

Outline

- Digital CMOS design
 - Boolean algebra
 - Basic digital CMOS gates
 - Combinational and sequential circuits
 - Coding - Representation of numbers



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Digital Dessign

February 2010

Representing Numbers

How can I represent a Real number ?

2's complement Fixed Point :

The bits represents the successive powers of 2

$$\begin{array}{r}
 \begin{array}{cccc}
 & 0 & 1 & 0 & 0 \\
 & \nearrow & \nearrow & \nearrow & \nearrow \\
 & -2^3 & 2^0 & 2^{-1} & 2^{-4}
 \end{array}
 \end{array}
 \cdot 0110 = 2^2 + 2^{-2} + 2^{-3} = 4.375$$



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Representing Numbers

How can I represent a Real number ?

Range
Precision



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Representing Numbers

How can I represent a Real number ?

Wide range
High precision

Floating Point



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Representing Numbers

How can I represent a Real number ?

Normalized scientific representation

$$R = (-1)^S \times M \times 2^E$$

S : Sign (1 if negative)
 M : Mantissa ($\in [1, 2 [$)
 E : Exponent (relative number)



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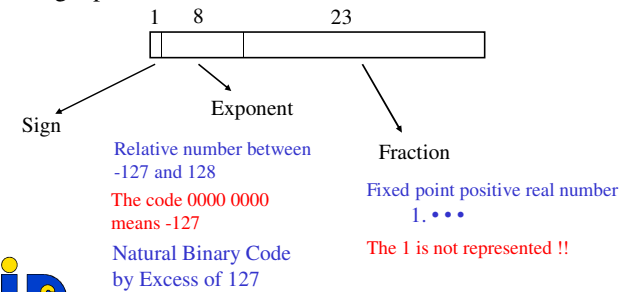
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Representing Numbers

$$R = (-1)^S \times M \times 2^E$$

Single precision :



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Representing Numbers

$$R = (-1)^S \times M \times 2^E$$

	Single Precision 32 bits	Double Precision 64 bits
S : Sign (1 if negative)	1 bit	1 bit
M : Mantissa ($\in [1, 2 [$)	23 bits	52 bits
E : Exponent	8 bits	11 bits



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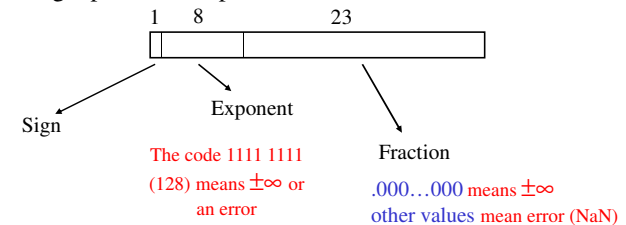
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Representing Numbers

$$R = (-1)^S \times M \times 2^E$$

Single precision : Special cases



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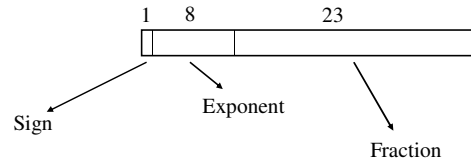
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Representing Numbers

$$R = (-1)^S \times M \times 2^E$$

Single precision : Range and precision



$$R \in]-2^{128}, 2^{128} [$$

$$\text{Precision} = 2^{-24+E}$$



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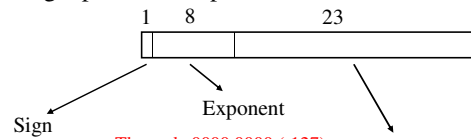
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Representing Numbers

$$R = (-1)^S \times M \times 2^E$$

Single precision : Special cases



The code 0000 0000 (-127)
indicates denormalized
Mantissa

0.00 ... 000 means 0



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