Numbering Systems and Digital Electronics

MEM 639 Real-Time Microcomputer Control 1

Objective: To understand and appreciate the binary number system

1. Quantities can be represented in any base

Example: The number 2157 is actually:

$$2\times10^3+1\times10^2+5\times10^1+7\times10^0$$

Or

$$2000+100+50+7=2157$$

Known as Base-10 system (decimal). Perhaps evolved because people have 10 fingers

2. Computers use a Base-2 system (binary)

3. Bits represent on-off switches, 1 and 0 respectively

Example: The (binary) number 10011 (to a computer) is actually:

$$1\times2^4+0\times2^3+0\times2^2+1\times2^1+1\times2^0$$

Or

$$16+0+0+2+1=19$$

This process is called a binary-to-decimal conversion

4. Decimal-to-binary conversion

Example: Convert 234_{10} to binary

Step 1: Form table

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

(1)

Step 2: Populate table

234_{10} =

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
1	1	1	0	1	0	1	0

Sanity Check: $128+64+32+0+8+0+2+0=234$

Answer: $234_{10}=11101010_2$

5. n-bit machine Largest decimal number represented by n-bits: $2^n - 1$

Example:

255_{10} =

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
1	1	1	1	1	1	1	1

n = 8 bits, 2^8-1 = 255

256_{10} =

2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
256	128	64	32	16	8	4	2	1
1	0	0	0	0	0	0	0	0

256_{10} appears to be 0_{10} on 8-bit machines.
This is called overflow

6. C Programming: `int` is a 16-bit number (2 bytes)

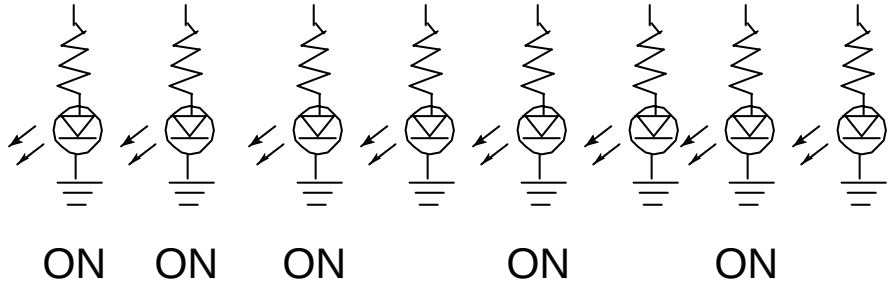
n = 16 bits, 2^{16}-1 = 65535

7. Digital Electronics: +5 Volts = 1_2 and GND = 0_2

Example:

234_{10} =

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
1	1	1	0	1	0	1	0



Digital Output Port
(e.g. USB-6211)

8. Turning on LEDs is a big deal