

Other Binary Codes (3A)

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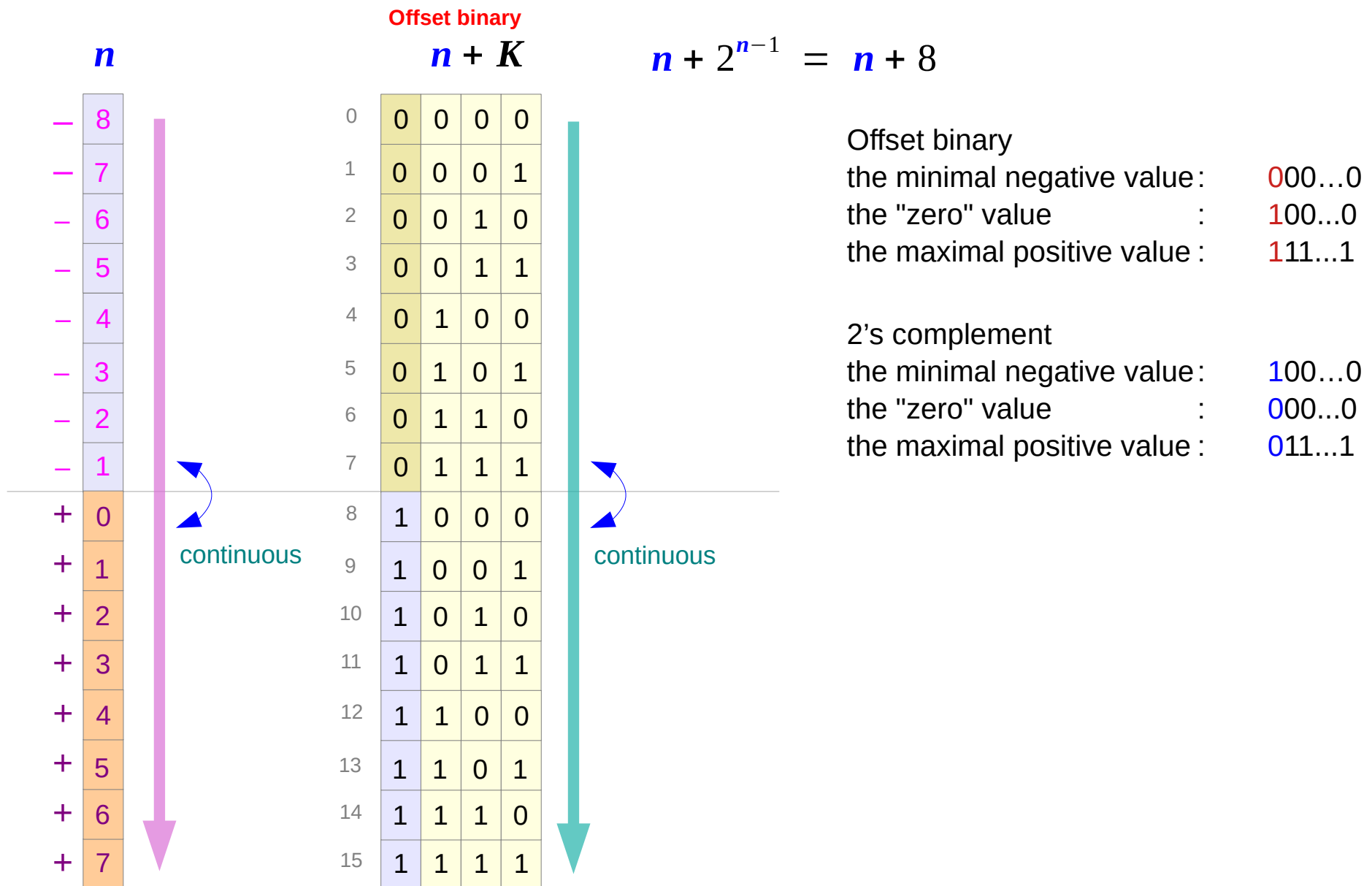
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Offset Binary

Offset Binary (Excess-K) Code

code for signed number representation
where a signed number n is represented
by the bit pattern corresponding
to the unsigned number $n+K$,
 K being the biasing value or offset.

Offset Binary (Excess K) Code



Comparisons w.r.t. bit patterns

bit patters

0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
0	1	0	0
0	1	0	1
0	1	1	0
0	1	1	1
1	0	0	0
1	0	0	1
1	0	1	0
1	0	1	1
1	1	0	0
1	1	0	1
1	1	1	0
1	1	1	1

2's complement

+	0
+	1
+	2
+	3
+	4
+	5
+	6
+	7
-	8
-	7
-	6
-	5
-	4
-	3
-	2
-	1

1's complement

+	0
+	1
+	2
+	3
+	4
+	5
+	6
+	7
-	7
-	6
-	5
-	4
-	3
-	2
-	1
-	0

sign magnitude

+	0
+	1
+	2
+	3
+	4
+	5
+	6
+	7
-	0
-	1
-	2
-	3
-	4
-	5
-	6
-	7

Offset binary

-	8
-	7
-	6
-	5
-	4
-	3
-	2
-	1
+	0
+	1
+	2
+	3
+	4
+	5
+	6
+	7

Comparisons w.r.t. decimal numbers

Decimal numbers

2's complement

1's complement

sign magnitude

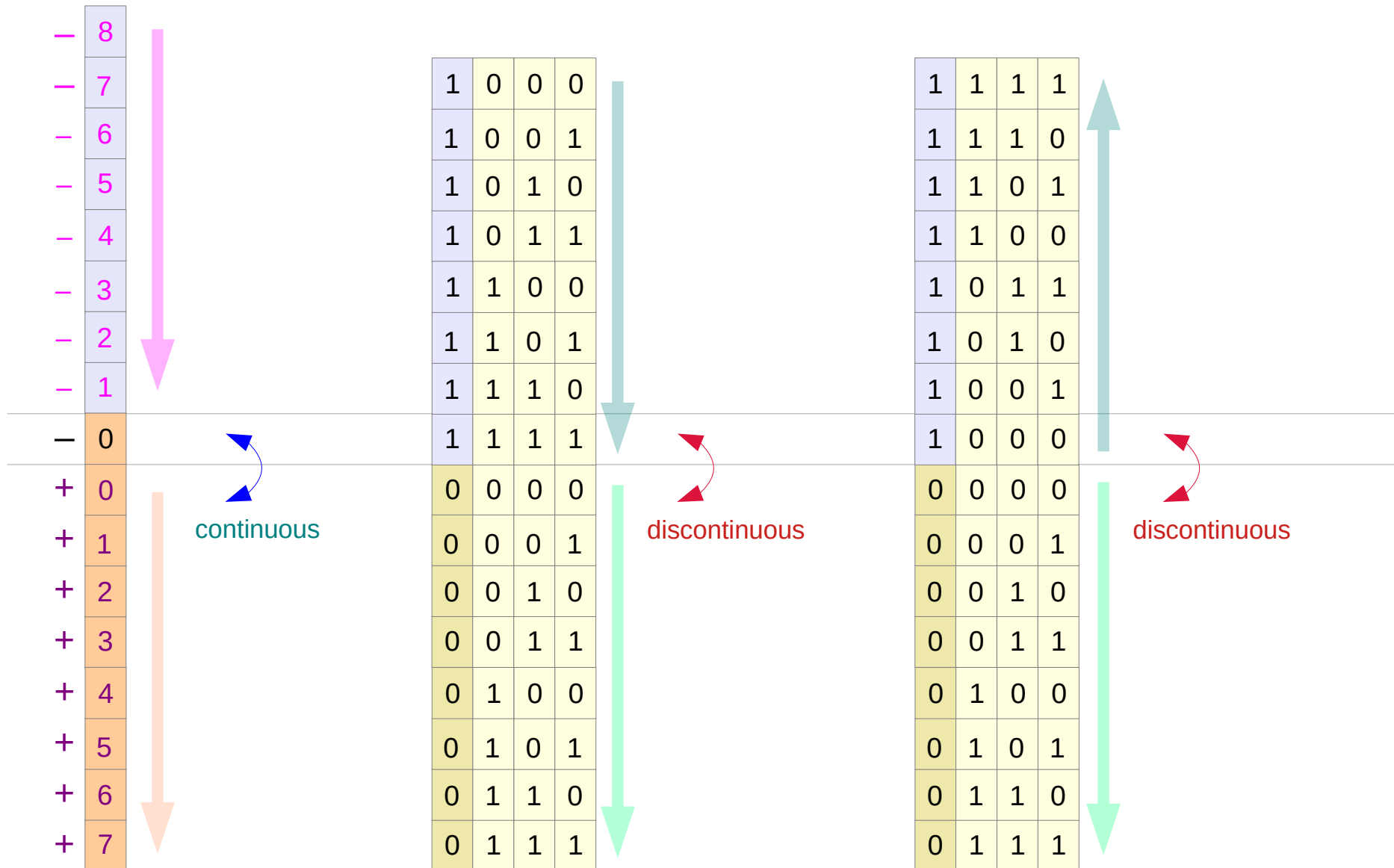
Offset binary

- 8	1	0	0	0	1	0	0	0	0	0	0	0	0
- 7	1	0	0	1	1	0	0	1	1	1	1	0	1
- 6	1	0	1	0	1	0	0	1	1	1	0	0	1
- 5	1	0	1	1	1	0	1	0	1	0	1	1	0
- 4	1	1	0	0	1	0	1	1	1	0	0	0	1
- 3	1	1	0	1	1	1	0	0	0	1	1	0	0
- 2	1	1	1	0	1	1	0	1	0	0	1	1	0
- 1	1	1	1	1	1	1	1	0	1	0	1	1	1
- 0					1	1	1	1	1	0	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	1
+ 2	0	0	1	0	0	0	1	0	0	0	1	0	0
+ 3	0	0	1	1	0	0	1	1	0	0	1	1	0
+ 4	0	1	0	0	0	1	0	0	0	1	0	0	1
+ 5	0	1	0	1	0	1	0	1	0	1	0	1	0
+ 6	0	1	1	0	0	1	1	0	0	1	1	0	1
+ 7	0	1	1	1	0	1	1	1	0	1	1	1	0

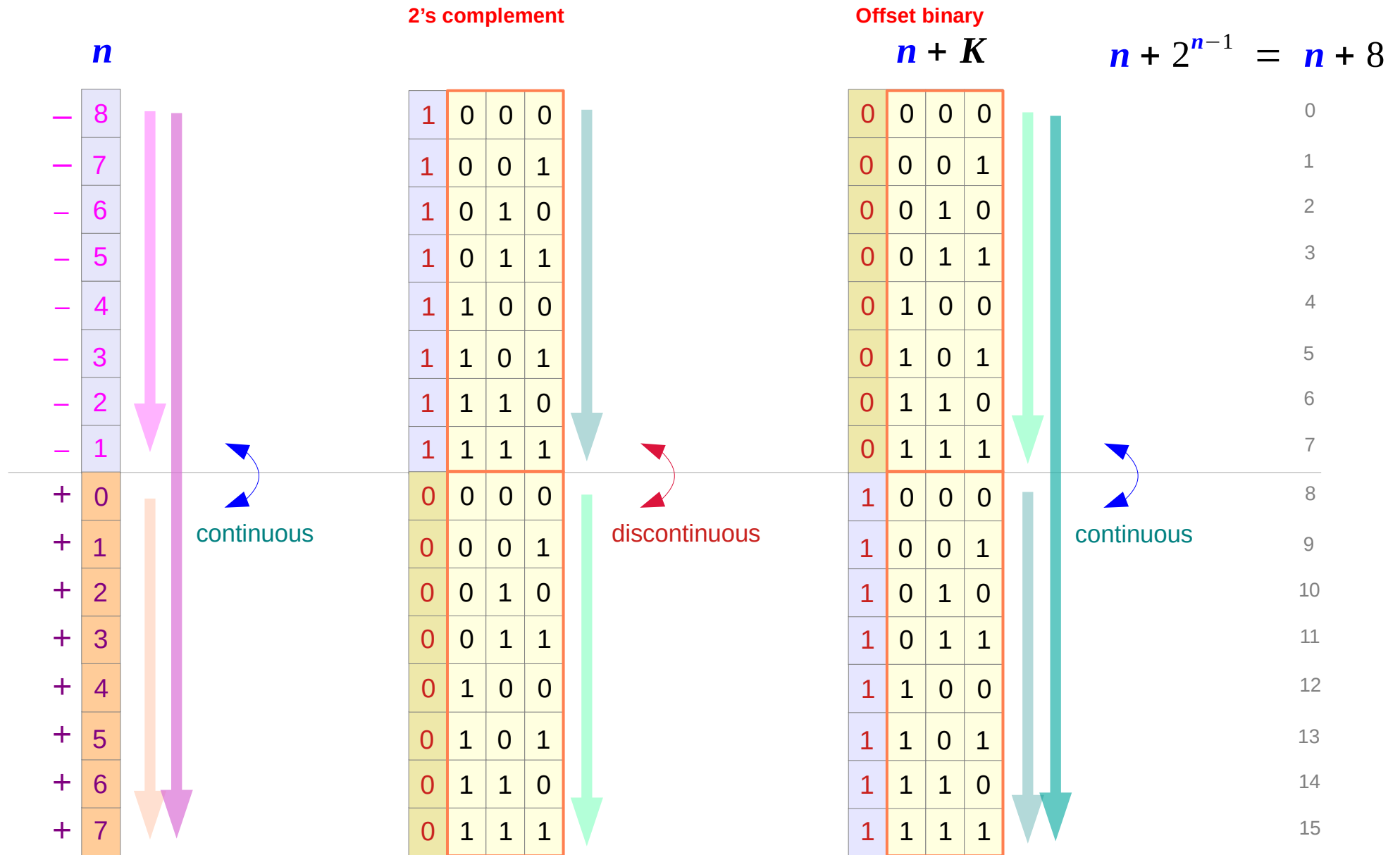
1's complement vs. sign magnitude

1's complement

sign magnitude



2's complement vs. offset binary



Logical vs. numerical comparisons

a logical comparison (unsigned comparison)
a numerical comparison (signed comparison)

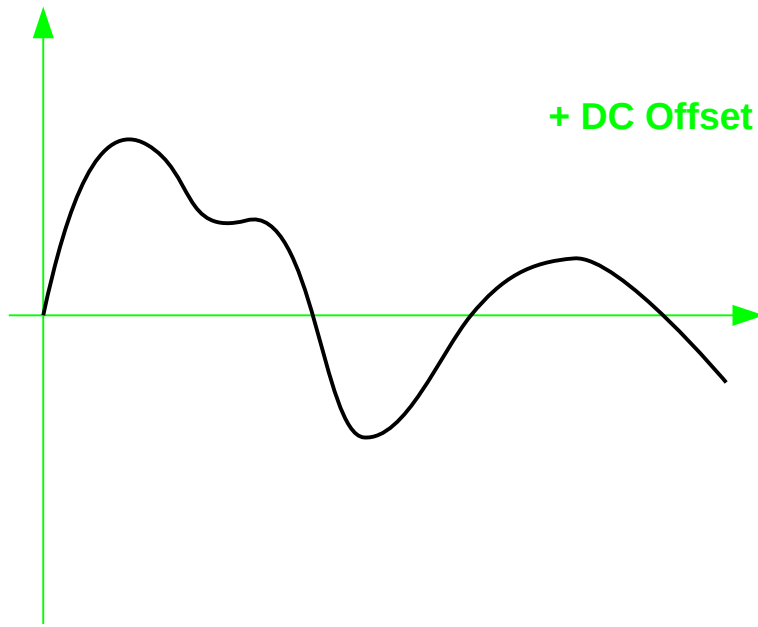
offset binary representation :
the same results

two's complement notation :
the same result only for same signed numbers
otherwise inverted results

		2's complement				Offset binary			
-	8	1	0	0	0	0	0	0	0
-	7	1	0	0	1	0	0	0	1
-	6	1	0	1	0	0	0	1	0
-	5	1	0	1	1	0	0	1	1
-	4	1	1	0	0	0	1	0	0
-	3	1	1	0	1	0	1	0	1
-	2	1	1	1	0	0	1	1	0
-	1	1	1	1	1	0	1	1	1
+	0	0	0	0	0	1	0	0	0
+	1	0	0	0	1	1	0	0	1
+	2	0	0	1	0	1	0	1	0
+	3	0	0	1	1	1	0	1	1
+	4	0	1	0	0	1	1	0	0
+	5	0	1	0	1	1	1	0	1
+	6	0	1	1	0	1	1	1	0
+	7	0	1	1	1	1	1	1	1

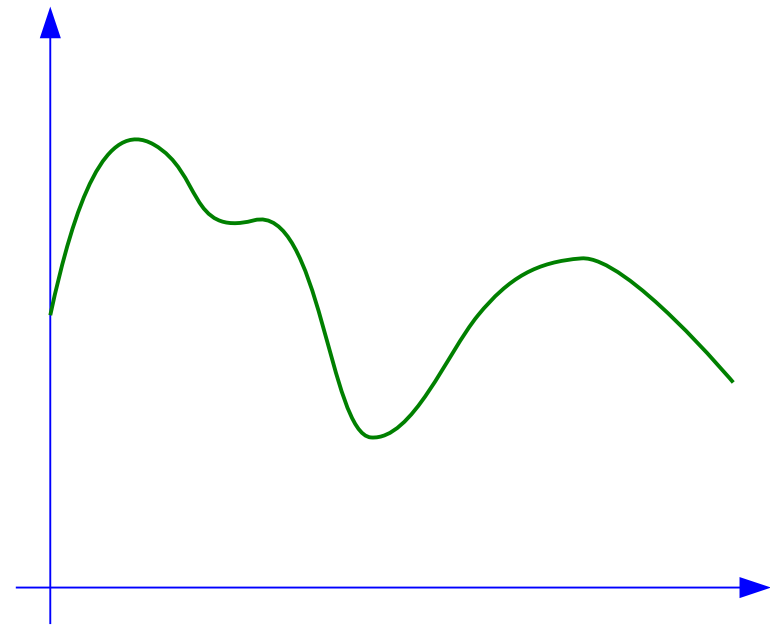
Offset Binary and ADC / DAC

Bipolar Signal



2's complement

Unipolar Signal



Offset binary

Excess K-1 Code

n		2's complement	Excess K $n + K$	n	Excess K-1 $n + K - 1$
- 8		1 0 0 0	0 0 0 0	- 7	0 0 0 0
- 7		1 0 0 1	0 0 0 1	- 6	0 0 0 1
- 6		1 0 1 0	0 0 1 0	- 5	0 0 1 0
- 5		1 0 1 1	0 0 1 1	- 4	0 0 1 1
- 4		1 1 0 0	0 1 0 0	- 3	0 1 0 0
- 3		1 1 0 1	0 1 0 1	- 2	0 1 0 1
- 2		1 1 1 0	0 1 1 0	- 1	0 1 1 0
- 1		1 1 1 1	0 1 1 1	+ 0	0 1 1 1
+ 0		0 0 0 0	1 0 0 0	+ 1	1 0 0 0
+ 1		0 0 0 1	1 0 0 1	+ 2	1 0 0 1
+ 2		0 0 1 0	1 0 1 0	+ 3	1 0 1 0
+ 3		0 0 1 1	1 0 1 1	+ 4	1 0 1 1
+ 4		0 1 0 0	1 1 0 0	+ 5	1 1 0 0
+ 5		0 1 0 1	1 1 0 1	+ 6	1 1 0 1
+ 6		0 1 1 0	1 1 1 0	+ 7	1 1 1 0
+ 7		0 1 1 1	1 1 1 1	+ 8	1 1 1 1

Excess K vs. K-1 Codes

	Excess K $n + K$					n		n		Excess K-1 $n + K - 1$				
0	0	0	0	0		- 8		- 7		0	0	0	0	0
1	0	0	0	1		- 7		- 6		0	0	0	1	1
2	0	0	1	0		- 6		- 5		0	0	1	0	2
3	0	0	1	1		- 5		- 4		0	0	1	1	3
4	0	1	0	0		- 4		- 3		0	1	0	0	4
5	0	1	0	1		- 3		- 2		0	1	0	1	5
6	0	1	1	0		- 2		- 1		0	1	1	0	6
7	0	1	1	1		- 1		+ 0		0	1	1	1	7
8	1	0	0	0		+ 0		+ 1		1	0	0	0	8
9	1	0	0	1		+ 1		+ 2		1	0	0	1	9
10	1	0	1	0		+ 2		+ 3		1	0	1	0	10
11	1	0	1	1		+ 3		+ 4		1	0	1	1	11
12	1	1	0	0		+ 4		+ 5		1	1	0	0	12
13	1	1	0	1		+ 5		+ 6		1	1	0	1	13
14	1	1	1	0		+ 6		+ 7		1	1	1	0	14
15	1	1	1	1		+ 7		+ 8		1	1	1	1	15

Excess K code

the minimal negative value :

000...0 (-2^{n-1})

the "zero" value :

100...0 (0)

the maximal positive value :

111...1 ($+2^{n-1}-1$)

Excess K-1 code

the minimal negative value :

000...0 ($-2^{n-1}+1$)

the "zero" value :

011...1 (0)

the maximal positive value :

111...1 ($+2^{n-1}$)

Offset Binary

0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
0	1	0	0
0	1	0	1
0	1	1	0
0	1	1	1
1	0	0	0
1	0	0	1
1	0	1	0
1	0	1	1
1	1	0	0
1	1	0	1
1	1	1	0
1	1	1	1

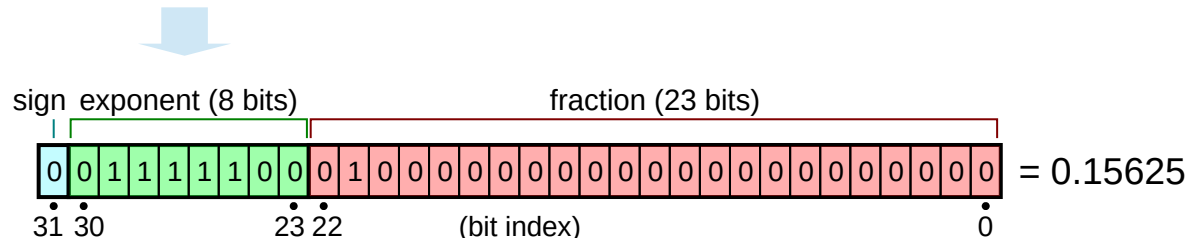


0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
0	1	0	0
0	1	0	1
0	1	1	0
0	1	1	1
1	0	0	0
1	0	0	1
1	0	1	0
1	0	1	1
1	1	0	0
1	1	0	1
1	1	1	0
1	1	1	1

Offset Binary and Floating Pointer Numbers

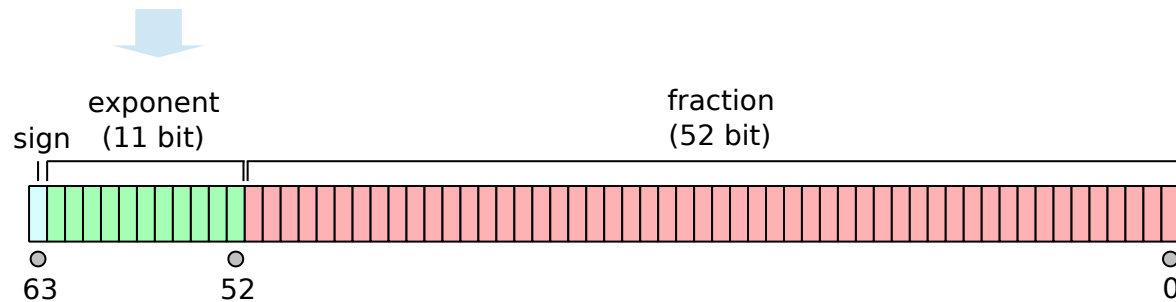
Excess-127 Code

$$K = 2^7 - 1$$

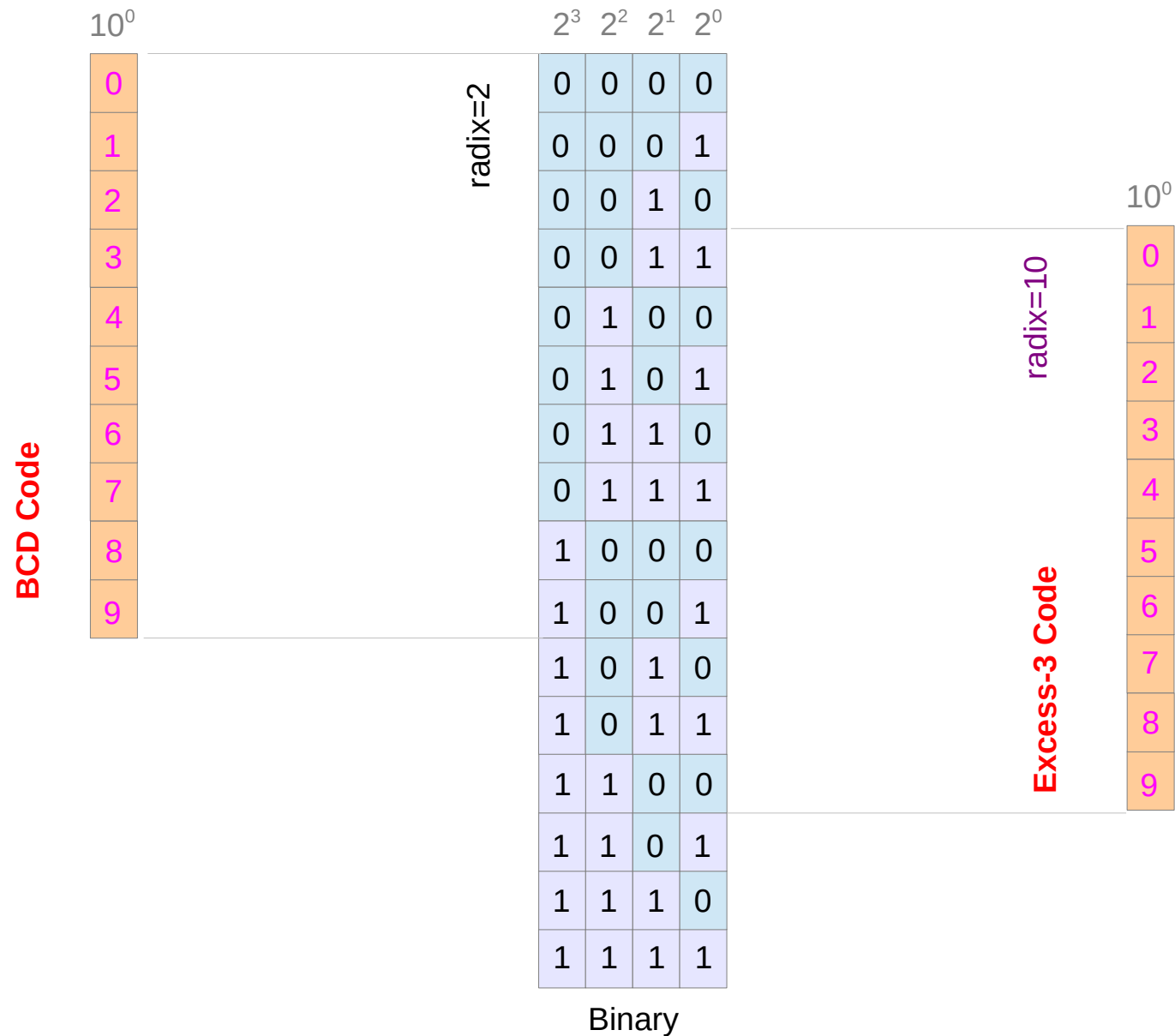


Excess-1023 Code

$$K = 2^{10} - 1$$



Excess-3 and BCD Codes



Coding

A code is a rule for converting a piece of information (for example, a letter, word, phrase, or gesture) into another form or representation (one sign into another sign), not necessarily of the same type.

In *communications and information processing*, **encoding** is the process by which information from a source is converted into symbols to be communicated. **Decoding** is the reverse process, converting these code symbols back into information understandable by a receiver.

International Morse Code

1. The length of a dot is one unit.
2. A dash is three units.
3. The space between parts of the same letter is one unit.
4. The space between letters is three units.
5. The space between words is seven units.

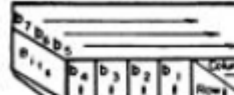
A	• —	U	• • —
B	— • • •	V	• • — —
C	— • — •	W	• — —
D	— • •	X	— • • —
E	•	Y	— • — —
F	• • — •	Z	— — • •
G	— — •		
H	• • • •		
I	• •		
J	• — — —		
K	— • — —		
L	• — • •		
M	— —		
N	— •		
O	— — —		
P	• — — •		
Q	— • — •		
R	• — • •		
S	• • •		
T	—		
		1	• — — — —
		2	• • — — —
		3	• • • — —
		4	• • • • —
		5	• • • • •
		6	— • • • •
		7	— — • • •
		8	— — — • •
		9	— — — — •
		0	— — — — —

Character Coding

ASCII code

definitions for 128 characters:
33 non-printing control characters
(many now obsolete)
95 printable characters

USASCII code chart



				0 0	0 0	0 1	0 1	1 0	1 0	1 1	1 1
				0	1	2	3	4	5	6	7
0	0	0	0	NUL	DLE	SP	0	@	P	\	p
0	0	0	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	STX	DC2	"	2	B	R	b	r
0	0	1	1	ETX	DC3	#	3	C	S	c	s
0	1	0	0	EOT	DC4	\$	4	D	T	d	t
0	1	0	1	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	ACK	SYN	&	6	F	V	f	v
0	1	1	1	BEL	ETB	'	7	G	W	g	w
1	0	0	0	BS	CAN	(	8	H	X	h	x
1	0	0	1	HT	EM	)	9	I	Y	i	y
1	0	1	0	LF	SUB	*	:	J	Z	j	z
1	0	1	1	VT	ESC	+	;	K	[	k	{
1	1	0	0	FF	FS	,	<	L	\	l	
1	1	0	1	CR	GS	-	=	M	]	m	}
1	1	1	0	SO	RS	.	>	N	^	n	~
1	1	1	1	SI	US	/	?	O	_	o	DEL

BCD (Binary Coded Decimal)

Number characters (0-9)

Decimal Digit	BCD
	8 4 2 1
0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
4	0 1 0 0
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1

Representation of Numbers

Fixed Point Number

+1234
0
-582978

representation



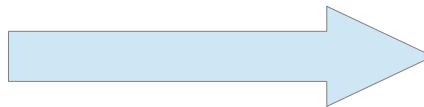
coding

- 2's complement
- 1's complement
- sign-magnitude

Floating Point Number

+23.84380
-1.388E+08

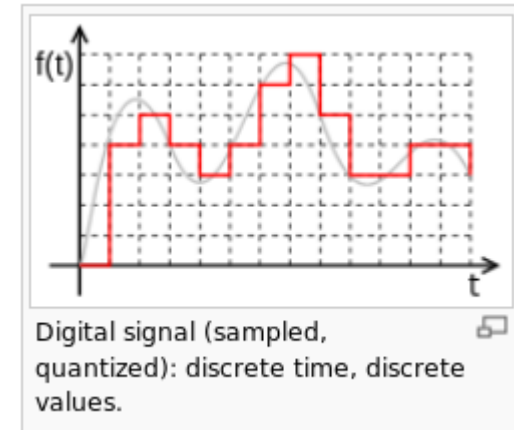
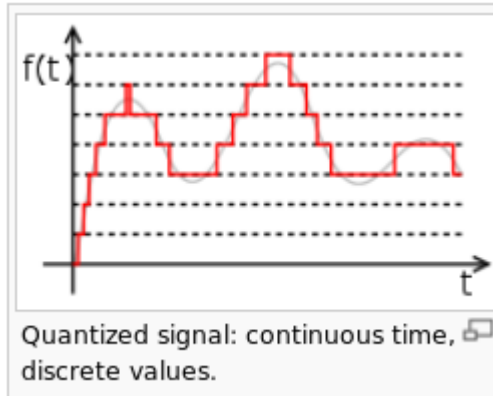
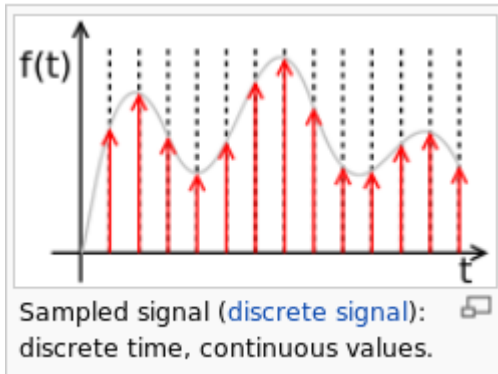
representation



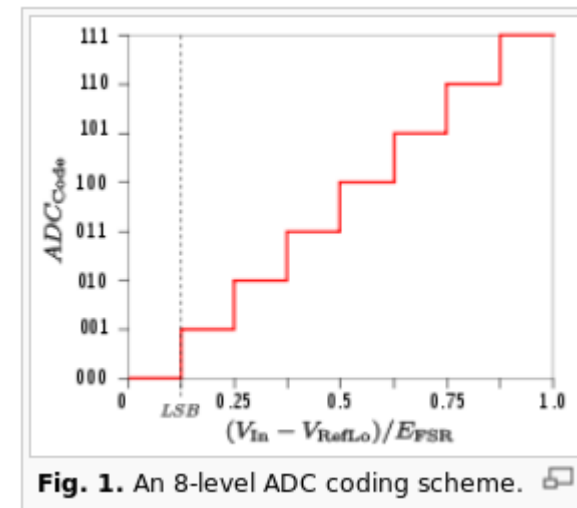
coding

- IEEE 754

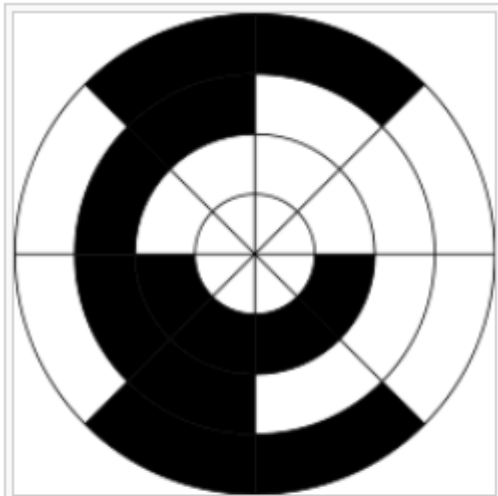
Representation of Signals



Analog to Digital Converter



Angular Position Sensors



Rotary encoder for angle-measuring devices marked in 3-bit binary-reflected Gray code (BRGC)

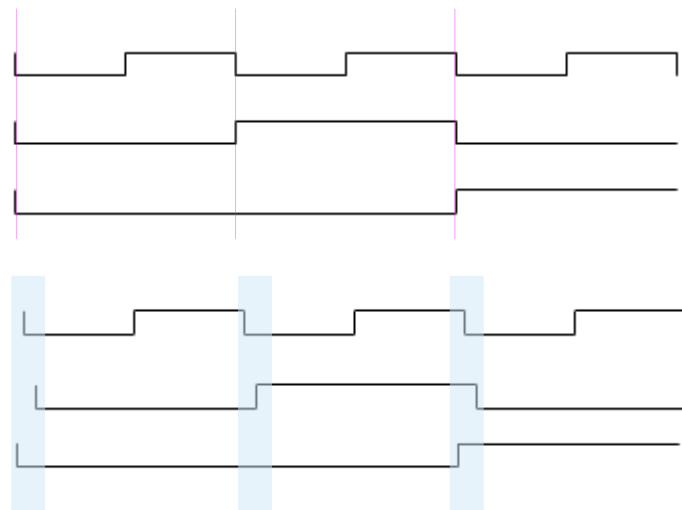
Ideal

Problems in ordinary binary coding

Gray Coding				
Sector	Contact 1	Contact 2	Contact 3	Angle
0	off	off	off	0° to 45°
1	off	off	ON	45° to 90°
2	off	ON	ON	90° to 135°
3	off	ON	off	135° to 180°
4	ON	ON	off	180° to 225°
5	ON	ON	ON	225° to 270°
6	ON	off	ON	270° to 315°
7	ON	off	off	315° to 360°

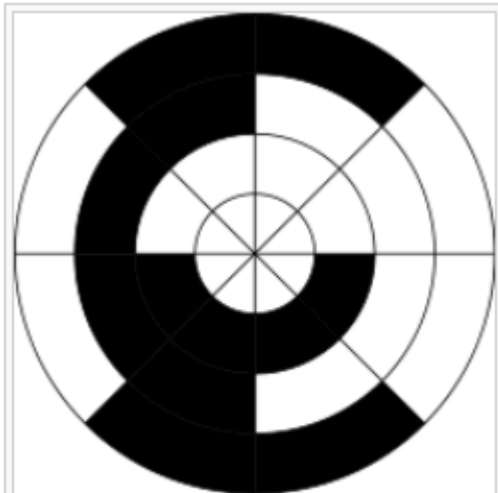


Absolute rotary encoder ROQ 425

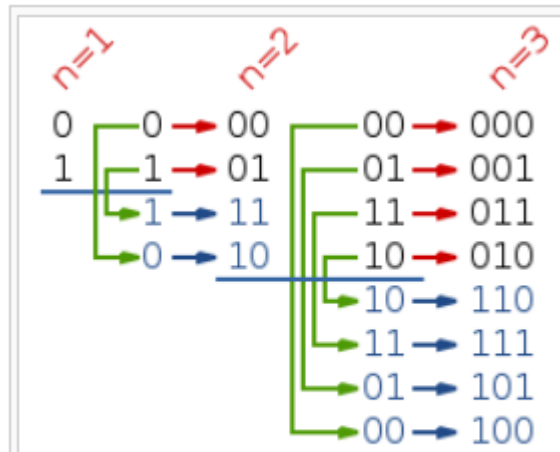


Dec	Gray	Binary
0	000	000
1	001	001
2	011	010
3	010	011
4	110	100
5	111	101
6	101	110
7	100	111

Gray Code



Rotary encoder for angle-measuring devices marked in 3-bit binary-reflected Gray code (BRGC)

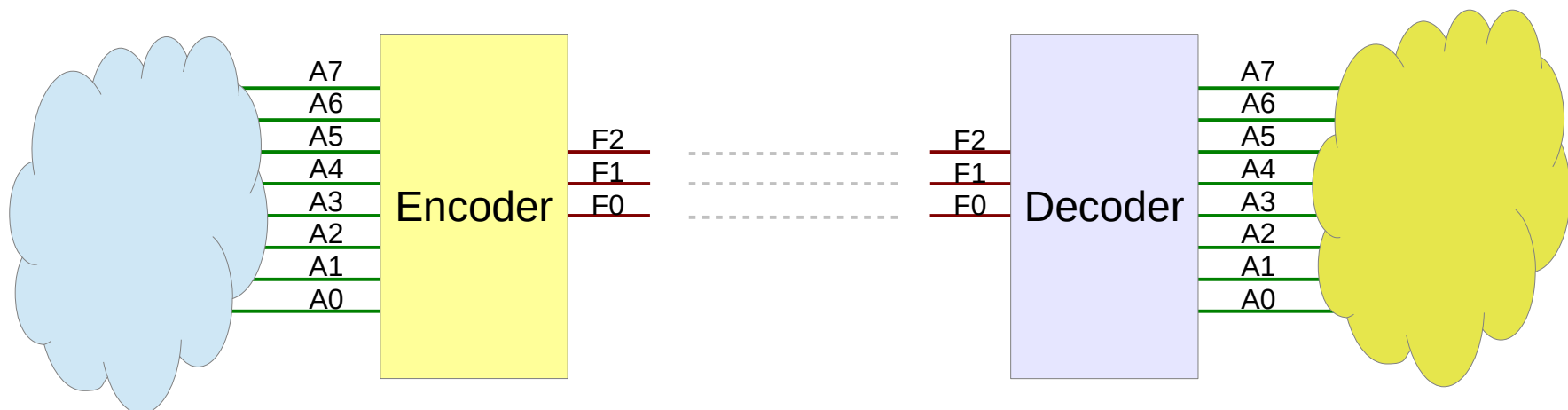
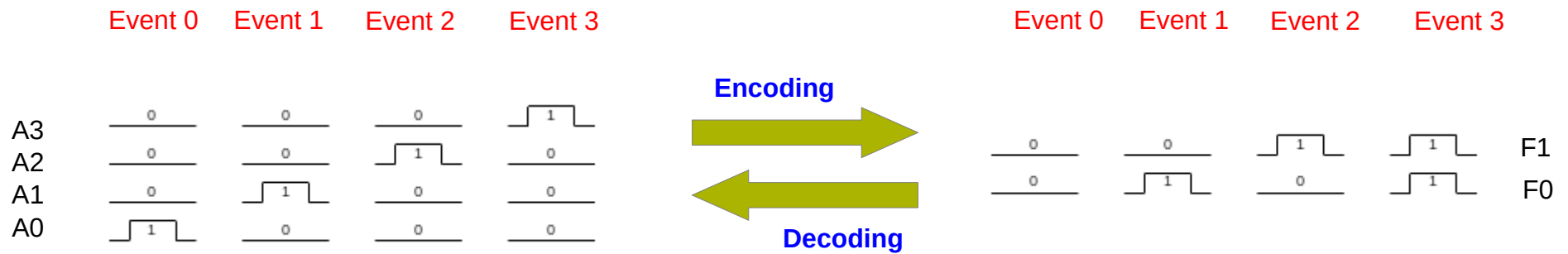


The first few steps of the reflect-and-prefix method.

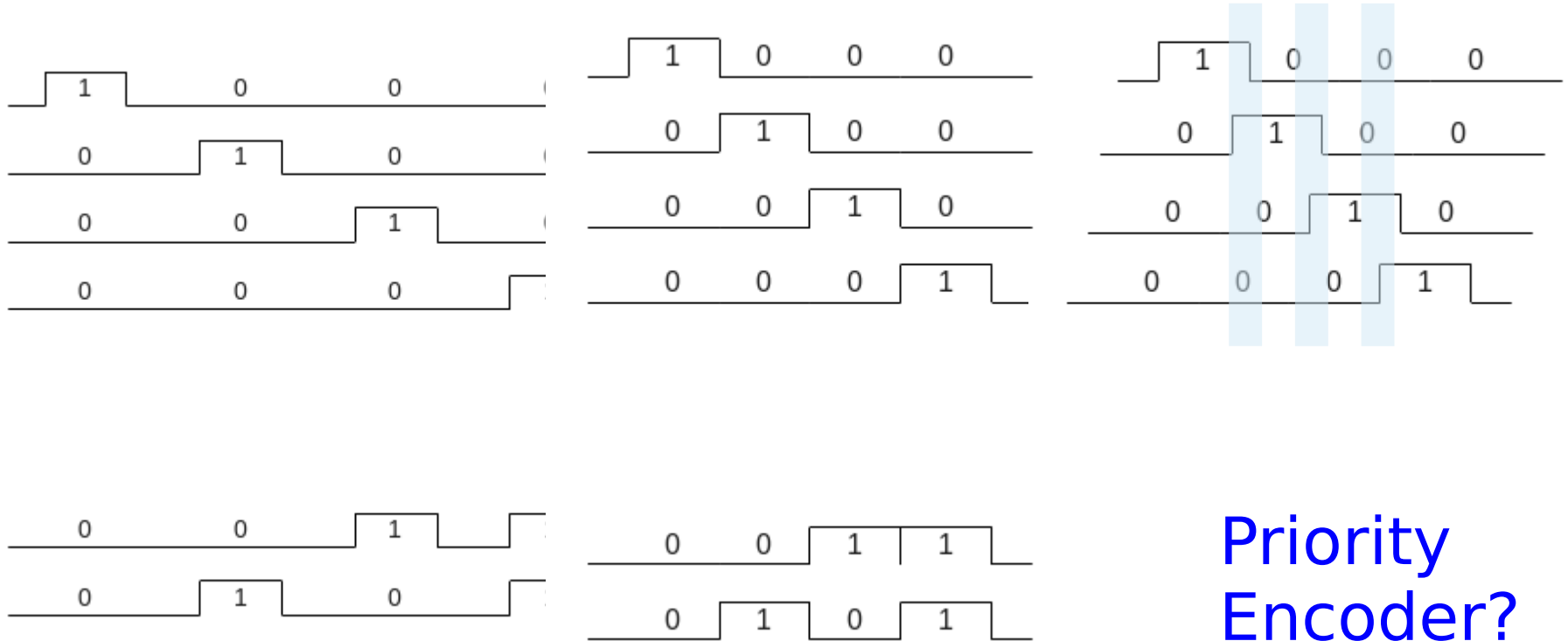
Gray code by bit width

2-bit	4-bit
00	0000
01	0001
11	0011
10	0010
	0110
	0111
3-bit	0101
000	0100
001	1100
011	1101
010	1111
110	1110
111	1010
101	1011
100	1001
	1000

Encoder and Decoder



Priority Encoder



Priority
Encoder?

Binary Code Decimal

Decimal Digit	BCD 8 4 2 1
0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
4	0 1 0 0
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1

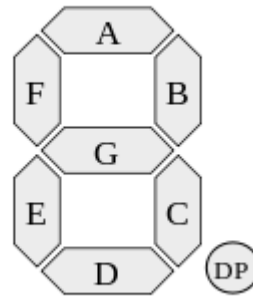
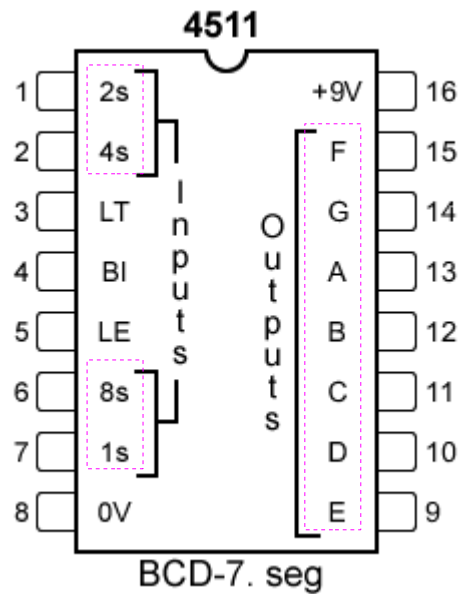
the manipulation of numerical data for display can be greatly **simplified** by treating each digit as **a separate single sub-circuit**.

If the numeric quantity were stored and manipulated as **pure binary**, interfacing to such a display would require **complex** circuitry.

Often, **smaller code** results when representing numbers internally in BCD format, since **a conversion from or to binary representation** can be **expensive** on limited microprocessors.

BCD arithmetic is used in calculators
: No rounding off error

7 Segment Display



Hexadecimal encodings for displaying the digits 0 to F

Digit	gfedcba	abcdefg	a	b	c	d	e	f	g
0	0x3F	0x7E	on	on	on	on	on	on	off
1	0x06	0x30	off	on	on	off	off	off	off
2	0x5B	0x6D	on	on	off	on	on	off	on
3	0x4F	0x79	on	on	on	on	off	off	on
4	0x66	0x33	off	on	on	off	off	on	on
5	0x6D	0x5B	on	off	on	on	off	on	on
6	0x7D	0x5F	on	off	on	on	on	on	on
7	0x07	0x70	on	on	on	off	off	off	off
8	0x7F	0x7F	on	on	on	on	on	on	on
9	0x6F	0x7B	on	on	on	on	off	on	on
A	0x77	0x77	on	on	on	off	on	on	on
b	0x7C	0x1F	off	off	on	on	on	on	on
C	0x39	0x4E	on	off	off	on	on	on	off
d	0x5E	0x3D	off	on	on	on	on	off	on
E	0x79	0x4F	on	off	off	on	on	on	on
F	0x71	0x47	on	off	off	off	on	on	on

References

- [1] <http://en.wikipedia.org/>
- [2] <http://planetmath.org/>
- [3] M.L. Boas, “Mathematical Methods in the Physical Sciences”