The AVR Microcontroller and Embedded Systems: Using Assembly and C

1st Edition

Contents

CHAPTER 0: INTRODUCTION TO COMPUTING

SECTION 0.1: NUMBERING AND CODING SYSTEMS

1.
   (a) $12_{10} = 1100_2$
   (b) $123_{10} = 0111\ 1011_2$
   (c) $63_{10} = 0011\ 1111_2$
   (d) $128_{10} = 1000\ 0000_2$
   (e) $1000_{10} = 0011\ 1110\ 1000_2$
2.
   (a) $100100_2 = 36_{10}$
   (b) $1000001_2 = 65_{10}$
   (c) $11101_2 = 29_{10}$
   (d) $1010_2 = 10_{10}$
   (e) $00100010_2 = 34_{10}$
3.
   (a) $100100_2 = 24_{16}$
   (b) $1000001_2 = 41_{16}$
   (c) $11101_2 = 1D_{16}$
   (d) $1010_2 = 0A_{16}$
   (e) $00100010_2 = 22_{16}$
4.
   (a) $2B9_{16} = 0010\ 1011\ 1001_2, 697_{10}$
   (b) $F44_{16} = 1111\ 0100\ 0100_2, 3908_{10}$
   (c) $912_{16} = 1001\ 0001\ 0010_2, 2322_{10}$
   (d) $2B_{16} = 0010\ 1011_2, 43_{10}$
   (e) $FFFF_{16} = 1111\ 1111\ 1111\ 1111_2, 65535_{10}$
5.
   (a) $12_{10} = 0C_{16}$
   (b) $123_{10} = 7B_{16}$
   (c) $63_{10} = 3F_{16}$
   (d) $128_{10} = 80_{16}$
   (e) $1000_{10} = 3E8_{16}$
6.
   (a) 1001010 ➔ 0011 0110
   (b) 111001 ➔ 0000 0111
   (c) 10000010 ➔ 0111 1110
   (d) 111110001 ➔ 0000 1111
7.
   (a) 2C+3F = 6B
   (b) F34+5D6 = 150A
   (c) 20000+12FF = 212FF
   (d) FFFF+2222 = 12221
8.
   (a) $24F-129 = 126_{16}$

(b) FE9-5CC = $A1D_{16}$
(c) 2FFFF-FFFFF = 30000_{16}
(d) 9FF25-4DD99 = $5218C_{16}$

9.

(a) Hex: 30, 31, 32, 33, 34, 35, 36, 37, 38, 39
(b) Binary: 11 0000, 11 0001, 11 0010, 11 0011, 11 0100, 11 0101, 11 0110, 11 0111, 11 1000, 11 1001.

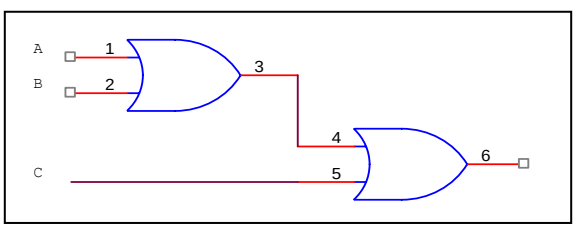
	ASCII (hex)	Binary
0	30	011 0000
1	31	011 0001
2	32	011 0010
3	33	011 0011
4	34	011 0100
5	35	011 0101
6	36	011 0110
7	37	011 0111
8	38	011 1000
9	39	011 1001

10.

```
000000 22 55 2E 53 2E 41 2E 20 69 73 20 61 20 63 6F 75    "U.S.A. is a cou
000010 6E 74 72 79 22 0D 0A 22 69 6E 20 4E 6F 72 74 68    ntry".."in North
000020 20 41 6D 65 72 69 63 61 22 0D 0A                   America"..
```

SECTION 0.2: DIGITAL PRIMER

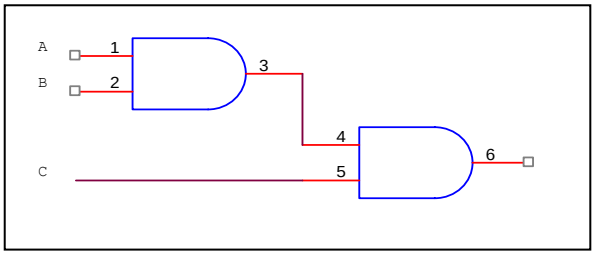
11.



12.

A	B	C	Y
0	0	0	0
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	1

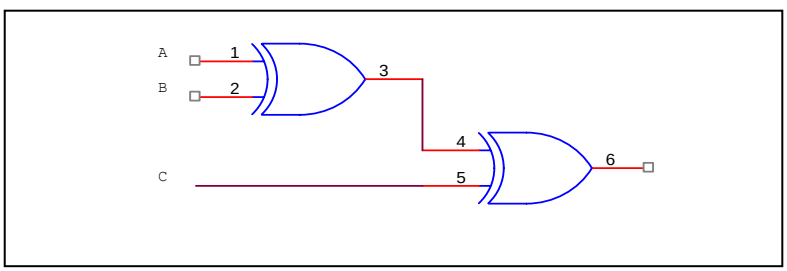
13.



14.

A	B	C	Y
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

15.



A	B	C	Y
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

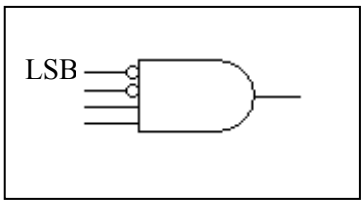
16.

A	B	C	Y
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

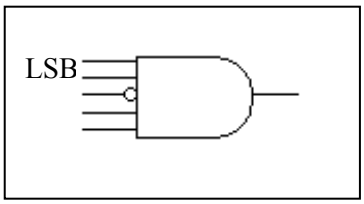
17.

A	B	C	Y
0	0	0	1
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	0

18.



19.



20.

CLK	D	Q
No	X	NC
Yes	0	0
Yes	1	1

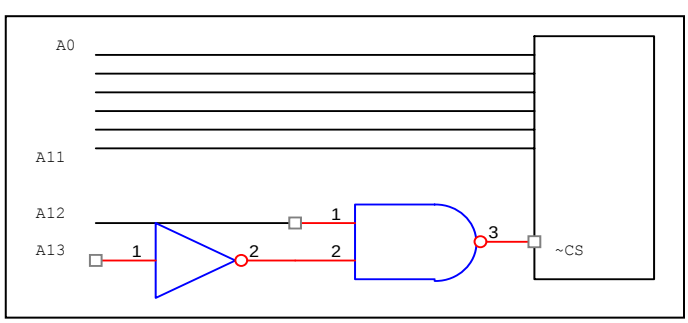
SECTION 0.3: SEMICONDUCTOR MEMORY

21.

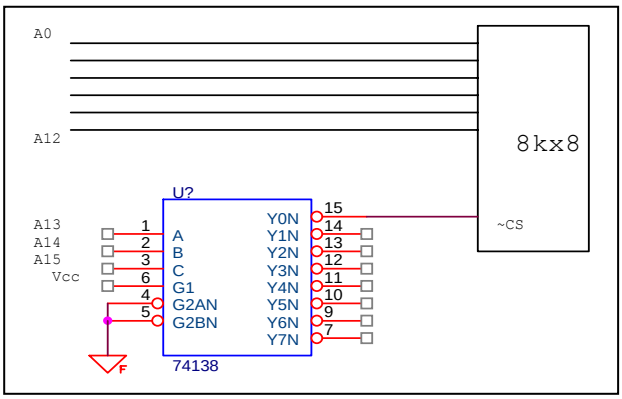
(a) 4
(b) 4
(c) 4
(d) 1 048 576, 2^{20}
(e) 1024K
(f) 1 073 741 824, 2^{30}
(g) 1 048 576 K
(h) 1024M
(i) 8388608, 8192K

22. Disk storage capacity / size of a page = $(2*2^{30}) / (25*80)$ = 1 million pages

23. (a) 9FFFFh – 10000h = 8FFFFh = 589 824 bytes
    (b) 576 kbytes
24. $2^{32} - 1 = 4\ 294\ 967\ 295$
25. (a) FFh, 255
    (b) FFFFh, 65535
    (c) FFFF FFFFh, 4 294 967 295
    (d) FFFF FFFF FFFF FFFFh, 18 446 744 073 709 551 615
26. (a) $2^{16} = 64K$
    (b) $2^{24} = 16M$
    (c) $2^{32} = 4096$ Mega, 4G
    (d) $2^{48} = 256$ Tera, 262144 Giga, 268435456 Mega
27. Data bus is bidirectional, address bus is unidirectional (exit CPU).
28. The storage of the chip is measured in Megabits while the Computer memory is measured in Megabytes.
29. True, the more address lines the more memory locations.
30. True, the memory location size is fixed.
31. True, the more data lines the more memory locations
32. True
33. access time
34. True
35. electrically erasable
36. True
37. DRAM
38. SRAM
39. DRAM and SRAM
40. (c)
41. (c)
42. (a) 32Kx8, 256K
    (b) 8Kx8, 64K
    (c) 4Kx8, 32K
    (d) 8Kx8, 64K
    (e) 4Mx1, 4M
    (f) 8Kx1, 8K
    (g) 4Kx8, 32K
    (h) 2Kx8, 16K
    (i) 256Kx4, 1M
    (j) 64Kx8, 512K
43. (a) 128K 14 8
    (b) 256K 15 8
    (c) 512K 16 8
    (d) 2M 18 8
    (e) 512K 16 8
    (f) 256K 8 4
    (g) 8M 20 8
    (h) 16M 11 4
    (i) 512K 16 8
44. 4000h - 7FFFh
45.

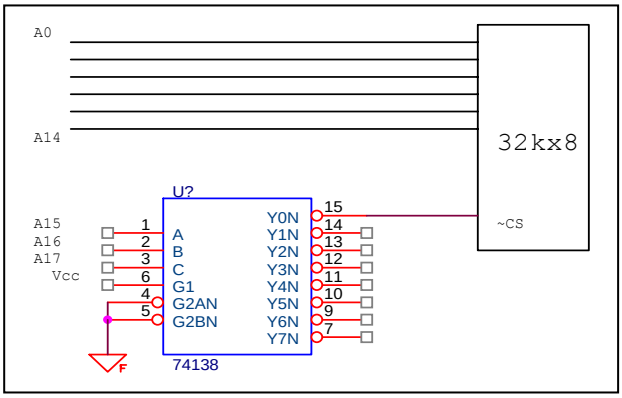


46. 8000h - 8FFFh, B000h - BFFFh, E000 – EFFFh
47.



Each controls 8K bytes block

48. 6000h - 7FFFh, C000h - DFFFh, E000h – FFFFh
49.



Each controls 32K bytes block

50. 4000h - 7FFFh, 8000h - BFFFh, C000h – FFFFh

SECTION 0.4: CPU AND HARVARD ARCHITECTURE

51. PC (Program Counter)
52. ALU is responsible for all arithmetic and logic calculations in the CPU.
53. Address, control and data

CHAPTER 1: THE AVR MICROCONTROLLERS: HISTORY AND FEATURES

SECTION 1.1: MICROCONTROLLERS AND EMBEDDED PROCESSORS

1. False.
2. True.
3. True.
4. True.
5. CPU, RAM, ROM, EEPROM, I/O, Timer, Serial COM port, ADC.
6. RAM and ROM.
7. Keyboard, mouse, printer.
8. Computing power and compatibility with millions and millions of PCs.
9. PIC 16x – Microchip Technology, 8051 - Intel, AVR – Atmel, Z8 – Zilog, 68HC11 – Freescale Semiconductor (Motorola).
10. 8051.
11. Power consumption.
12. The ROM area is where the executable code is stored.
13. Very, in case there is a shortage by one supplier.
14. Suppliers other than the manufacturer of the chip.
15. B is absolutely wrong; 16 bit software can not run on an 8 bit system due to special instructions and registers. But A can be true (in the case of software compatibility).

SECTION 1.2: OVERVIEW OF THE AVR FAMILY

16. Flash memory is ideal for fast development because Flash memory can be erased in seconds compared to 20 minutes or more needed for the UV-EPROM.
17. 32 pins
18. 32 Kbytes
19. 256 bytes
20. 8
21. 4K
22. 6
23. 2K
24. ATtiny11, ATtiny12, ATting15L
25. All AVRs have Flash ROM; but a few of them, like ATtiny20, ATtiny28L, and ATtiny4 have no EEPROM
26. AT90USB1286, AT90USB1287, AT90USB162, AT90USB646, AT90USB647, AT90USB82
27. AT90CAN128, AT90CAN32, AT90CAN64
28.

	Program ROM	Data RAM
(a) ATmega32	32 Kbytes	2048
(b) ATtiny44	2 Kbytes	128

(c) ATtiny84	8 Kbytes	512
(d) 90CAN128	128 Kbytes	4 K

29.

	Program ROM	Data RAM	EEPROM
ATmega32	32 Kbytes	2048	1024
ATmega16	16 Kbytes	1024	512

30. 512