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DEPARTMENT OF GRAPHIC & CREATIVE DESIGN AND DATA ANALYTICS

COURSE NAME : Computer SYSTEM Architecture (23UCU402)

I YEAR /I SEMESTER

Unit I- Data Representation

Topic 9 : Other Binary Code

Binary Codes

- Electronic digital systems use signals that have two distinct values and circuit elements that have two stable states.
- Digital systems represent and manipulate not only binary numbers, but also many other discrete elements of information.
- Any discrete element of information distinct among a group of quantities can be represented by a binary code.
- Binary codes merely change the symbols, not the meaning of the elements of information that they represent.

Binary Codes

- To represent a group of 2^n distinct elements in a binary code requires a minimum of n bits.
- There is no maximum number of bits that may be used for a binary code.

Binary Codes for Decimal Numbers

- A set of *n*-bit string in which different bit strings represent different numbers or other things is called a code.
- A particular combination of *n* bit values is called a code word.
- A code that uses *n*-bit strings need not contain 2^n valid code words.

Binary Codes for Decimal Numbers

- The usual interpretation of a binary number is as defined according to the definition of a number in in base-2 system.
- There are, however, alternate methods used to encode numeric data into binary bit patterns. Table 2-9 in the course text presents five such codes. These are BCD, 2421, Excess-3, Biquinary (5043210) and lastly the “1-out-of-10” code.

Binary Codes for Decimal Numbers

Table 2-9 Decimal codes.

Decimal digit	BCD (8421)	2421	Excess-3	Biquinary	1-out-of-10
0	0000	0000	0011	0100001	1000000000
1	0001	0001	0100	0100010	0100000000
2	0010	0010	0101	0100100	0010000000
3	0011	0011	0110	0101000	0001000000
4	0100	0100	0111	0110000	0000100000
5	0101	1011	1000	1000001	0000010000
6	0110	1100	1001	1000010	0000001000
7	0111	1101	1010	1000100	0000000100
8	1000	1110	1011	1001000	0000000010
9	1001	1111	1100	1010000	0000000001
Unused code words					
	1010	0101	0000	0000000	0000000000
	1011	0110	0001	0000001	0000000011
	1100	0111	0010	0000010	0000000101
	1101	1000	1101	0000011	0000000110
	1110	1001	1110	0000101	0000000111
	1111	1010	1111	. . .	. . .

Binary Codes for Decimal Numbers

- It is important to note that this table presents binary codes and not binary numbers.
- A binary number is mathematically defined, while a binary code is just an assignment of numeric values to bit patterns.

Binary Codes for Decimal Numbers

- Each such assignment in table 2-9 does have some particular property associated with it that makes it a reasonable method of assignment.
- For example, a BCD number is just a natural binary encoding of the decimal digits from 0 to 9 on four bits.
- Therefore a string of bits is grouped into groups of four bits, and interpreted as a string of decimal digits.

Binary-Coded Decimal (BCD)

- a BCD number is just a natural binary encoding of the decimal digits from 0 to 9 on four bits.

0101 0111

59 in BCD (0 ~ 99)

because there are unused code words

87 in normal unsigned binary number (0 ~ 255)

Binary-Coded Decimal (BCD)

- Binary-Coded Decimal is a weighted code because each decimal digit can be obtained from its code word by assigning a fixed weight to each code-word bit.
- The weights for the BCD bits are 8, 4, 2, and 1, and for this reason the code is sometimes called the 8421 code.

2421 code

- This code has the advantage that it is self-complementing, that is, the code word for the 9s' complement of any digit may be obtained by complementing the individual bits of the digit's code word.

0010 = 2

9s'complement of 2 can be obtained by complementing individual bits

1101 = (2+4+0+1) = 7

Excess-3 code

- This code is also self-complementing like 2421 code.
- Although this code is not weighted, it has an arithmetic relationship with the BCD code.
- The code word for each decimal digit is the corresponding BCD code word plus 0011_2.

  0010 = 2   in BCD

  + 0011_2

  = 0101 = 2   in excess-3

biquinary code

- This is a 7-bit code.
- The first two bits in this code indicate the range 0~4 or 5~9, and the last five bits indicate which of the five numbers in the selected range is represented.

  0100100 = 2

  1000100 = 7
- The redundant bits gave this code the error-detecting property.
- The biquinary code has the property that if any single bit is corrupted as the result of (say) a circuit malfunction, the error can be recognized.
- Note that for all values from 0 to 9, the biquinary encoding has precisely two “1” bits and five “0” bits. Obviously the corruption of any one bit will result in either one or three “1” bits and can be detected on that basis.

1-out-of-10 code

- This code is is the sparsest encoding of decimal digits, using 10 out of 1024 possible 10-bit code words.

    10000 00000 = 0

    01000 00000 = 1

    00100 00000 = 2

- The redundant bits gave this code the error-detecting property.

Binomial Coefficients

- The number of different ways to choose m items from a set of n items is given by a binomial coefficient, denoted by $\binom{n}{m}$ whose value is n!/(m!*(n-m)!)

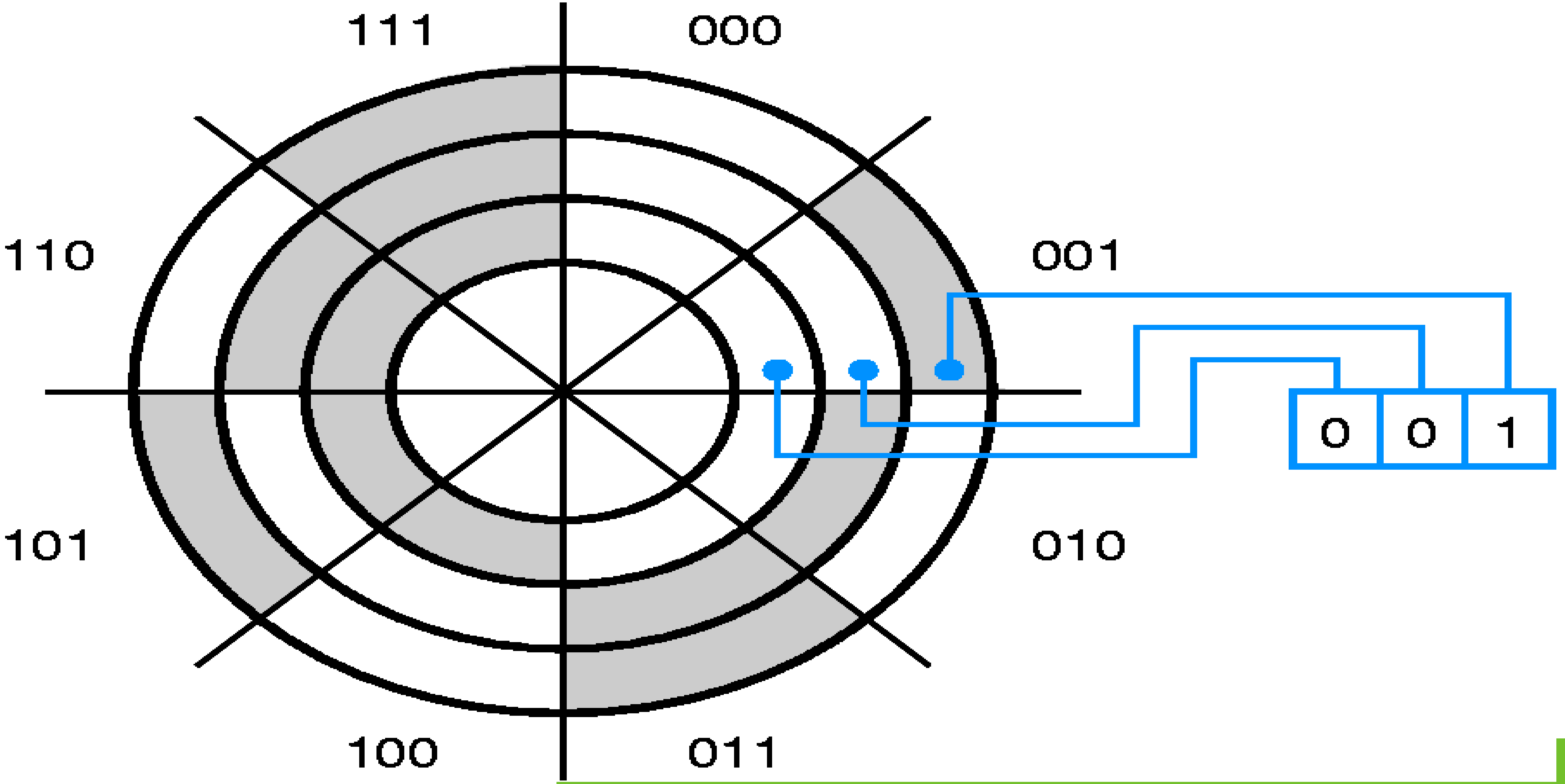
for a 4-bit decimal code, there are $\binom{16}{10}$ different ways to choose 10 out of 16 4-bit code words, and 10! ways to assign each different choice to the 10 digits. So there are (16!/(10!*(16-10)!))*10! Or 29059430400 different 4-bit decimal codes.

Gray Code

- Gray code is a code where only one bit changes at a time while traversing from 0 to any decimal number in sequence.
- This is a useful property when converting analog values into digital values, since it eliminates the problem of misinterpreting asynchronous changes to bits between valid values.

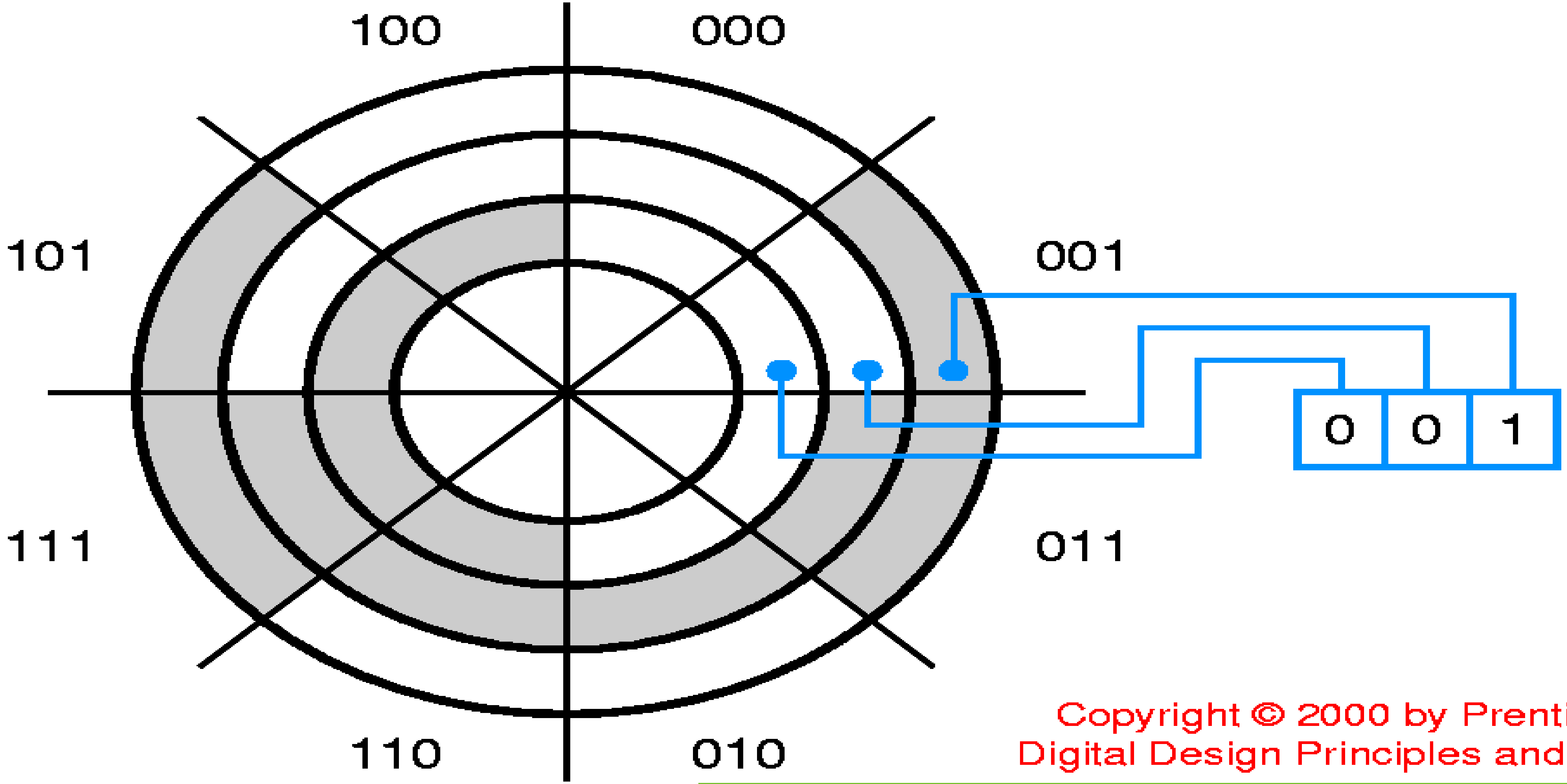
Gray Code

- What value will the encoder produce if the disk is positioned right on the theoretical boundary?



Gray Code

- The encoding-disk problem can be solved by devising a digital code in which only one bit changes between each pair of successive code words. Such a code is called a Gray code.



Gray Code

Table 2-10
A comparison of 3-bit binary code and Gray code.

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

Gray Code

Two ways to construct a Gray code with any number of bits:

- Reflected code defined recursively
- From binary code

Gray Code

Gray code is defined recursively using the following rules:

- A 1-bit Gray code has two code words, 0 and 1.
- The first 2^n code words of an (n+1)-bit Gray code equal the code words of an n-bit Gray code, written in order with a leading 0 appended.
- The last 2^n code words of an (n+1)-bit Gray code equal the code words of an n-bit Gray code, written in reverse order with a leading 1 appended.

Gray Code

Gray code is defined from the binary code using the following rules:

- The bits of an n-bit binary or Gray-code code-word are numbered from right to left, from 0 to n-1.
- Bit i of a Gray-code code-word is 0 if bits i and i+1 of the corresponding binary code word are the same, else bit i is 1.
  (When i+1=n, bit n of the binary code word is considered to be 0.)

Character Codes

- Many applications of digital computers require the handling of data not only of numbers, but also of letters.
- The most commonly used character code is ASCII (the American Standard Code for Information Interchange).
- ASCII represents each character with a 7-bit string, yielding a total of 128 characters.
- The code contains the uppercase and lower case alphabet, numeral, punctuation, and various nonprinting control characters.

ASCII Code

Table 2-11 American Standard Code for Information Interchange (ASCII), Standard No. X3.4-1968 of the American National Standards Institute.

		$b_6b_5b_4$ (column)							
$b_3b_2b_1b_0$	Row (hex)	000 0	001 1	010 2	011 3	100 4	101 5	110 6	111 7
0000	0	NUL	DLE	SP	0	@	P	`	p
0001	1	SOH	DC1	!	1	A	Q	a	q
0010	2	STX	DC2	"	2	B	R	b	r
0011	3	ETX	DC3	#	3	C	S	c	s
0100	4	EOT	DC4	$	4	D	T	d	t
0101	5	ENQ	NAK	%	5	E	U	e	u
0110	6	ACK	SYN	&	6	F	V	f	v
0111	7	BEL	ETB	'	7	G	W	g	w
1000	8	BS	CAN	(	8	H	X	h	x
1001	9	HT	EM	)	9	I	Y	i	y
1010	A	LF	SUB	*	:	J	Z	j	z
1011	B	VT	ESC	+	;	K	[	k	{
1100	C	FF	FS	,	<	L	\	l	|
1101	D	CR	GS	-	=	M	]	m	}
1110	E	SO	RS	.	>	N	^	n	~
1111	F	SI	US	/	?	O	_	o	DEL

Other Codes

- Characters can be encoded according to variety standards:
  - **Baudot code** uses 5 bits; used for teletype transmission
  - **ASCII** (American Standard Code for Information Interchange) code uses 7 bits; used in PCs.
  - **EBCDIC** (Extended Binary Coded Decimal Interchange Code) uses 8 bits; used by IBM mainframes. It is an extension of BCD code.
  - **Unicode and ISO10646** use 16bits; Windows NT supports Unicode.

Codes for detecting and correcting errors

- An error in a digital system is the corruption of data from its correct value to some other value.
- i.e., a change of some bits from 0 to 1 or vice versa.
- During the processing or transmission of digital data a noise may change some bits from 0 to 1 or vice versa.
- A short duration noise can affect only a single bit causes a single-bit error.
- A long duration noise can affect two or more bits causes a multi-bit error.

Codes for detecting and correcting errors

- Error-detecting codes normally add extra information to the data.
- In general, error-detecting codes contains redundant code.
- That is a code that uses n-bit strings need not contain 2^n valid code words.
- An error-detecting code has the property that corrupting or garbling a code word will likely produce a bit string that is not a code word.
- Thus errors in a bit string can be detected by a simple rule - if it is not a code word it contains an error.

Parity check

- One of the most common ways to achieve error detection is by means of a parity bit.
- A parity bit is an extra bit included with a message to make the total number of 1’s transmitted either odd or even.
- If an odd parity is adopted, the P bit is chosen such that the total number of 1’s is odd.

Information Bits	Even-parity Code	Odd-parity Code
000	000 0	000 1
001	001 1	001 0
010	010 1	010 0
011	011 0	011 1
100	100 1	100 0
101	101 0	101 1
110	110 0	110 1
111	111 1	111 0

Table 2-13
Distance-2 codes with three information bits.

References

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Thank You