

# Binary Number System

- The binary number system is a radix-2 number system with '0' and '1' as the two independent digits
- All larger binary numbers are represented in terms of '0' and '1'.
- Instead of using ten digits, 0 - 9, the binary system uses only two digits, 0 and 1.
- Example

$$\begin{array}{ccccccc} \underline{1} & \underline{0} & \underline{0} & \underline{1} & \underline{1} & \underline{0} & \underline{1} \\ 2^6 & 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 \end{array}$$

- $1 \times 64 + 0 \times 32 + 0 \times 16 + 1 \times 8 + 1 \times 4 + 0 \times 2 + 1 \times 1 = 77$

# Converting from Binary to Decimal

$$\begin{array}{ccccccc} \underline{1} & \underline{0} & \underline{0} & \underline{1} & \underline{1} & \underline{0} & \underline{1} \\ 2^6 & 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 \end{array}$$

$$1 \times 2^0 = 1$$

$$0 \times 2^1 = 0$$

$$1 \times 2^2 = 4$$

$$1 \times 2^3 = 8$$

$$0 \times 2^4 = 0$$

$$0 \times 2^5 = 0$$

$$1 \times 2^6 = \underline{64}$$

$$77_{10}$$

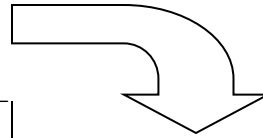
## Powers of 2

$N$	$2^N$	<i>Comments</i>
0	1	
1	2	
2	4	
3	8	
4	16	
5	32	
6	64	
7	128	
8	256	
9	512	
10	1,024	“Kilo” as $2^{10}$ is the closest power of 2 to 1,000 (decimal)
11	2,048	
15	32,768	$2^{15}$ Hz often used as clock crystal frequency in digital watches
20	1,048,576	“Mega” as $2^{20}$ is the closest power of 2 to 1,000,000 (decimal)
30	1,073,741,824	
		“Giga” as $2^{30}$ is the closest power of 2 to 1,000,000,000 (decimal)

# Cont...

## Negative Powers of 2

$N < 0$	$2^N$
-1	$2^{-1} = 0.5$
-2	$2^{-2} = 0.25$
-3	$2^{-3} = 0.125$
-4	$2^{-4} = 0.0625$
-5	$2^{-5} = 0.03125$
-6	$2^{-6} = 0.015625$
-7	$2^{-7} = 0.0078125$
-8	$2^{-8} = 0.00390625$
-9	$2^{-9} = 0.001953125$
-10	$2^{-10} = 0.0009765625$
...	



Binary numbers less than 1

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*Binary*

*Decimal value*

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$$0.101101 = 1 \times 2^{-1} + 1 \times 2^{-3} + 1 \times 2^{-4} + 1 \times 2^{-6} = 0.703125$$

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