Other Binary Codes (3A)

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1/3/14

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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.

Character Coding

ASCII code

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

USASCII code chart

					Row	0	1	2	3	4	5	6	7
0	0	0	0	0		NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1		SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2		STX	DC2	"	2	B	R	b	r
0	0	1	1	3		ETX	DC3	#	3	C	S	c	s
0	1	0	0	4		EOT	DC4	$	4	D	T	d	t
0	1	0	1	5		ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6		ACK	SYN	&	6	F	V	f	v
0	1	1	1	7		BEL	ETB	'	7	G	W	g	w
1	0	0	0	8		BS	CAN	(	8	H	X	h	x
1	0	0	1	9		HT	EM	)	9	I	Y	i	y
1	0	1	0	10		LF	SUB	*	:	J	Z	j	z
1	0	1	1	11		VT	ESC	+	;	K	[	k	{
1	1	0	0	12		FF	FS	,	<	L	\	l		
1	1	0	1	13		CR	GS	–	=	M	]	m	}
1	1	1	0	14		SO	RS	.	>	N	^	n	~
1	1	1	1	15		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
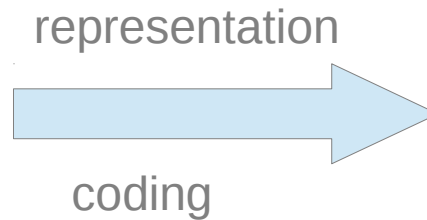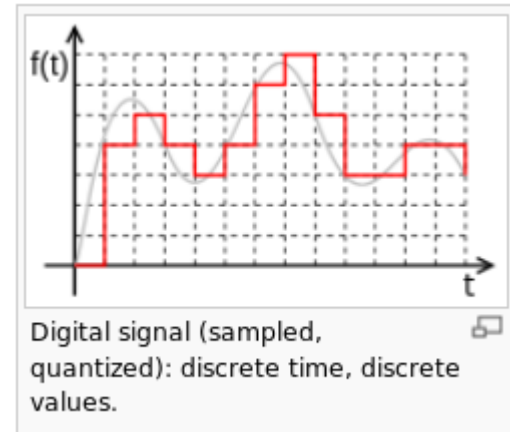
- 2's complement
- 1's complement
- sign-magnitude

Floating Point Number

+23.84380
-1.388E+08

representation

coding
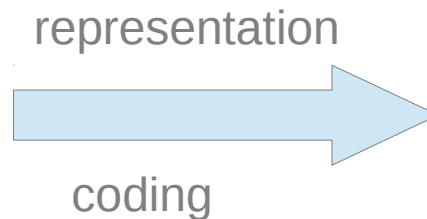
- IEEE 754

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Representation of Signals

Sampled signal (discrete signal): discrete time, continuous values.

Quantized signal: continuous time, discrete values.

Digital signal (sampled, quantized): discrete time, discrete values.
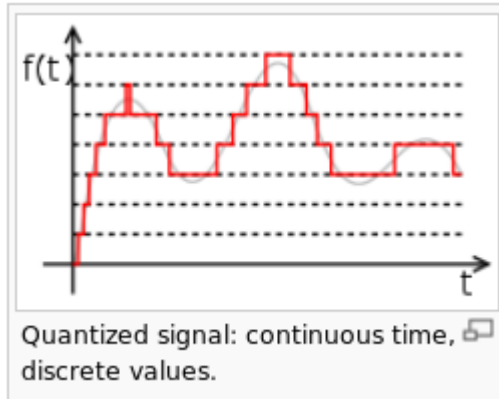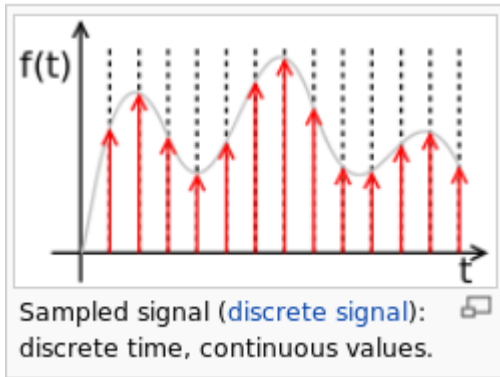
Analog to Digital Converter

Fig. 1. An 8-level ADC coding scheme.
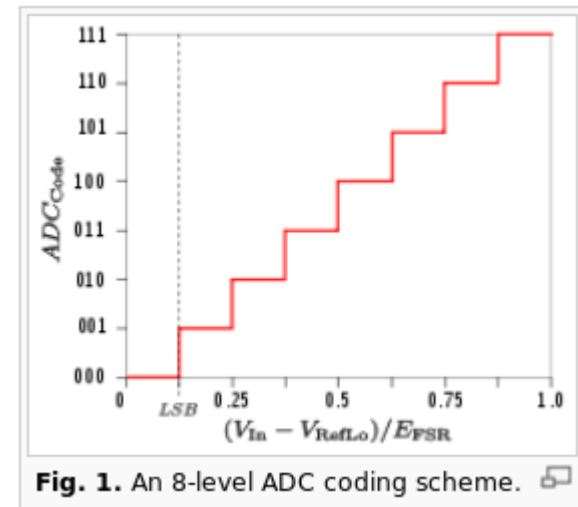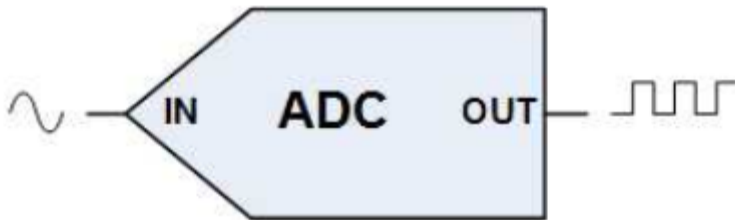
Angular Position Sensors
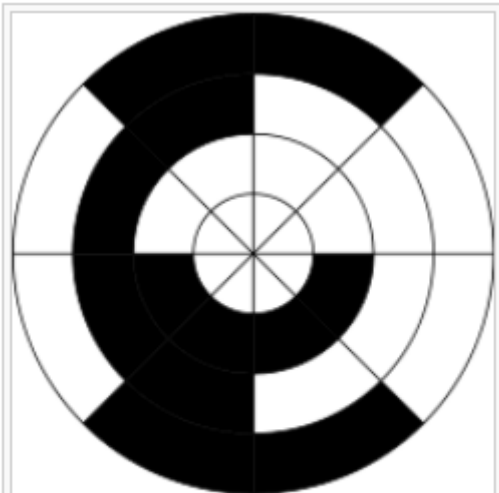
Rotary encoder for angle-measuring devices marked in 3-bit binary-reflected Gray code (BRGC)

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

Ideal
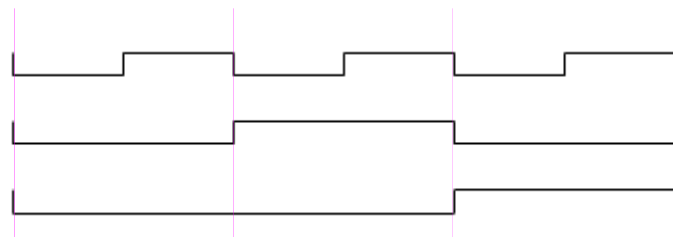
Problems in ordinary binary coding
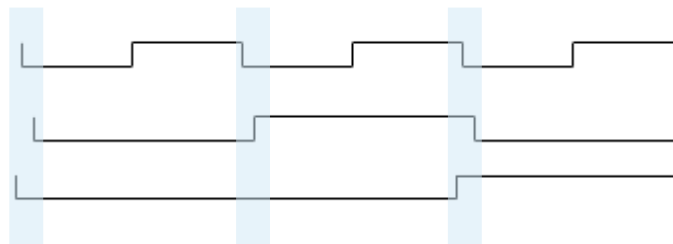
Dec	Gray	Binary
0	000	000
1	001	001
2	011	010
3	010	011
4	110	100
5	111	101
6	101	110
7	100	111

Gray Code
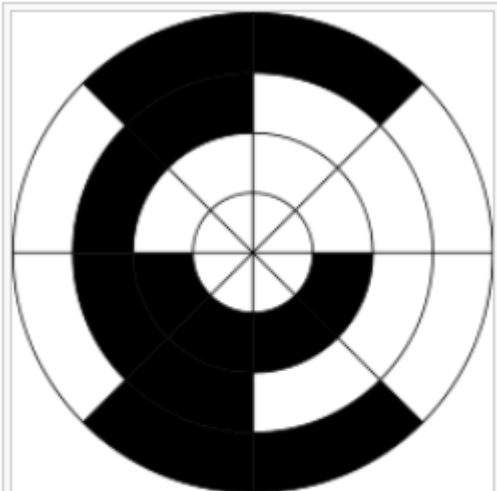
Rotary encoder for angle-measuring devices marked in 3-bit binary-reflected Gray code (BRGC)
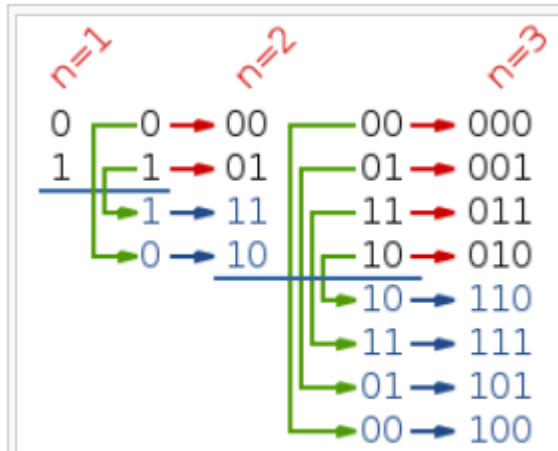
The first few steps of the reflect-and-prefix method.

Gray code by bit width

2-bit	4-bit
00	0000
01	0001
11	0011
10	0010
	0110
	0111

3-bit	4-bit
	0101
000	0100
001	1100
011	1101
010	1111
110	1110
111	1010
101	1011
100	1001
	1000

Encoder and Decoder

Event 0   Event 1   Event 2   Event 3

A3
A2
A1
A0

Encoding →
← **Decoding**

Event 0   Event 1   Event 2   Event 3

F1
F0

Encoder

A7
A6
A5
A4
A3
A2
A1
A0

F2
F1
F0

Decoder

F2
F1
F0

A7
A6
A5
A4
A3
A2
A1
A0
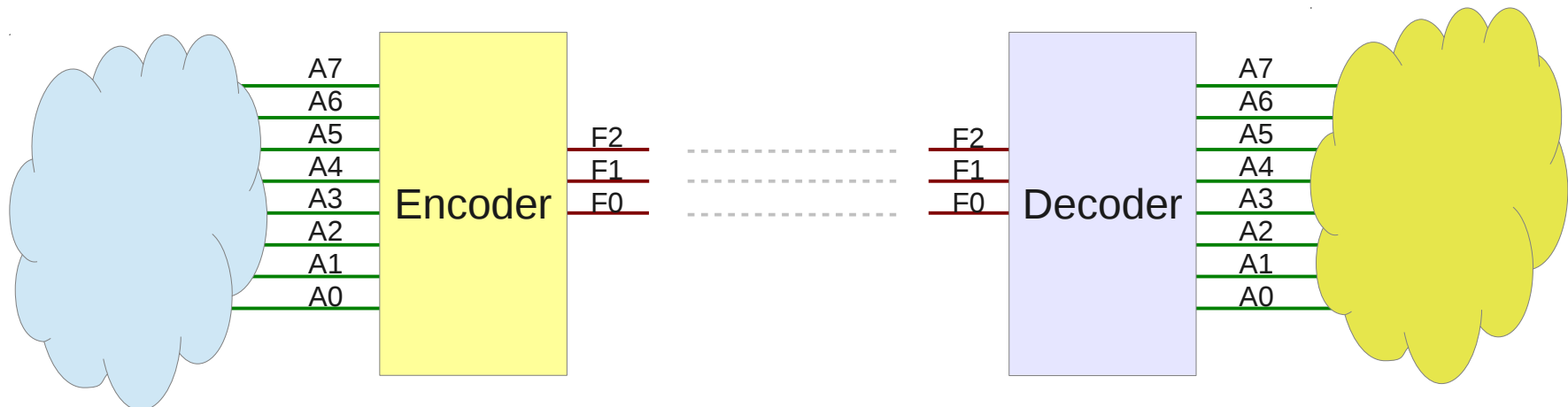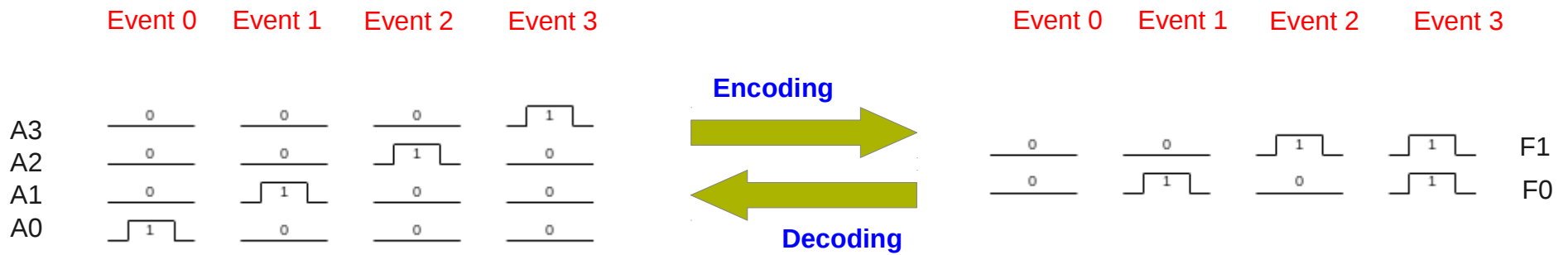
Priority Encoder?
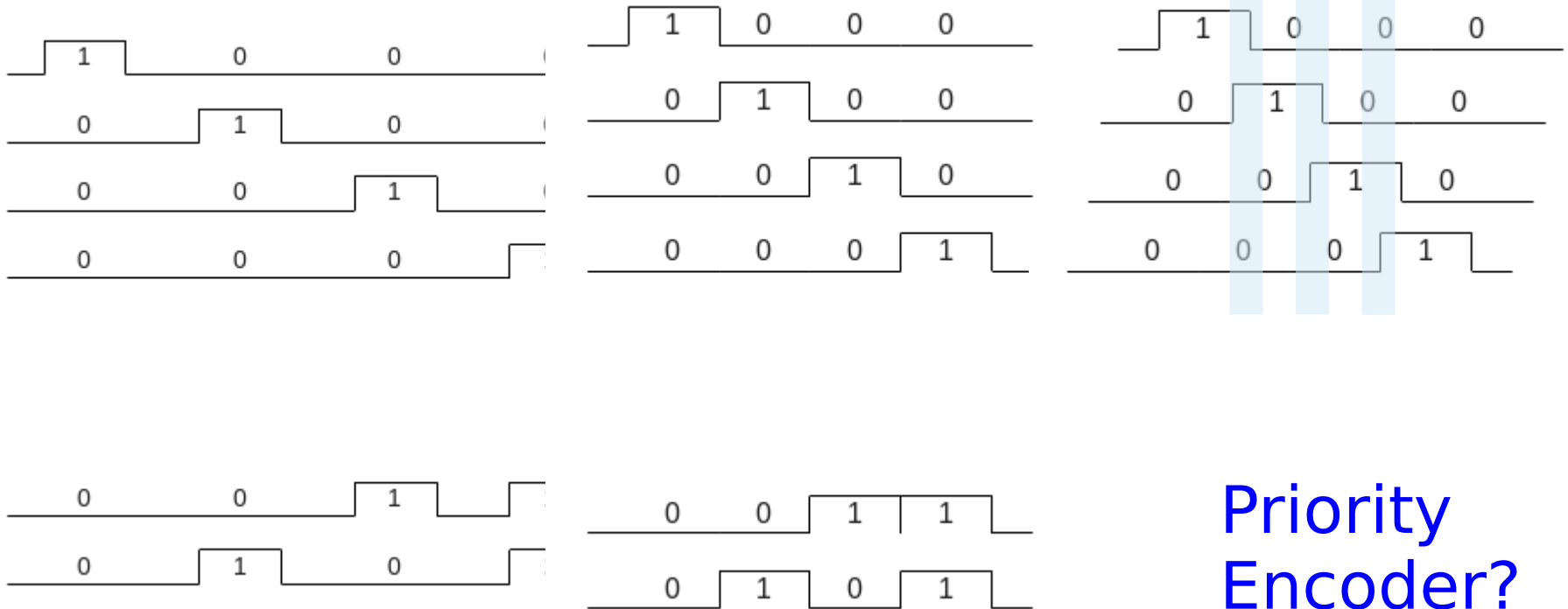
Binary Code Decimal

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

4511

1	2s	+9V	16
2	4s	F	15
3	LT	G	14
4	BI	A	13
5	LE	B	12
6	8s	C	11
7	1s	D	10
8	0V	E	9

Inputs / Outputs

BCD-7. seg
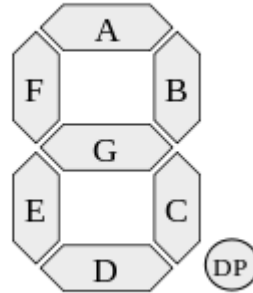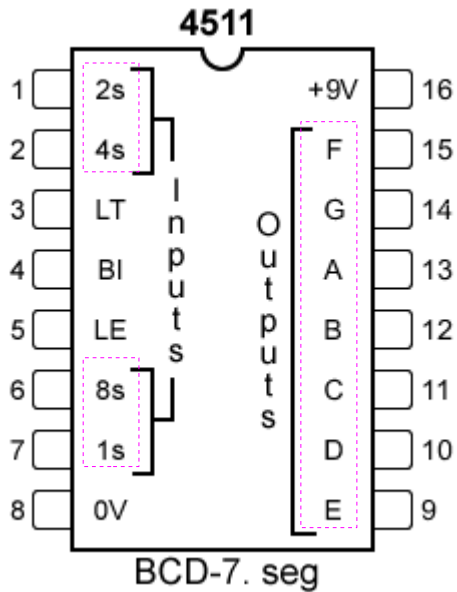
Hexadecimal encodings for displaying the digits 0 to F

Digit	gfedcba	abcdefg	a	b	c	d	e	f	g
0	0×3F	0×7E	on	on	on	on	on	on	off
1	0×06	0×30	off	on	on	off	off	off	off
2	0×5B	0×6D	on	on	off	on	on	off	on
3	0×4F	0×79	on	on	on	on	off	off	on
4	0×66	0×33	off	on	on	off	off	on	on
5	0×6D	0×5B	on	off	on	on	off	on	on
6	0×7D	0×5F	on	off	on	on	on	on	on
7	0×07	0×70	on	on	on	off	off	off	off
8	0×7F	0×7F	on	on	on	on	on	on	on
9	0×6F	0×7B	on	on	on	on	off	on	on
A	0×77	0×77	on	on	on	off	on	on	on
b	0×7C	0×1F	off	off	on	on	on	on	on
C	0×39	0×4E	on	off	off	on	on	on	off
d	0×5E	0×3D	off	on	on	on	on	off	on
E	0×79	0×4F	on	off	off	on	on	on	on
F	0×71	0×47	on	off	off	off	on	on	on

Offset Binary

2^3	2^2	2^1	2^0		Offset binary (radix=10)	2's complement (radix=10)	1's complement (radix=10)	sign magnitude (radix=10)
0	0	0	0		− 8	+ 0	+ 0	+ 0
0	0	0	1		− 7	+ 1	+ 1	+ 1
0	0	1	0		− 6	+ 2	+ 2	+ 2
0	0	1	1		− 5	+ 3	+ 3	+ 3
0	1	0	0		− 4	+ 4	+ 4	+ 4
0	1	0	1		− 3	+ 5	+ 5	+ 5
0	1	1	0		− 2	+ 6	+ 6	+ 6
0	1	1	1		− 1	+ 7	+ 7	+ 7
1	0	0	0		+ 0	− 8	− 7	− 0
1	0	0	1		+ 1	− 7	− 6	− 1
1	0	1	0		+ 2	− 6	− 5	− 2
1	0	1	1		+ 3	− 5	− 4	− 3
1	1	0	0		+ 4	− 4	− 3	− 4
1	1	0	1		+ 5	− 3	− 2	− 5
1	1	1	0		+ 6	− 2	− 1	− 6
1	1	1	1		+ 7	− 1	− 0	− 7

Binary

Offset Binary and 2's Complement
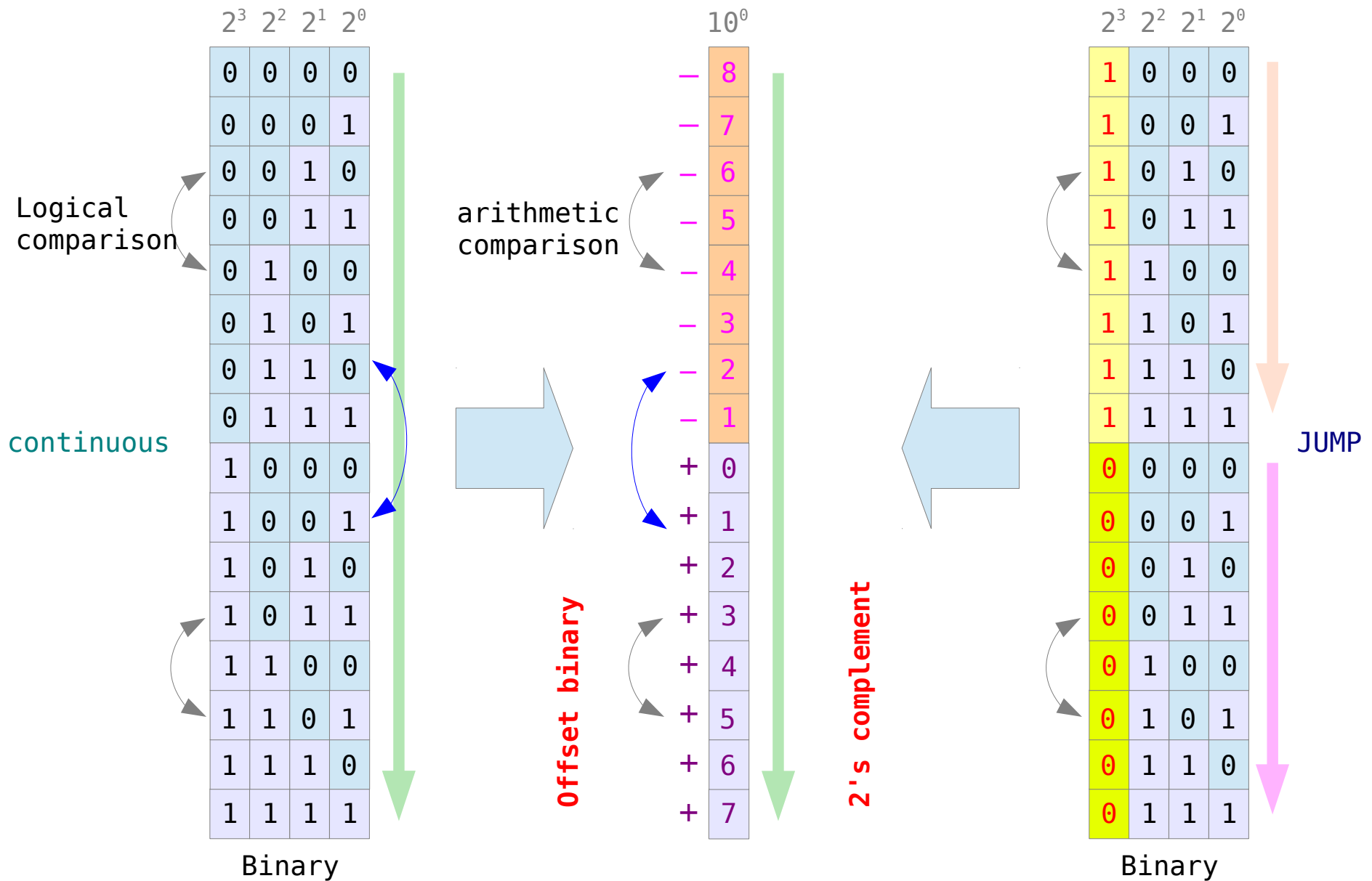
Offset Binary (Excess K Code)

radix=10

10^0

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

radix=2   Offset binary

2^3	2^2	2^1	2^0
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

Binary

$$+\ 1\ 0\ 0\ 0$$

$$K\ =\ 2^{n-1}$$

radix=2   2's complement

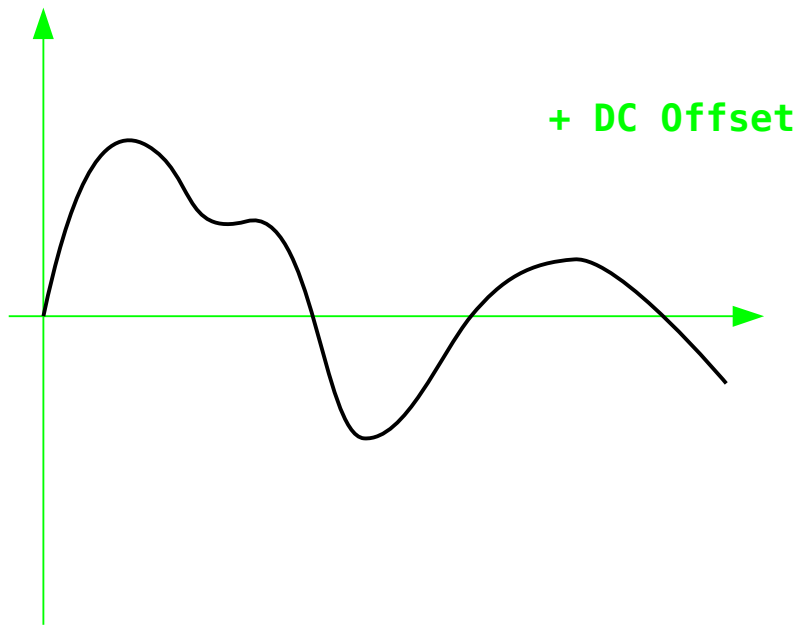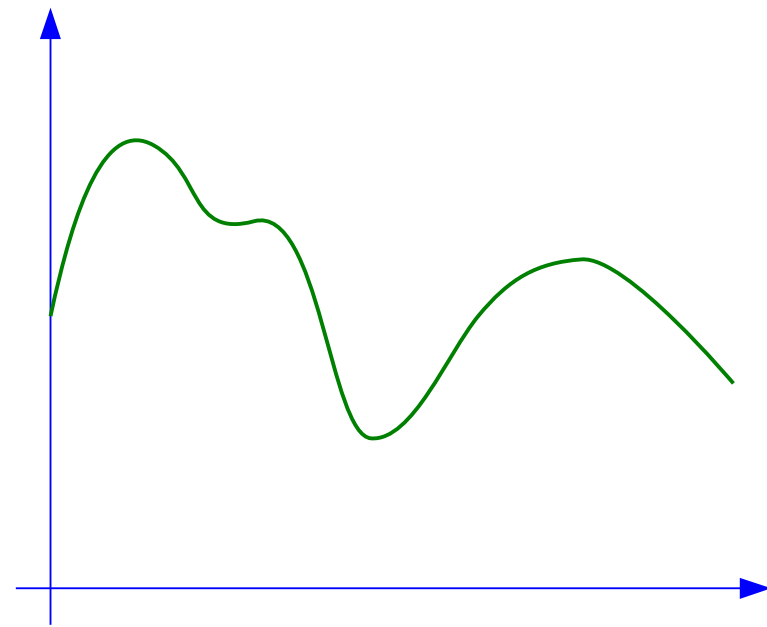| 2^3	2^2	2^1	2^0
1	0	0	0
1	0	0	1
1	0	1	0
1	0	1	1
1	1	0	0
1	1	0	1
1	1	1	0
1	1	1	1
0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
0	1	0	0
0	1	0	1
0	1	1	0
0	1	1	1

JUMP
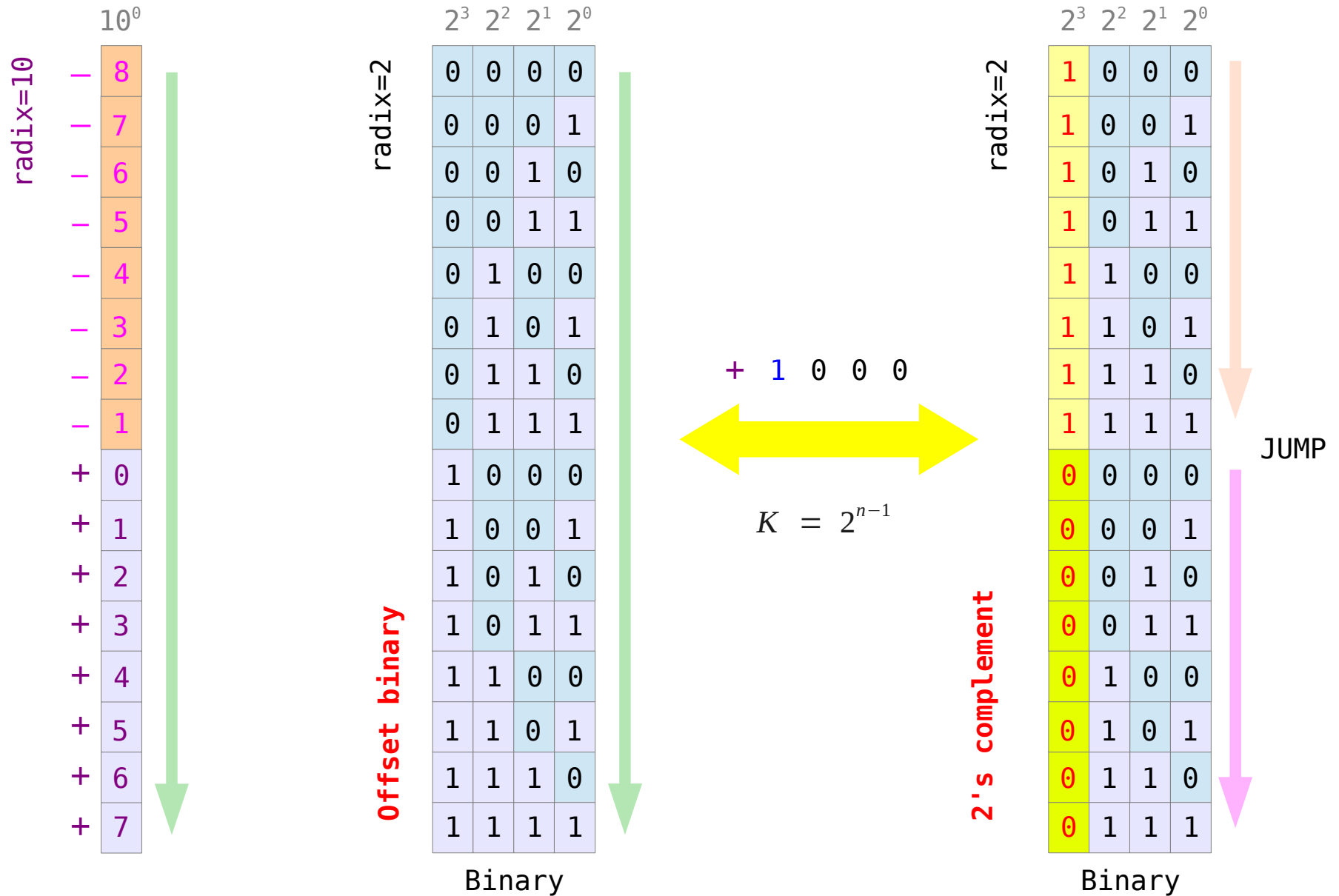
Binary

Offset Binary and ADC / DAC

Bipolar Signal

+ DC Offset

2's complement

Unipolar Signal

Offset binary

Offset Binary and Floating Pointer Numbers

Excess-127 Code $K = 2^7 - 1$

sign exponent (8 bits)   fraction (23 bits)

| 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | = 0.15625

31 30   23 22   (bit index)   0

Excess-1023 Code $K = 2^{10} - 1$

          exponent   fraction
sign   (11 bit)   (52 bit)

63   52   0

Excess-3 and BCD Codes

		2^3	2^2	2^1	2^0

BCD Code

radix=2

BCD 10^0		2^3	2^2	2^1	2^0		Excess-3 10^0
0		0	0	0	0		
1		0	0	0	1		
2		0	0	1	0		
3		0	0	1	1		0
4		0	1	0	0		1
5		0	1	0	1		2
6		0	1	1	0		3
7		0	1	1	1		4
8		1	0	0	0		5
9		1	0	0	1		6
		1	0	1	0		7
		1	0	1	1		8
		1	1	0	0		9
		1	1	0	1		
		1	1	1	0		
		1	1	1	1		

radix=10

Excess-3 Code

Binary

References

[1] http://en.wikipedia.org/
[2] http://planetmath.org/
[3] M.L. Boas, "Mathematical Methods in the Physical Sciences"