Digital signals and Binary systems

Signals systems

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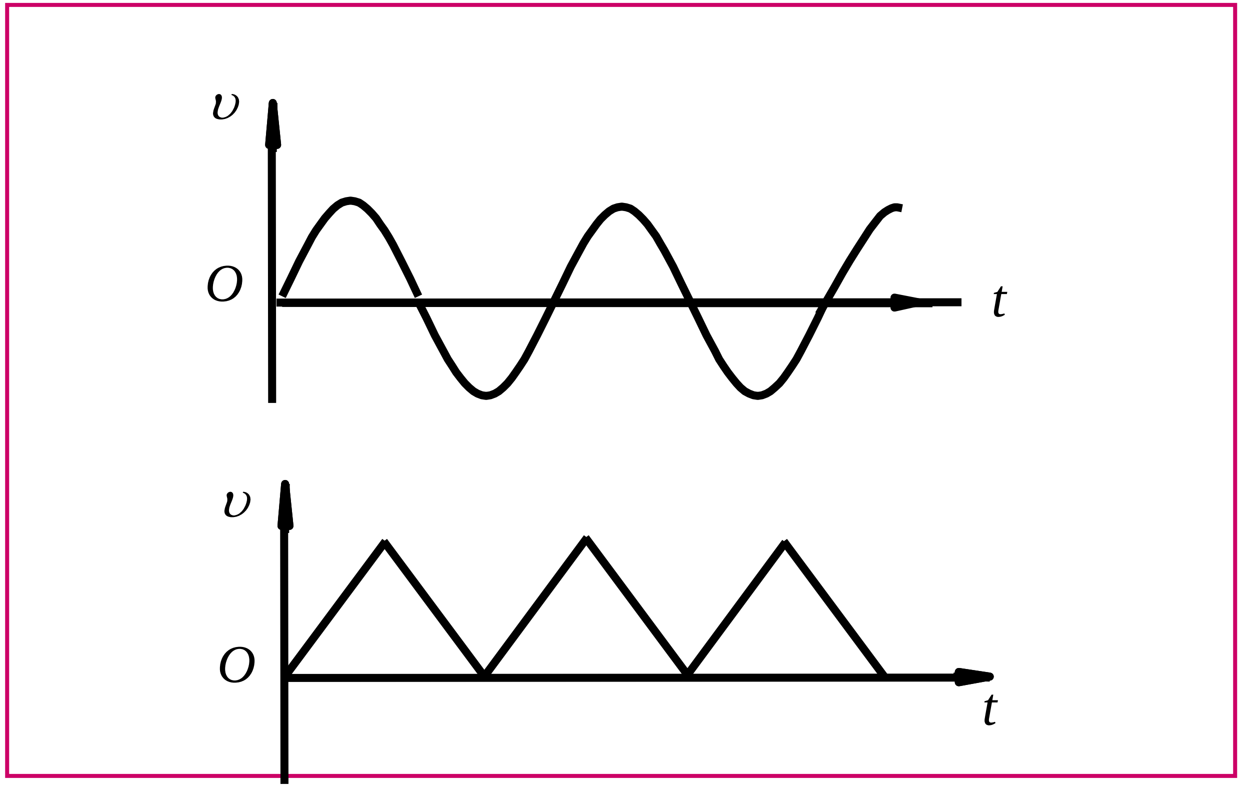
Website: https://www.bilibili.com/video/BV1CZ4y1j7hs/?spm_id_from=333.337.search-card.all.click&vd_source=ed912de2a7c8e9d44920a04fb9487f94

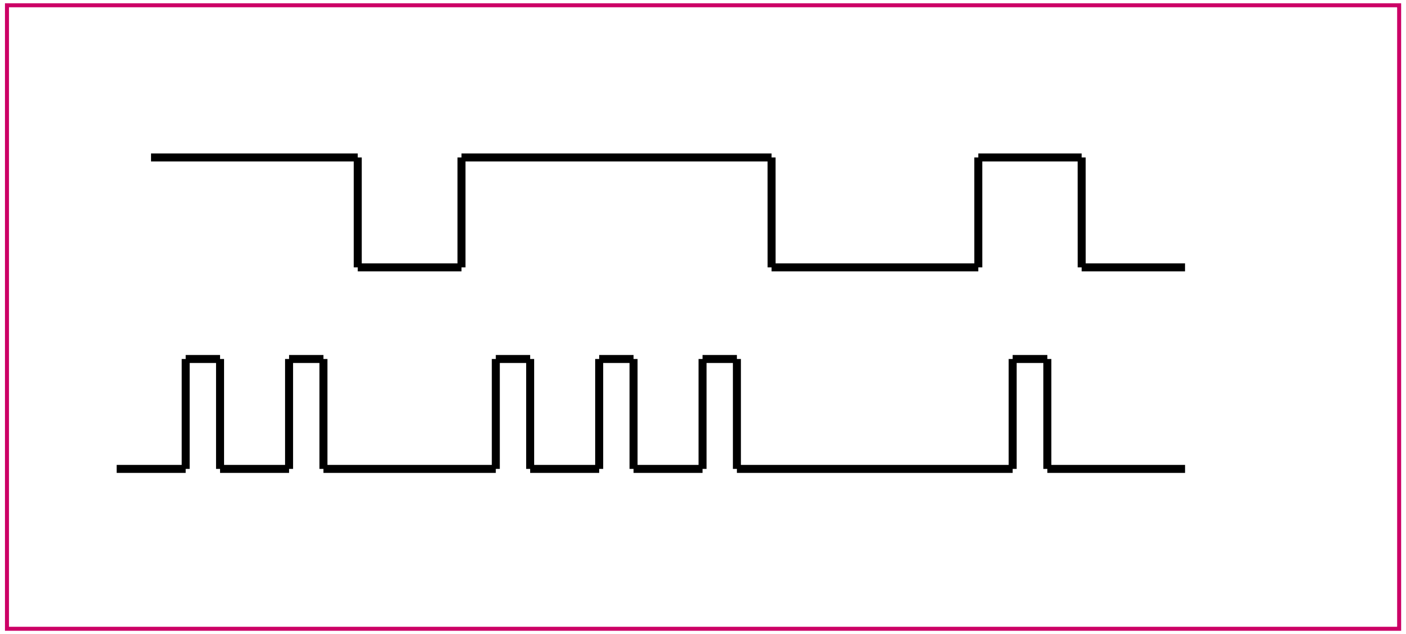
1.Analog signal

Electrical signals with continuous changes in time and value, such as sine waves, triangular waves, etc.



2. Digital signals

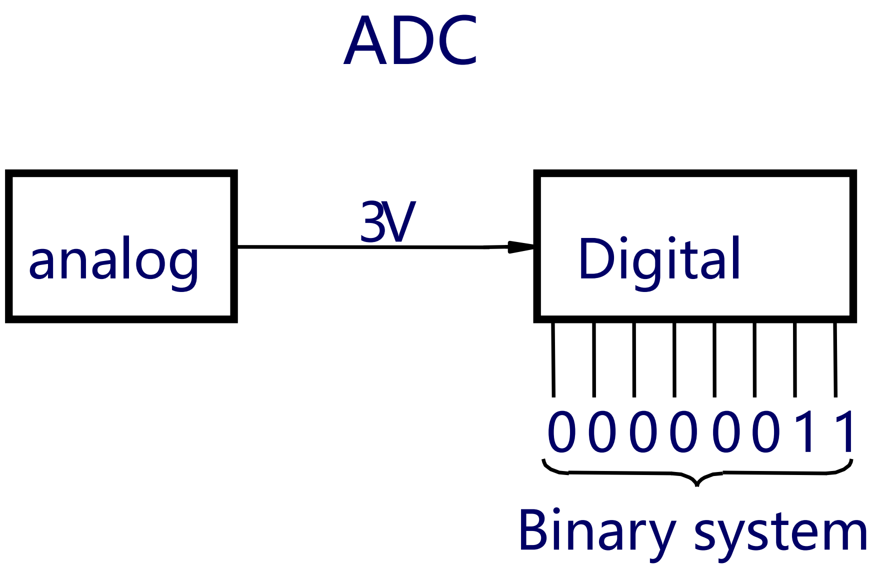
A discrete signal in both time and value.

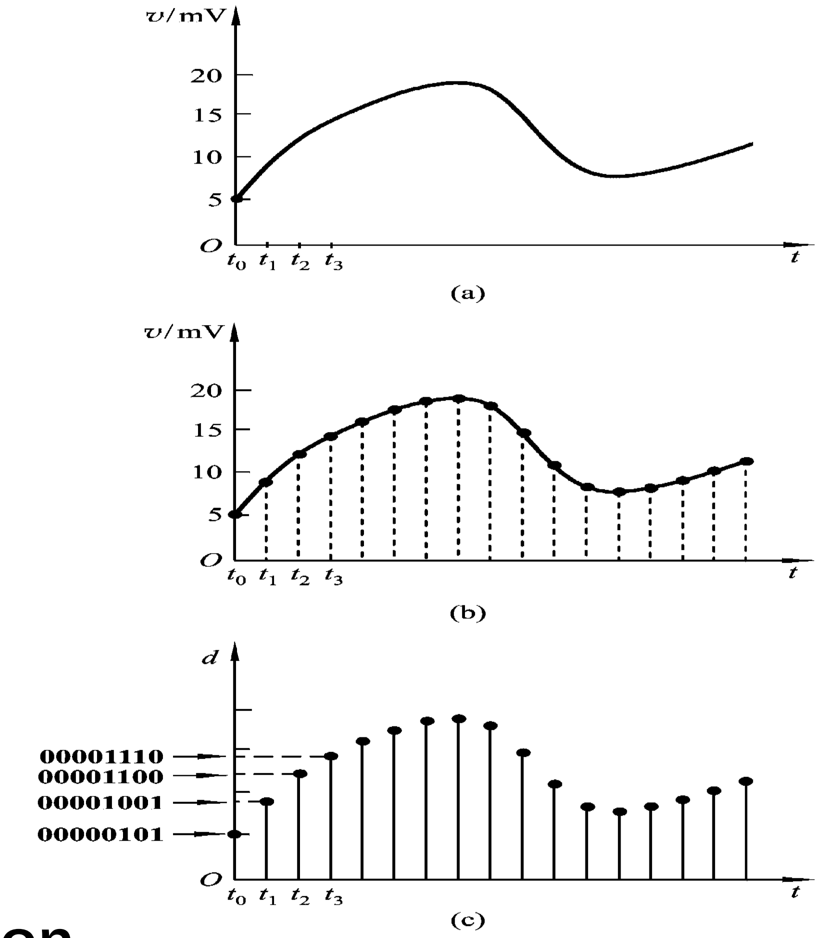


Digital circuits and analog circuits: working signals, different objects of study, the methods of analysis, design and mathematical tools used are also different.

3.Analog-digital conversion-----ADC

Because digital signals are easy to store, analyze and transmit, analog signals are often converted to digital signals.





Mathematical tool: Discretization

Calculus and convolution

4.Sampling and aliasing

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5.Description of digital signals
-Binary digital logic and logic voltage level

Binary digital logic:

a. Only use 0, 1 digit -- binary number when representing quantity
b. Expressing the state of things is called two-valued logic

Such as： Switch-on 1
Switch-off 0

Logic voltage level:

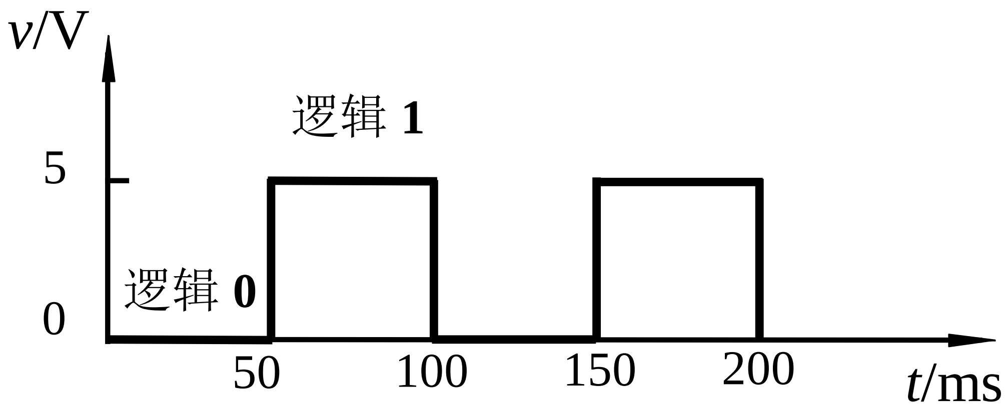
Logic level and Voltage value （Positive logic）

Voltage(V)	Binary logic	Logic level
+5	1	H(high)
0	0	L(low)

Digital waveform

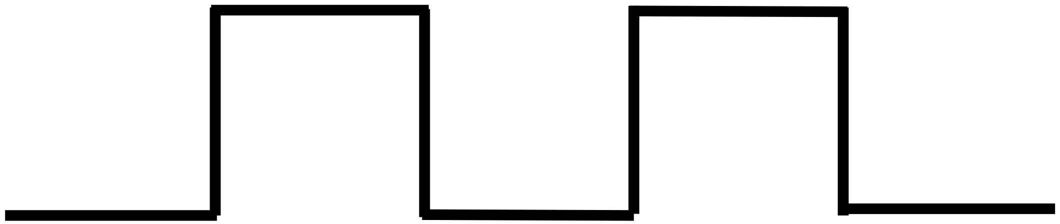
The digital waveform ------ is a graphical representation of the signal logic level against time.

Logic level description

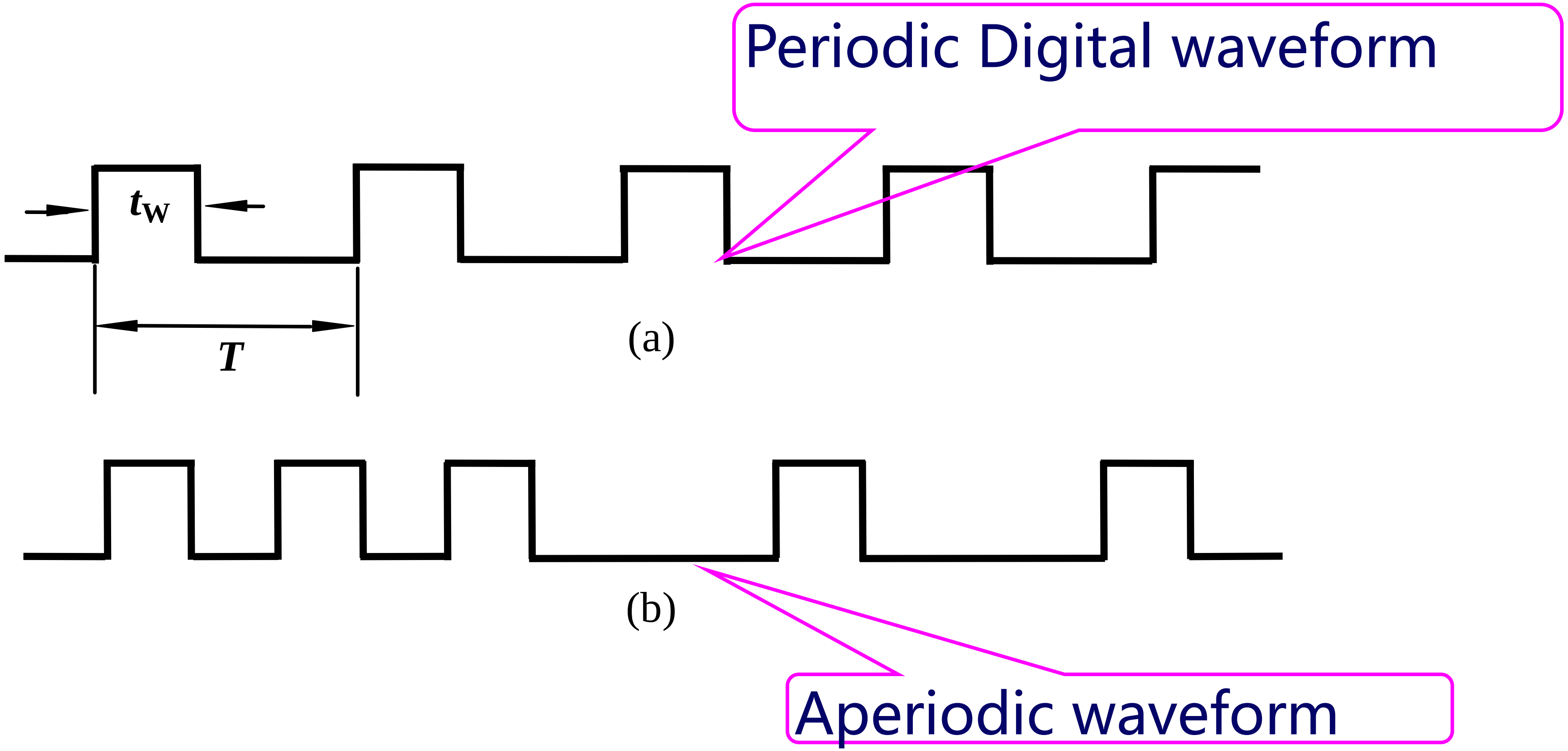


Only 0&1

Conventional description



Periodic and aperiodic



For Periodic Digital waveform: $q(\%) = \dfrac{t_W}{T} \times 100\%$ (**Duty cycle**)

例1.1.2 设周期性数字波形的高电平持续6ms，低电平持续10ms，求占空比q。

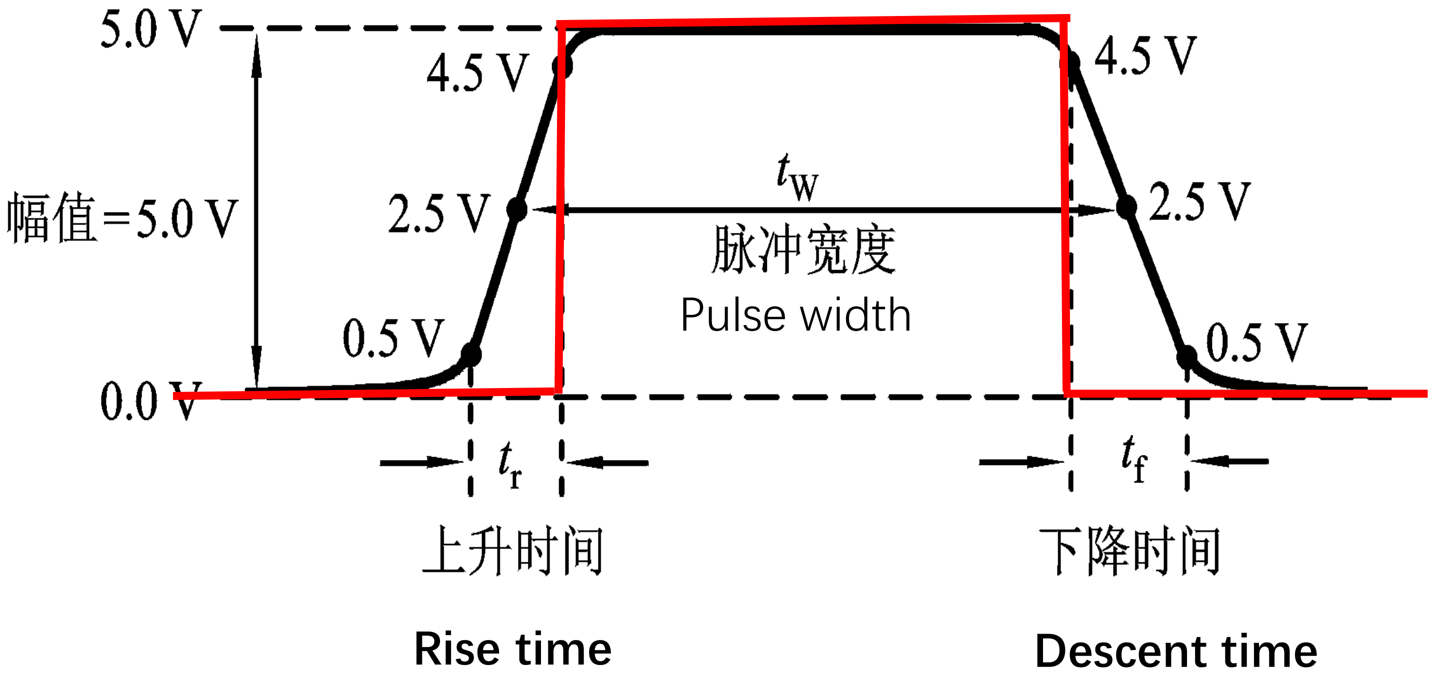
解：因数字波形的脉冲宽度t_w=6ms，周期T=6ms+10ms=16ms。

$$q = \frac{6\text{ms}}{16\text{ms}} \times 100\% = 37.5\%$$

Actual pulse waveform and main parameters

理想脉冲波形- Ideal waveform

非理想脉冲波形-Actual pulse waveform



Binary system

Number system: The formation of each digit in a multi-digit number and the rules for carrying from low to high.

Decimal number system: 0,1,2,3,4,5,6,7,8,9

______The number system most commonly used in daily life

The carry rule is "every ten to one."

Polynomial expansion:

$$4587.29=4\times10^{3}+5\times10^{2}+8\times10^{1}+7\times10^{0}+2\times10^{-1}+9\times10^{-2}$$

coefficient

digit weight

General expression:

$$(N)_D = \sum_{i=-\infty}^{\infty} K_i \times 10^i$$

Each weights are all powers of 10.

imitate

The general expression for an arbitrary base number is:

$$(N)_r = \sum_{i=-\infty}^{\infty} K_i \times r^i$$

The general expression for a binary number is:

coefficient

Digit weight

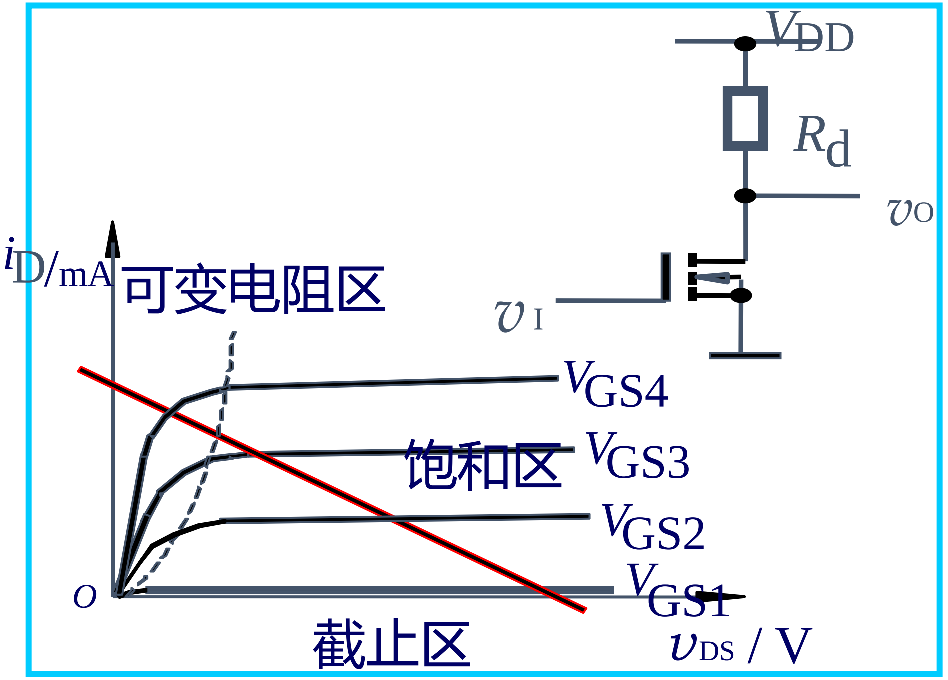
$$(N)_B = \sum_{i=-\infty}^{\infty} K_i \times 2^i$$

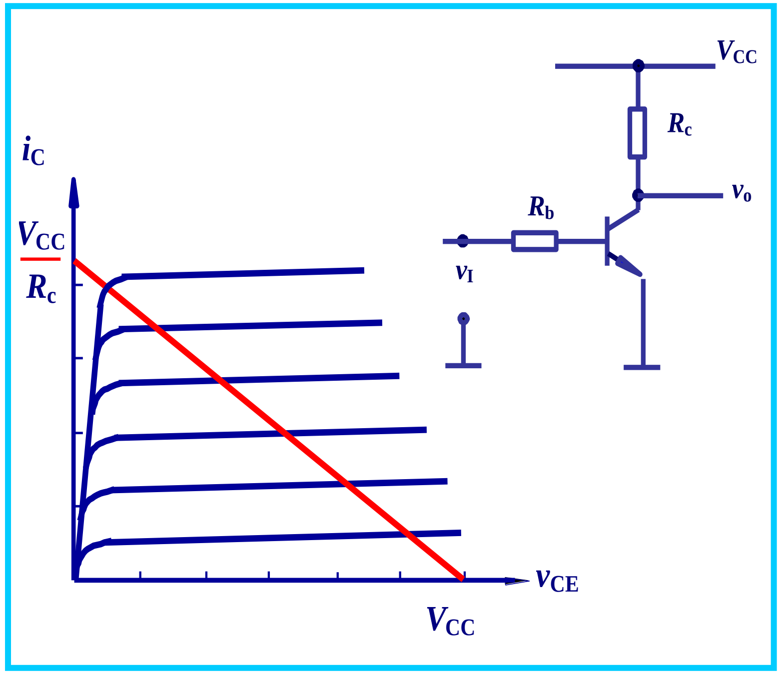
Each weights are all powers of 2.

0000-0
0001-1
0010-2
0011-3
…

1.Advantages of binary:

(1) Easy to circuit expression: 0, 1 two values, can be expressed by the tube on or off, light bulb or off, the relay contact closed or disconnected.。

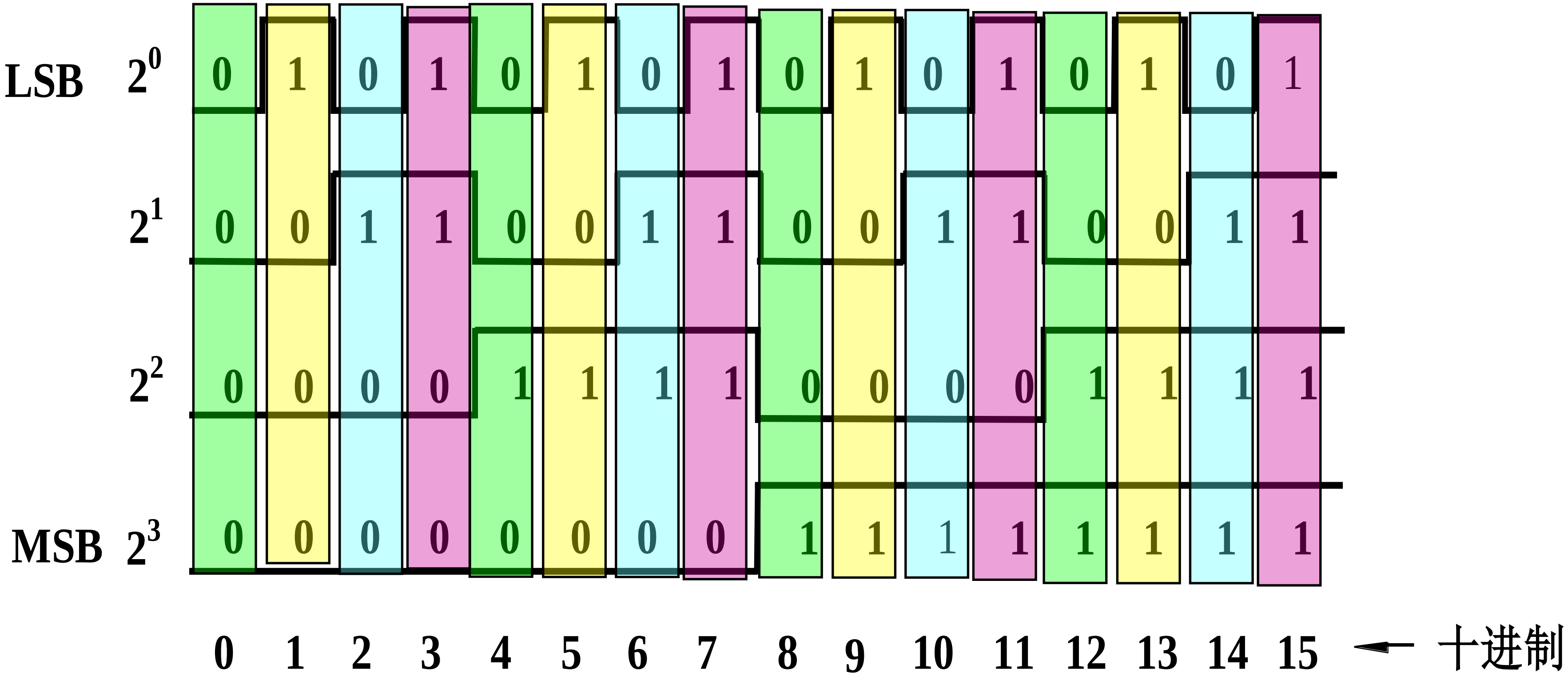




（2）The binary digital device uses fewer components, and the circuit is simple and reliable.

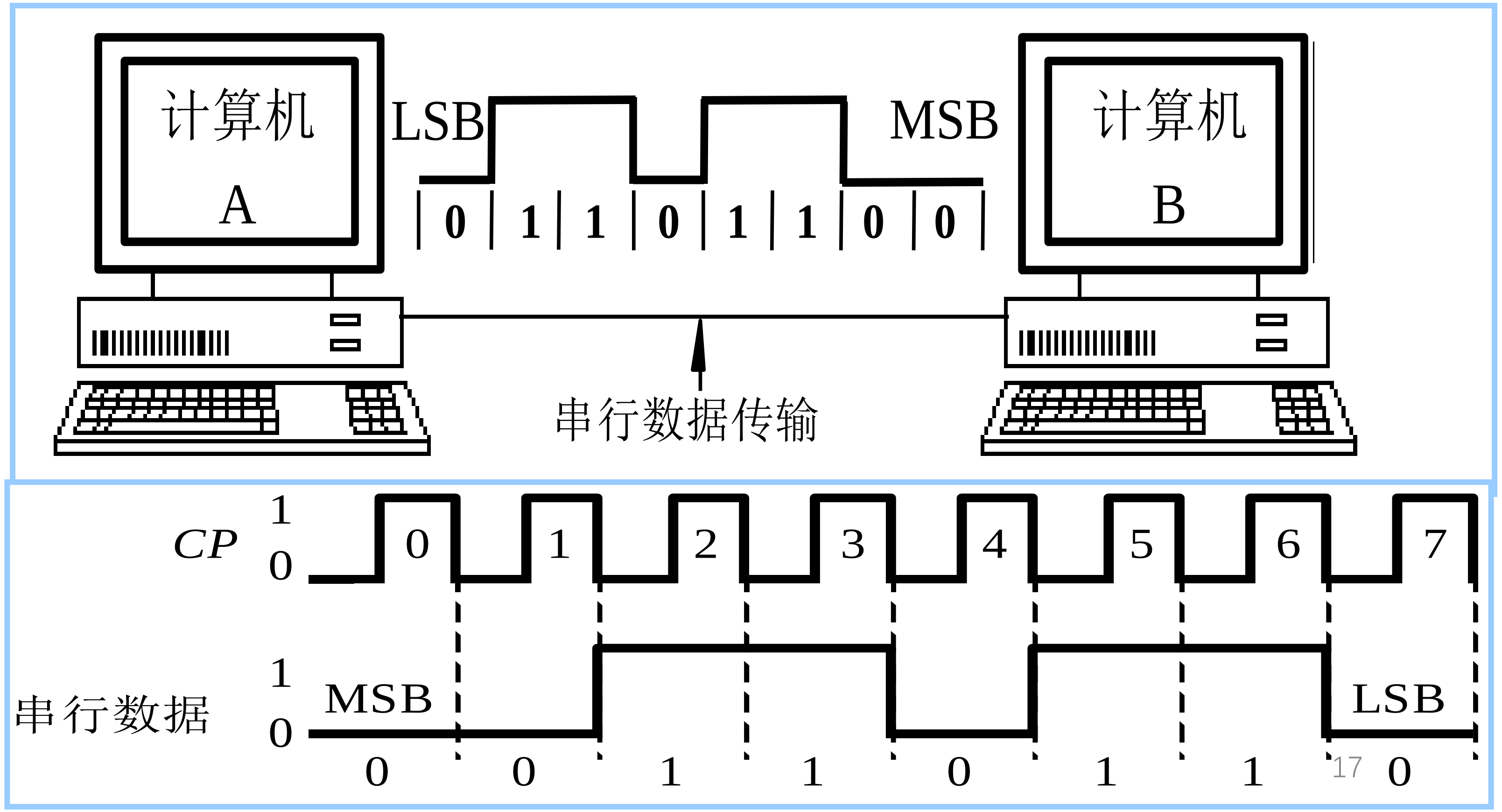
（3）The basic operation rules are simple and the operation is convenient.

2. Binary number waveform representation:



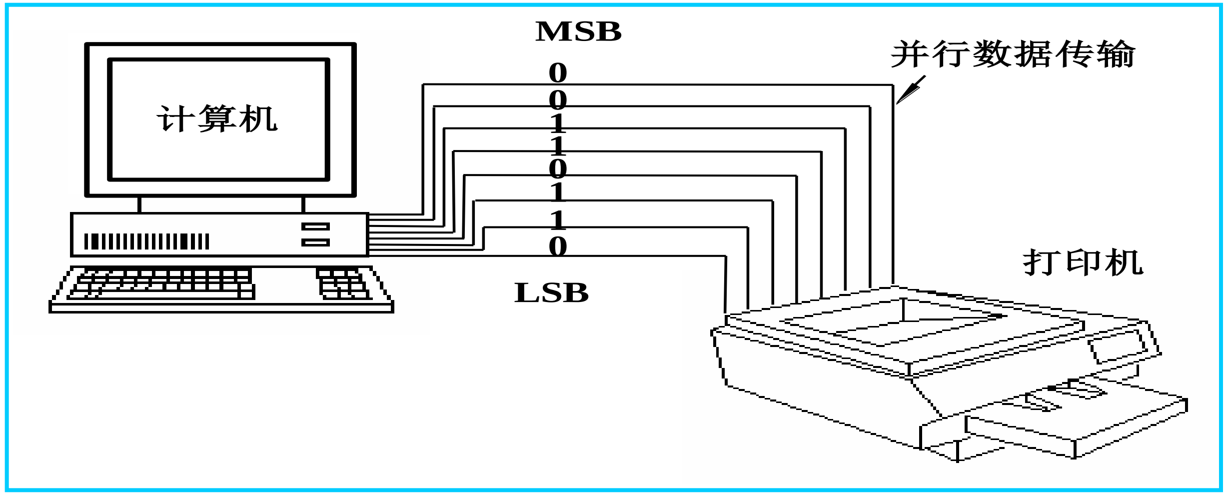
3. Transmission of binary data

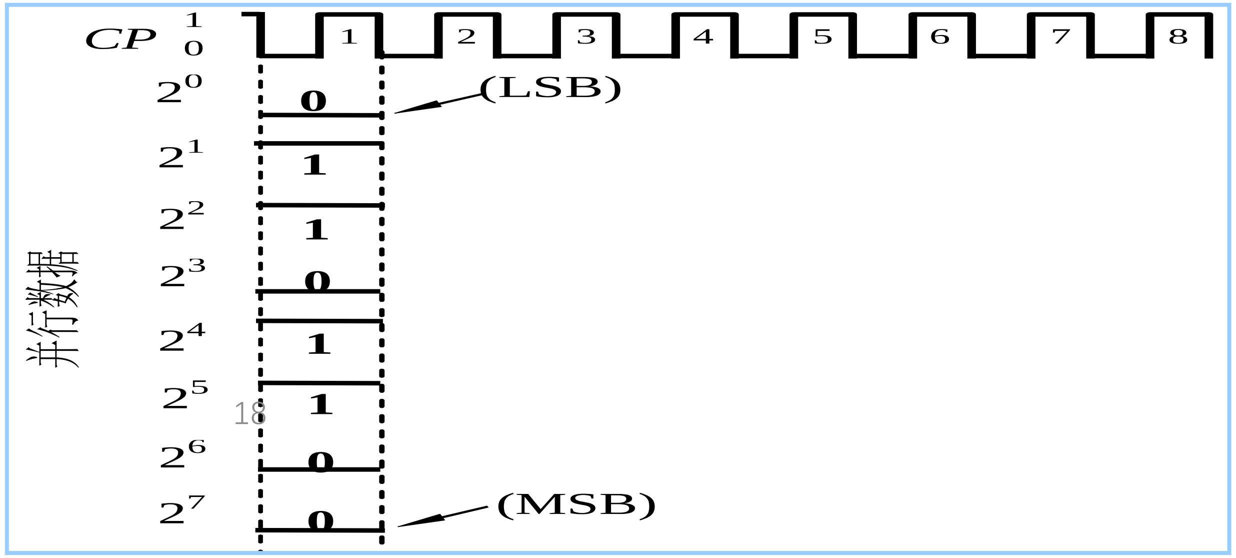
(1) Serial transmission of binary data



（2）Parallel transmission of binary data

To transmit all bits of a set of binary data simultaneously.
The transmission rate is fast, but the data line is more, and the sending and receiving equipment is more complex.





Conversion between binary and decimal

Decimal numbers are converted to binary numbers： a. Integral part
b. Fractional part

a. Integer conversion

"Toss and turn" method:

The decimal number is continuously divided by 2 until the quotient is zero, and the remaining number is arranged from low to high, that is, the desired binary number.

Q1:Converts a decimal number $(37)_D$ to a binary number.

2	37	…………… 1	……b_0
2	18	…………… 0	……b_1
2	9	…………… 1	……b_2
2	4	…………… 0	……b_3
2	2	…………… 0	……b_4
2	1	…………… 1	……b_5
	0		

So, $(37)_D=(100101)_B$

Q2: Converts $(133)_D$ to a binary number.

Because $2^7=128$

And $133 - 128=5=2^2 + 2^0$

So the corresponding binary number b7=1, b2=1, b0=1, and the other coefficients are 0, so we get

$$(133)_D=(10000101)_B$$

b. Conversion of decimal's **Fractional part**:

For the fractional part of binary can be written:

$$(N)_{\mathrm{D}} = b_{-1} \times 2^{-1} + b_{-2} \times 2^{-2} + \cdots + b_{-(\mathrm{n}-1)} \times 2^{-(\mathrm{n}-1)} + b_{-n} \times 2^{-n}$$

Multiply both sides of the above equation by 2, and you get:

$$2 \times (N)_{\mathrm{D}} = b_{-1} \times 2^{0} + b_{-2} \times 2^{-1} + \cdots + b_{-(\mathrm{n}-1)} \times 2^{-(\mathrm{n}-2)} + b_{-n} \times 2^{-(\mathrm{n}-1)}$$

Thus, multiply the decimal fractional number by 2, and the integer of the resulting product is b_{-1} .

For example:

To convert a decimal fraction (0.39)D to a binary number, an accuracy of 1% is required.

Since the accuracy is required to reach 1%, it needs to be accurate to 7 decimal places in binary, that is $1/2^7=1/128$.

$0.39\times 2=\boxed{0}.78$	$b_{-1}=\boxed{0}$	$0.24\times 2=\boxed{0}.48$	$b_{-5}=\boxed{0}$
$0.78\times 2=\boxed{1}.56$	$b_{-2}=\boxed{1}$	$0.48\times 2=\boxed{0}.96$	$b_{-6}=\boxed{0}$
$0.56\times 2=\boxed{1}.12$	$b_{-3}=\boxed{1}$	$0.96\times 2=\boxed{1}.92$	$b_{-7}=\boxed{1}$
$0.12\times 2=\boxed{0}.24$	$b_{-4}=\boxed{0}$	$0.92\times 2=\boxed{1}.84$	$b_{-8}=\boxed{1}$

When calculating, it is necessary to calculate 1 bit more, and then consider "4 round 5". $b_{-8}=1$ generates carry.

$$(0.39)_D=(0.0110010)_B$$

二进制的算术运算- Binary arithmetic operations

1. Unsigned binary number arithmetic operation

2.Signed binary number arithmetic operation

1. Unsigned binary number arithmetic operation

Addition rules for unsigned binary:

$0+0=0$, $0+1=1$, $1+1=10$

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

"Every two into one“!!!

1. Unsigned binary number arithmetic operation

Subtraction rules for unsigned binary numbers:

$$0-0=0,\quad 1-1=0,\quad 1-0=1\quad \boxed{0-1=11}$$

$$\begin{array}{r} 1\ 0\ 1\ 0 \\ -\ 0\ 1\ 0\ 1 \\ \hline 0\ 1\ 0\ 1 \end{array}$$

2.Signed binary number arithmetic operation

The highest bit of the binary number represents the sign bit, and 0 represents the positive number and 1 represents the negative number. The rest of the code is used to represent numeric bits.

$$(+11)_D = (0\ 1011)_B$$
$$(-11)_D = (1\ 1011)_B$$

OIC

Original code, Inverse code and Complement code

The highest bit of the complement or inverse code is the sign bit, the positive number is 0, and the negative number is 1.
When the binary number is positive, its complement and inverse code are the same as the original code.
When the binary number is negative, the numeric digit of the original code is inverted bit by bit, and then the complement is obtained by adding 1 in the lowest position.

Use OIC to help us with signed binary arithmetic operations.

Subtracting A positive number is equivalent to adding A negative number.

A-B=A+(-B)

We can complementing (-B), and then adding.

Decimal	Binary		
	O	I	C
–8	—	—	1 0 0 0
–7	1 1 1 1	1 0 0 0	1 0 0 1
–6	1 1 1 0	1 0 0 1	1 0 1 0
–5	1 1 0 1	1 0 1 0	1 0 1 1
–4	1 1 0 0	1 0 1 1	1 1 0 0
–3	1 0 1 1	1 1 0 0	1 1 0 1
–2	1 0 1 0	1 1 0 1	1 1 1 0
–1	1 0 0 1	1 1 1 0	1 1 1 1
–0	1 0 0 0	1 1 1 1	0 0 0 0
+0	0 0 0 0	0 0 0 0	0 0 0 0
+1	0 0 0 1	0 0 0 1	0 0 0 1
+2	0 0 1 0	0 0 1 0	0 0 1 0
+3	0 0 1 1	0 0 1 1	0 0 1 1
+4	0 1 0 0	0 1 0 0	0 1 0 0
+5	0 1 0 1	0 1 0 1	0 1 0 1
+6	0 1 1 0	0 1 1 0	0 1 1 0
+7	0 1 1 1	0 1 1 1	0 1 1 1

Q3: Try 4-bit binary complement calculation 5-2.

解：因为$(5-2)_{补}=(5)_{补}+(-2)_{补}$
$=0101+1110$
$=0011$
所以 $5-2=3$

$$
\begin{array}{r}
0\ 1\ 0\ 1 \\
+\ 1\ 1\ 1\ 0 \\
\hline
\boxed{1}\ 0\ 0\ 1\ 1
\end{array}
$$

Remove it ↲

Overflow-溢出

Q4：Try the 4-bit binary complement to calculate 5+7.

解：因为$(5+7)_{补}=(5)_{补}+(7)_{补}$

$=0101+0111$

$=1100$

$$
\begin{array}{r}
0\ 1\ 0\ 1 \\
+\ \ 0\ 1\ 1\ 1 \\
\hline
[1]\ 1\ 0\ 0
\end{array}
$$

Remove it? Or not?

Solution to overflow: Do bit expansion

二进制代码-----Binary code

1.Binary Code Decimal-------BCD code

Decimal code	8421 code	2421code	5421 code	Remainder 3 code	Remainder 3 cyclic codes
0	0000	0000	0000	0011	0010
1	0001	0001	0001	0100	0110
2	0010	0010	0010	0101	0111
3	0011	0011	0011	0110	0101
4	0100	0100	0100	0111	0100
5	0101	1011	1000	1000	1100
6	0110	1100	1001	1001	1101
7	0111	1101	1010	1010	1111
8	1000	1110	1011	1011	1110
9	1001	1111	1100	1100	1010

Rights code: Easy conversion between the encoding and the represented decimal number.

Some cases:

$$(10010000)_{8421BCD}=(90)_D$$

$$[0111]_{8421BCD}=0\times 8+1\times 4+1\times 2+1\times 1=(7)_D$$

$$[1101]_{2421BCD}=1\times 2+1\times 4+0\times 2+1\times 1=(7)_D$$

$$(463.5)_{10}=\left[\underset{4}{\underline{0100}}\ \underset{6}{\underline{0110}}\ \underset{3}{\underline{0011}}.\ \underset{5}{\underline{0101}}\right]_{8421BCD}$$

Must reserved!

$$(863.2)_{10}=\left[\underset{8}{\underline{1110}}\ \underset{6}{\underline{1100}}\ \underset{3}{\underline{0011}}.\ \underset{2}{\underline{0010}}\right]_{2421BCD}$$

Must reserved!

格雷码----Gray code

Weighted code: There is no numerical connection between the codes.

There is only one difference between any two adjacent codes.

Binary code $b_3b_2b_1b_0$	Gray code $G_3G_2G_1G_0$
0000	0000
0001	0001
0010	0011
0011	0010
0100	0110
0101	0111
0110	0101
0111	0100
1000	1100
1001	1101
1010	1111
1011	1110
1100	1010
1101	1011
1110	1001
1111	1000

ASCII code (character encoding)

ASCII is the American Standard Information Interchange Code.

高四位 / 低四位		ASCII非打印控制字符										ASCII 打印字符												
		0000					0001					0010		0011		0100		0101		0110		0111		
		0					1					2		3		4		5		6		7		
		十进制	字符	ctrl	代码	字符解释	十进制	字符	ctrl	代码	字符解释	十进制	字符	十进制	字符	十进制	字符	十进制	字符	十进制	字符	十进制	字符	ctrl
0000	0	0	BLANK NULL	^@	NUL	空	16	►	^P	DLE	数据链路转意	32		48	0	64	@	80	P	96	`	112	p	
0001	1	1	☺	^A	SOH	头标开始	17	◄	^Q	DC1	设备控制 1	33	!	49	1	65	A	81	Q	97	a	113	q	
0010	2	2	☻	^B	STX	正文开始	18	↕	^R	DC2	设备控制 2	34	"	50	2	66	B	82	R	98	b	114	r	
0011	3	3	♥	^C	ETX	正文结束	19	‼	^S	DC3	设备控制 3	35	#	51	3	67	C	83	S	99	c	115	s	
0100	4	4	◆	^D	EOT	传输结束	20	¶	^T	DC4	设备控制 4	36	$	52	4	68	D	84	T	100	d	116	t	
0101	5	5	♣	^E	ENQ	查询	21	§	^U	NAK	反确认	37	%	53	5	69	E	85	U	101	e	117	u	
0110	6	6	♠	^F	ACK	确认	22	■	^V	SYN	同步空闲	38	&	54	6	70	F	86	V	102	f	118	v	
0111	7	7	●	^G	BEL	震铃	23	↨	^W	ETB	传输块结束	39	'	55	7	71	G	87	W	103	g	119	w	
1000	8	8	◘	^H	BS	退格	24	↑	^X	CAN	取消	40	(	56	8	72	H	88	X	104	h	120	x	
1001	9	9	○	^I	TAB	水平制表符	25	↓	^Y	EM	媒体结束	41	)	57	9	73	I	89	Y	105	i	121	y	
1010	A	10	◙	^J	LF	换行/新行	26	→	^Z	SUB	替换	42	*	58	:	74	J	90	Z	106	j	122	z	
1011	B	11	♂	^K	VT	竖直制表符	27	←	^[	ESC	转意	43	+	59	;	75	K	91	[	107	k	123	{	
1100	C	12	♀	^L	FF	换页/新页	28	∟	^\	FS	文件分隔符	44	,	60	<	76	L	92	\	108	l	124	|	
1101	D	13	♪	^M	CR	回车	29	↔	^]	GS	组分隔符	45	-	61	=	77	M	93	]	109	m	125	}	
1110	E	14	♫	^N	SO	移出	30	▲	^6	RS	记录分隔符	46	.	62	>	78	N	94	^	110	n	126	~	
1111	F	15	☼	^O	SI	移入	31	▼	^-	US	单元分隔符	47	/	63	?	79	O	95	_	111	o	127	⌂	^Back space

Keyboard