

The MSB is (0) for all positive numbers.

The MSB is (1) for all negative numbers.

In a signed number system, this allows you to instantly determine the sign of a number

2's Complement Process

1. Complement all digits of a number
2. Add 1