

8- AVR RISC ATMEGA

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1-31 03 07-02

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 (8 23 2024 .);
 07-02 (() (1-31 03 07
 1-31 03 -
))). -
 , , -
 8- Microchip AVR® -
 , . ATMEGA -
 Arduino. -
 AVR C/C++. -

korzhukov@bsu.by 398-02-22
2024

8- RISC AVR ATmega -

AVR-8 [1]. -

8- RISC- AVR Atmel -

Norwegian University of Science and Technology (NTNU) (Alf- Egil Bogen) (Vegard Wollen). - Alf Egil Bogen Vegard Wollan RISC – AVR. Advanced Virtual RISC.

– 1996. AVR : -

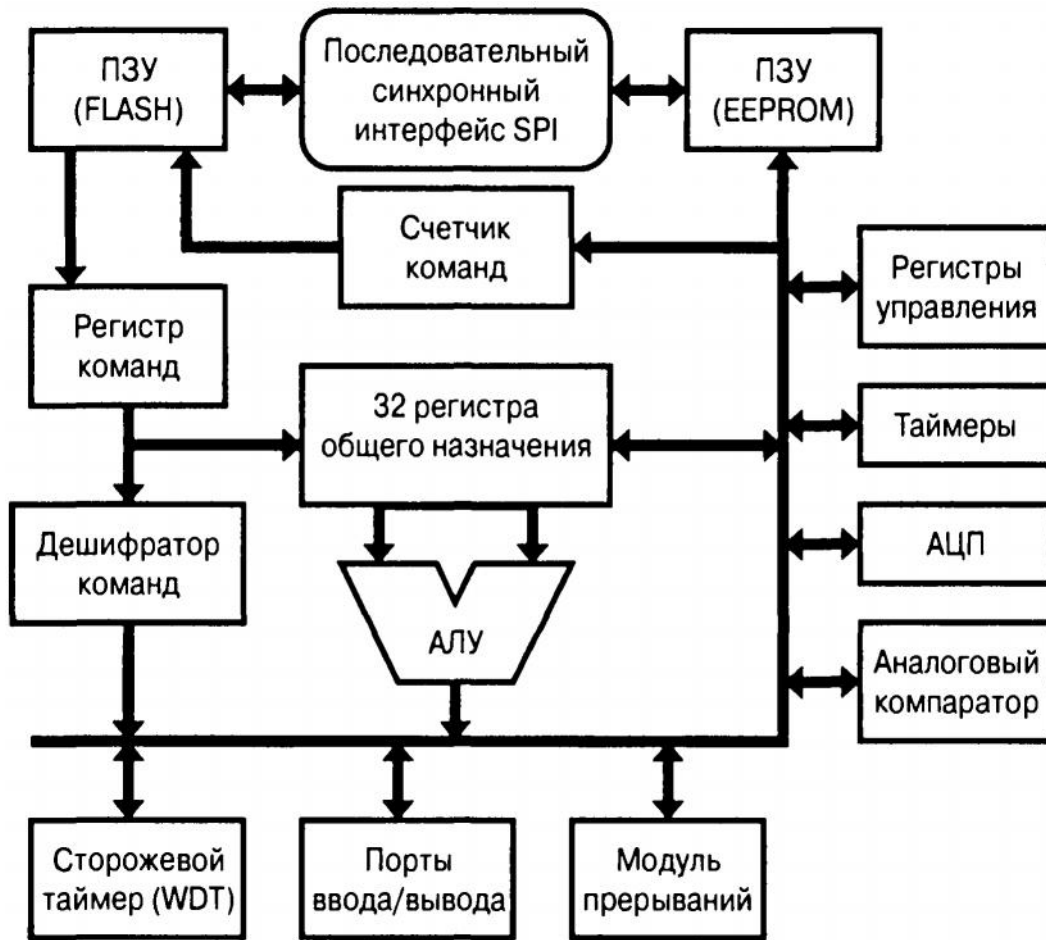
- Classic AVR;
- Tiny AVR;
- Mega AVR;
- Mega AVR ;
- ASIC/FPGA AVR;
- XMEGA AVR (,)

ATMEGA

Mega AVR , -

(CD-ROM/DVD-ROM .),

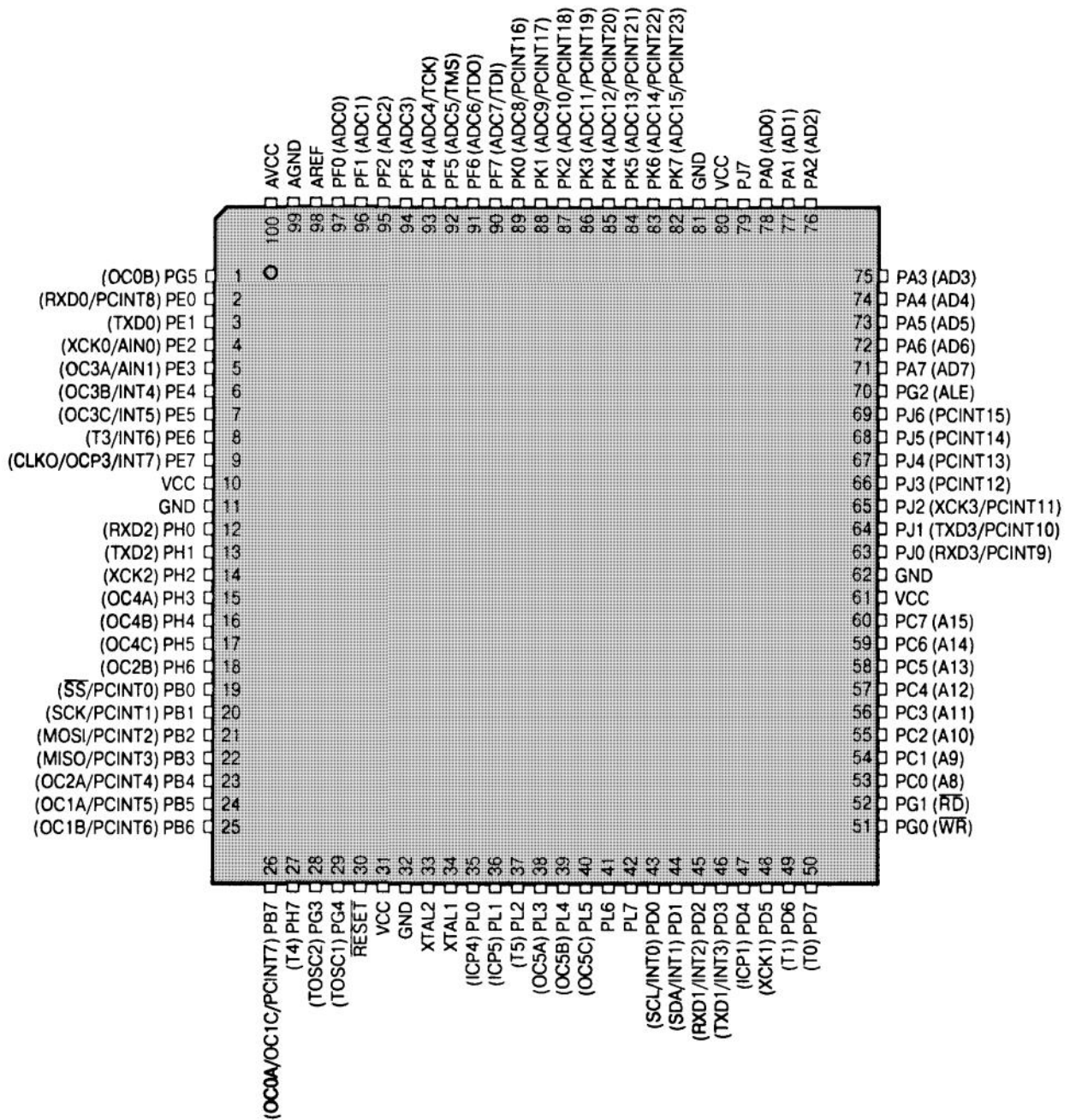
Mega -



1 –

AVR

	Mega						
1.	28-	32-	4	TQFP	MLF (-	24
/	,	23:		DIP)			
2.	40-	44-		TQFP	LF (-	
/	,	35 (DIP))	
	32 ():					
3.		64-		TQFP	MLF.	-	
		/	53, 54:				
4.		100-		TQFP.			
	/	68, 86.					



2 – () TQFP ATmega640x/1280x/2560x

ATmega640x/1280x/2560x

			-
XTAL1	34	I	
XTAL2	33		
RESET	30	I	
. 8-		/	-

0 (AD0)	78	I/O	0- 0- /	
1 (AD1)	77	I/O	1- 1- /	
2 (AD2)	76	I/O	2- 2- /	
(AD3)	75	I/O	3- 3- /	
4 (AD4)	74	I/O	4- 4- /	
5 (AD5)	73	I/O	5- 5- /	
6 (AD6)	72	I/O	6- 6- /	
7 (AD7)	71	I/O	7- 7- /	
. 8-			/	-
PB0 (SS/PCINT0)	19	I/O	0- Slave- SPI	-
1 (SCK/PCINT1)	20	I/O	1- (Master) (Slave) SPI	-
2 (MOSI/PCINT2)	21	I/O	2- (Master) SPI (Slave)	-
(MISO/PCINT3)	22	I/O	3- (Master) SPI (Slave)	-

4 (OC2A/PCINT4)	23	I/O	4- / 2 -
PB5 (OC1A/PCINT5)	24	I/O	5- / 1 -
PB6 (OC1B/PCINT6)	25	I/O	6- / 1 -
7 (OC0A/OC1C/PCINT7)	26	I/O	7- / 0 / 1 -
. 8-			/ -
0 (8)	53	I/O	0- 8-
PC1 (A9)	54	I/O	1- 9-
2 (10)	55	I/O	2- 10-
(11)	56	I/O	3- 11 -
4 (12)	57	I/O	4- 12-
5 (13)	58	I/O	5- 13-
6 (14)	59	I/O	6- 14-
7 (15)	60	I/O	7- 15-
D. 8-			/ -
PD0 (SCL/INT0)	43	I/O	0- D / TWI -
PD1 (SDA/INT1)	44	I/O	1 - D / TWI

PD2 (RXD1/INT2)	45	I/O	2- D USART1
PD3 (TXD1/INT3)	46	I/O	3- D USART1
PD4 (ICP1)	47	I/O	4- D / 1
PD5 ()	48	I/O	5- D / USART1
PD6 (T1)	49	I/O	6- D / T1
PD7 (T0)	50	I/O	7- D / 0
			8- / -
0 (RXD0/PCINT8)	2	I/O	0- USART0 -
1 (TXD0)	3	I/O	1- USART0
2 (AIN0/XCK0)	4	I/O	2- / USART0 -
PE3(A1N1/OC3A)	5	I/O	3- /
4 (OC3B/INT4)	6	I/O	4- /
5 (OC3C/INT5)	7	I/O	5- /
6 (T3/INT6)	8	I/O	6- /

7 (ICP3/CLKO/INT7)	9	I/O	7-	/	
F. 8-				/	-
PF0 (ADC0)	97	I/O	0-	F	
PF1 (ADC1)	96	I/O	1-	F	
PF2 (ADC2)	95	I/O	2-	F	
PF3 (ADC3)	94	I/O	3-	F	
PF4 (ADC4/TCK)	93	I/O	4-	F	JTAG
PF5 (ADC5/TMS)	92	I/O	5-	F	JTAG
PF6 (ADC6/TDO)	91	I/O	6-	F	JTAG
PF7 (ADC7/TDI)	90	I/O	7-	F	JTAG
G. 6-				/	-
PG0 (WR)	51	I/O	0-	G	
PG1 (RD)	52	I/O	1-	G	
PG2 (ALE)	70	I/O	2-	G	
PG3 (TOSC2)	28	I/O	3-	G	-
				/	2
PG4 (TOSC1)	29	I/O	4-	G	-
				/	2
PG5 (0B)	1	I/O	5-	G	0
				/	
. 8-				/	-

0 (RXD2)	12	I/O	0- USART2	
PH1 (TXD2)	13	I/O	1- USART2	
2 (2)	14	I/O	2- / USART2	
(4)	15	I/O	3- / 4	
4 (4)	16	I/O	4- / 4	
5 (4)	17	I/O	5- / 4	
6 (2)	18	I/O	6- / 2	
7 (4)	27	I/O	7- / 4	
J. 8-			/	-
PJ0 (RXD3/PCINT9)	63	I/O	0- J USART3	-
J1 (TXD3/PCINT10)	64	I/O	1- J USART3	-
PJ2 (XCK3/PCINT11)	65	I/O	2- / J USART3	-
PJ3 (PCINT12)	66	I/O	3- J	-
PJ4 (PCINT13)	67	I/O	4- J	-
PJ5 (PCINT14)	68	I/O	5- J	-
PJ6 (PCINT15)	69	I/O	6- J	-
PJ7	79	I/O	7- J	

. 8-		/		-	
PK0 (ADC8/PCINT16)	89	I/O	0-	-	
1 (ADC9/PCINT17)	88	I/O	1-	-	
PK2 (ADC10/PCINT18)	87	I/O	2-	-	
PK3 (ADC11/PCINT19)	86	I/O	3-	-	
PK4 (ADC12/PCINT20)	85	I/O	4-	-	
PK5 (ADC13/PCINT21)	84	I/O	5-	-	
PK6 (ADC14/PCINT22)	83	I/O	6-	-	
PK7 (ADC15/PCINT23)	82	I/O	7-	-	
L. 8-		/		-	
PL0 (ICP4)	35	I/O	0-	L	4
PL1 (ICP5)	36	I/O	1-	L	5
PL2 (5)	37	I/O	2-	L	5
PL3 (5)	38	I/O	3-	L	5

PL4 (5)	39	I/O	4-	L	5
PL5 (5)	40	I/O	5-	L	5
PL6	41	I/O	6-	L	
PL7	42	I/O	7-	L	
AREF	98				
AVCC	100				
VCC	10, 31, 61, 80				
GND	11, 32, 62, 81, 99				

ATmega281x/2561x

- 7 / (A...F – 8- , G – 6-);
- 8- (, 2) 16- (1, , 4, 5) / ;
- 6 ;
- 8- 10- ;
- USART, SPI;
- SPI TWI;
- JTAG.

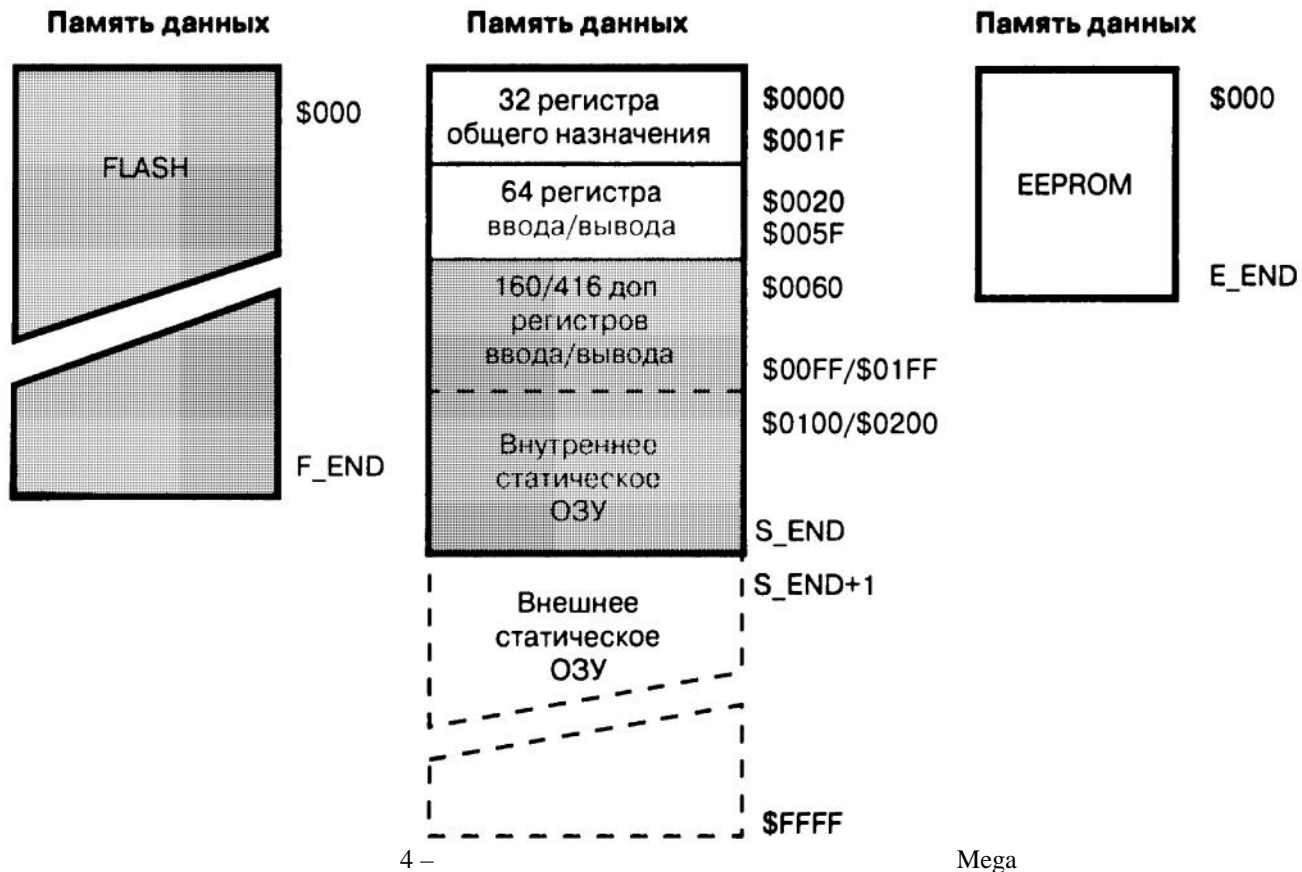
ATmega280x/2560x:

- 11 / (A...F, , J...L – 8- , G – 6-);
- 8- (, 2) 16- (1, , 4, 5) / ;
- 12 ;
- 16- 10- ;
- USART, SPI;
- SPI TWI;
- JTAG.

AVR Mega

(EEPROM)

AVR 16- , 16-



Mega

	- (FLASH)		()			(EEPROM)	
	[F_END]	[]	[S_END]	[]	- /	[E_END]	[]
AT-mega2560x	\$1FFFF	128	\$21FF	8	416	\$FFF	4
AT-mega2561x	\$1FFFF	128	\$21FF	8	416	\$FFF	4

16-

4 (4 * 1024) 64 (64 * 1024) 16-

Mega

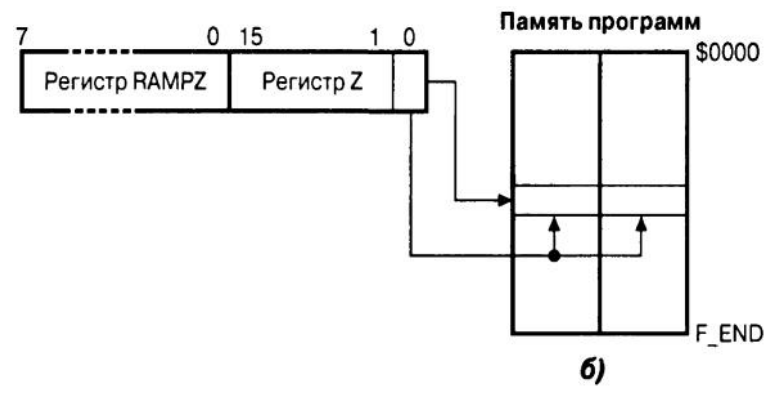
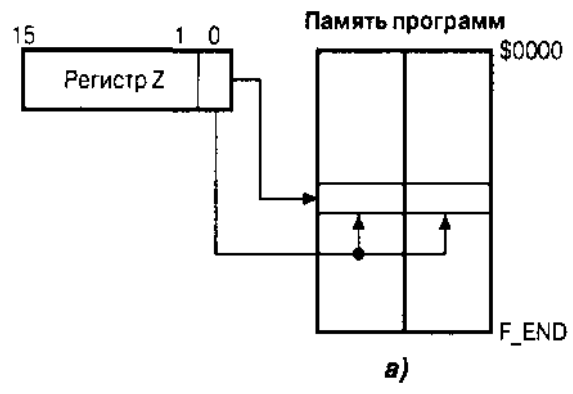
Counter – PC). 11 17 , (Program

\$0000
 ()
 ()
). \$001 (8
) \$0002 ()

(8)
 (R JMP),
 (J MP). Mega

\$0001.

– LPM ELPM (128)



RAMPZ

\$ (\$5)

/ , 6.

	7	6	5	4	3	2	1	0	
	—	—	—	—	—	—	—	RAMPZ0	
Чтение (R)/Запись (W)	R	R	R	R	R	R	R	R/W	ATmega128x ATmega1280x ATmega1281x
Начальное значение	0	0	0	0	0	0	0	0	

	7	6	5	4	3	2	1	0	
	—	—	—	—	—	—	RAMPZ1	RAMPZ0	
Чтение (R)/Запись (W)	R	R	R	R	R	R	R/W	R/W	ATmega2560x ATmega2561x
Начальное значение	0	0	0	0	0	0	0	0	

6- RAMPZ

Mega :
 (EEPROM).
 32 (),
 / ().
 (extended) 64 ,
 - 160 416 ().
 /
 (, . .),
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Vcc.

Mega (

AVR)

« / / ».

(SBI CBI),

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/

/

3

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-
-

PORTx (),

DDRx,

PINx ().

x.

– PORTB, DDRB, PINB . . .

PORTA, DDRA,

PINA,
PINx

ATmega8515x/8535x, ATmega8x/16x/32x/64x/128x

ATmega62x)

PINx

PORTx.

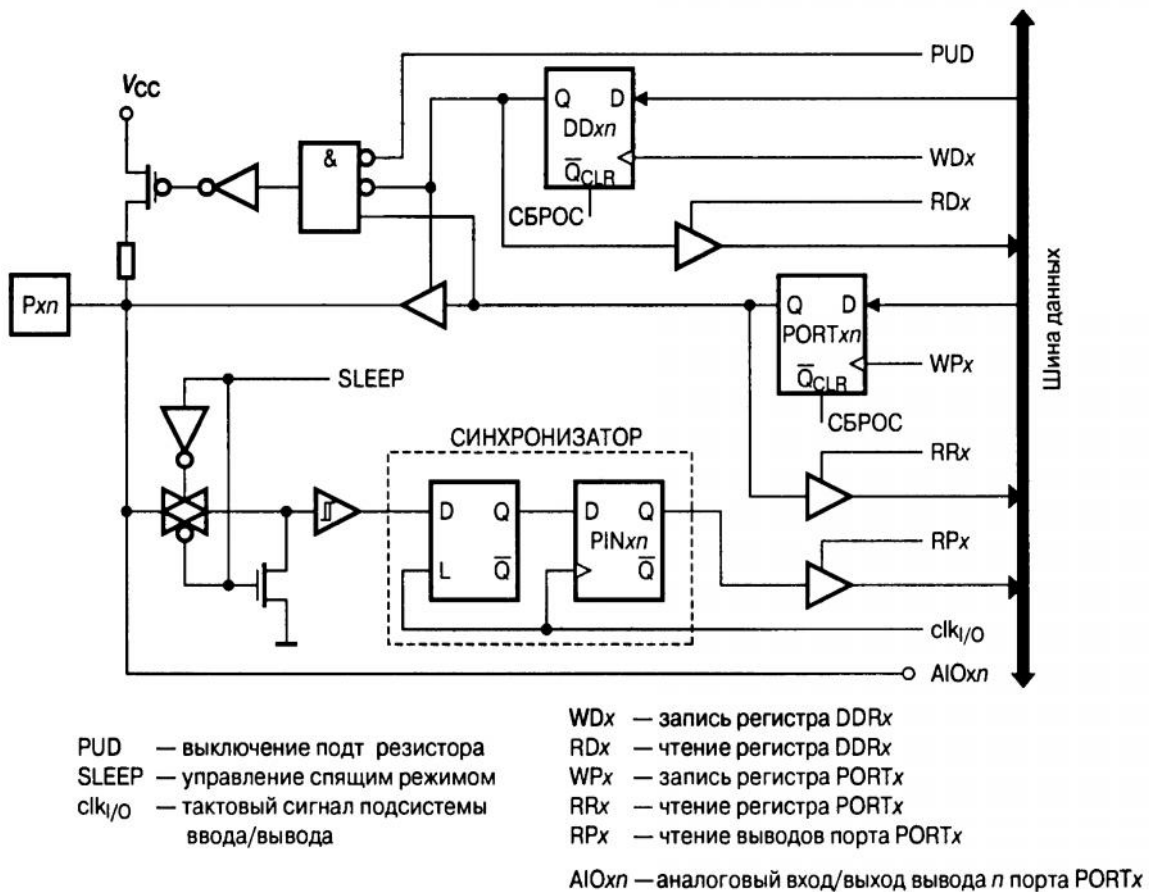
1

7.

PORT_{xn} (PORT_x), DD_{xn} (DDR_x) IN_{xn} (PIN_x).

x n.

0.



Примечание. Сигналы WP_x WD_x RP_x RD_x являются общими для всех выводов одного порта
 сигналы clk_{I/O} SLEEP и PUD являются общими для всех портов микроконтроллера

DD_{xn} DD_x
 / :
 • 1, n-
 • 0-
 PORT_{xn} PORT_x
 (DD_{xn} = 1),
 • 1,
 • ,
 • 0,

(DDxn = 0), PORTxn -

PORTxn 1 -

) PUD SFIOR
 ATmega64x ATmega128x MCUCR (SFIOR)
 (\$40), - \$30 (\$50). MCUCR \$20
 \$35 (\$55). 8.
 PUD 0
 PUD:
 • 0,
 PORTxn ;
 • 1, -

	7	6	5	4	3	2	1	0	
	X	X	X	X	X	PUD	X	X	ATmega8515x/8535x ATmega8x/16x/32x ATmega64x/128x ATmega162x
Чтение (R)/Запись (W)	X	X	X	X	X	R/W	X	X	
Начальное значение	0	0	0	0	0	0	0	0	

a)

	7	6	5	4	3	2	1	0	
	-	-	-	PUD	-	-	IVSEL	IVCE	ATmega48x/88x/168x
Чтение (R)/Запись (W)	R	R	R	R/W	R	R	R/W	R/W	
Начальное значение	0	0	0	0	0	0	0	0	

	7	6	5	4	3	2	1	0	
	JTD	-	-	PUD	-	-	IVSEL	IVCE	ATmega164x/324x/644x ATmega165x ATmega325x/3250x ATmega645x/6450x ATmega640x ATmega1280x/1281x ATmega2560x/2561x
Чтение (R)/Запись (W)	R/W	R	R	R/W	R	R	R/W	R/W	
Начальное значение	0	0	0	0	0	0	0	0	

b)

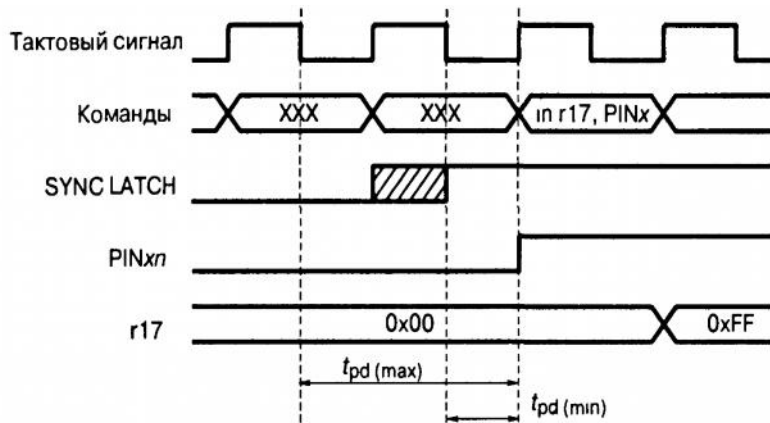
8 -

SFIOR () MCUCR ()

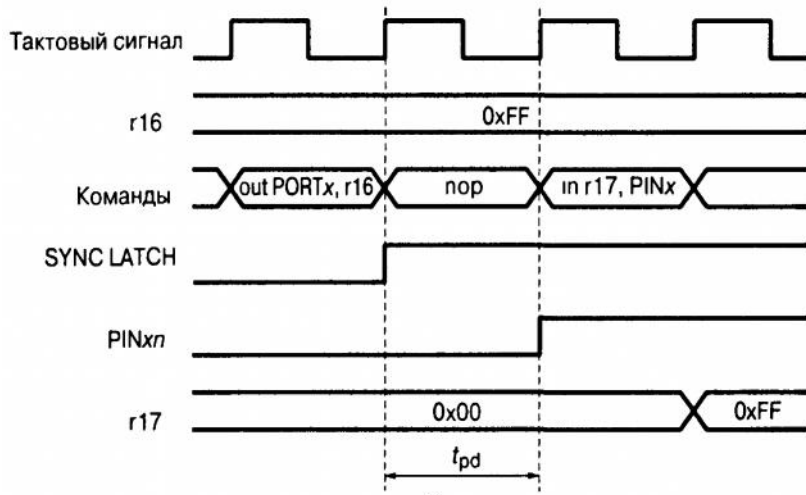
DDx	PORTxn	PUD	-		
0	0	X		-	(Hi-Z) 1)
0	1	0		-	-

0	1	1		-	(Hi-Z)
1	0	X		-	0
1	1	X		-	1
1)					

, (DDxn PORTxn)
 (DDxn = 0, PORTxn = 0) (DDxn = 1, PORTxn = 1) -
 : -
 (DDxn = 0, PORTxn = 1),
 (DDxn = 1, PORTxn = 0). ,
 , , ,
 , -
 ,
 PUD 1. -
 (DDxn = 0, PORTxn = 1)
 (DDxn = 1, PORTxn = 0). -
 (DDxn = 0, PORTxn = 0),
 (DDxn = 1, PORTxn = 1).
 (INxn INx. DDxn)
 ,
 INxn , 7, INxn -
 , -
 INxn , -
 0.5 1.5 ,
 9 . ,
 NOP. OUT
 «SYNC LATCH» 1 (-
 9).



a)



б)

INxn;

9 -

B

1, 2 3 - 0. 4...7 -

6 7 -

```

...
ldi r16, (1<< 7) | (1<< 6) | (1<< 1) | (1<< 0)
ldi r17, (1<<DDB3) | (1<<DDB2) | (1<<DDB1) | (1<<DDB0)
out PORTB, r16 ;
out DDRB, r17 ;
nop ;
in r16, PINB ;
...

```

```

unsigned char i;
...
/*
/*
PORTB = (1<< 7) | (1<< 6) | (1<< 1) | (1<< 0);
DDRB = (1<<DDB3) | (1<<DDB2) | (1<<DDB1) | (1<<DDB0);
_NOP();
i = PINB;
...

```

/

,

-

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1.

(UFD – USB Flash Drive)

mega2560_R3.

AVR

Mega
10.

Arduino-

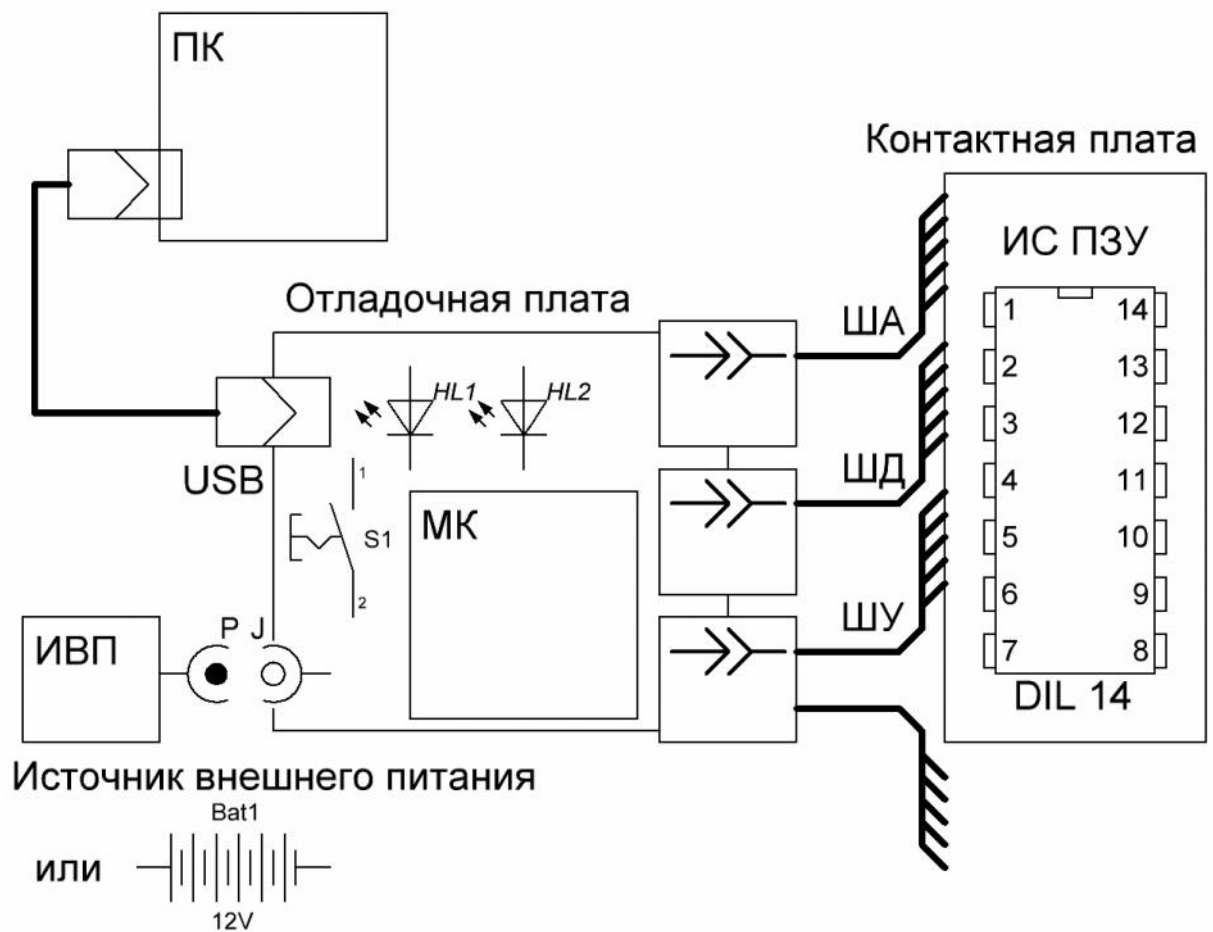


10 – Arduino MEGA 2560 R3

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ATmega

11.



11 -

1

AT27C010

AT27C010

1 (128K x 8) OTP CMOS EPROM, BIOS

128 (

).

5 . 12

AT27C010.

CE\ - CHIP ENABLE

OE\ - OUTPUT ENABLE

Pin Configurations

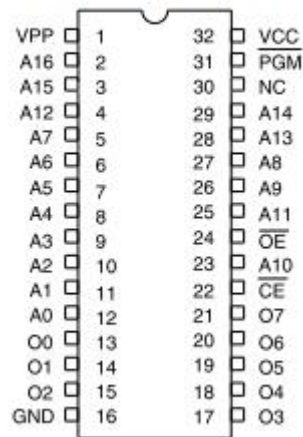
Pin Name	Function
A0 - A16	Addresses
O0 - O7	Outputs
\overline{CE}	Chip Enable
\overline{OE}	Output Enable
\overline{PGM}	Program Strobe
NC	No Connect

12 -

AT27C010

13

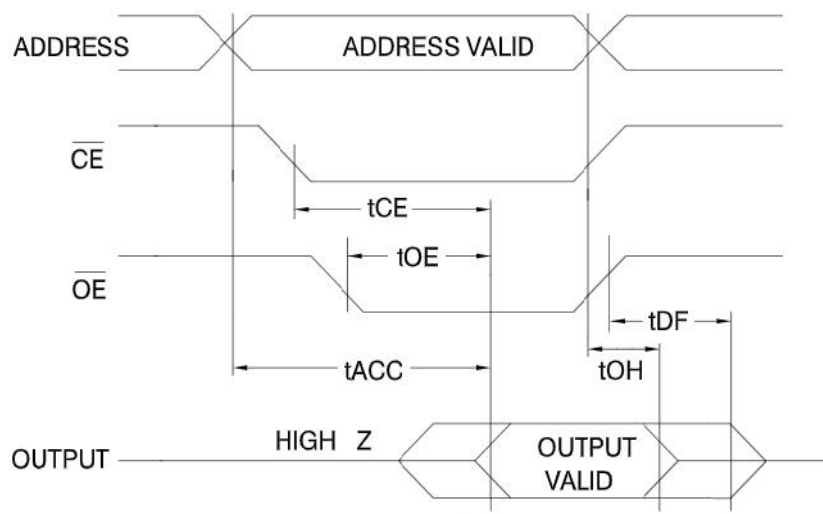
PDIP Top View



13 -

AT27C010

14.



14 -

AT27C010

14

13
 Arduino-mega2560 . 3 : Arduino-mega2560.
 PA – PA0-PA7 – A0-A7
 PC0-PC7, A8-A15.
 PG – PG0-PG2 – CE\, OE\
 A16. PL0-PL7 00-07.
 11.

2
 : USB 10, USB

3
 Arduino-mega2560 **UART**
 USB,
 Arduino. UART –

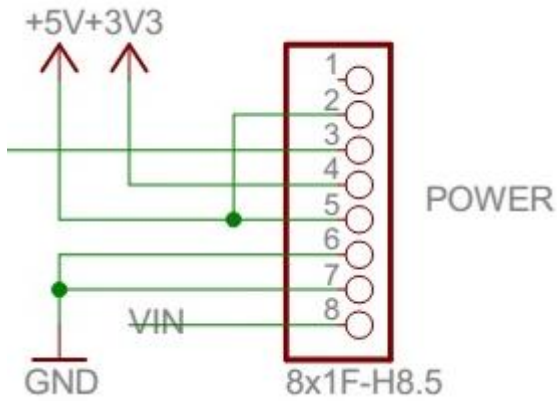
4
 10, Arduino-mega2560
 ()

5
 2
 – 2

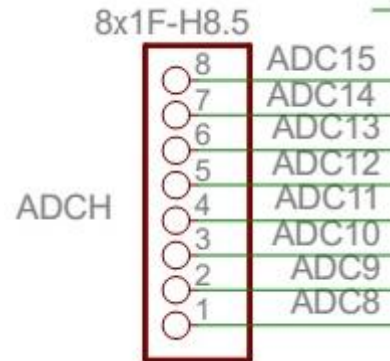
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ARDUINO-MEGA2560_R3

RESET – 3

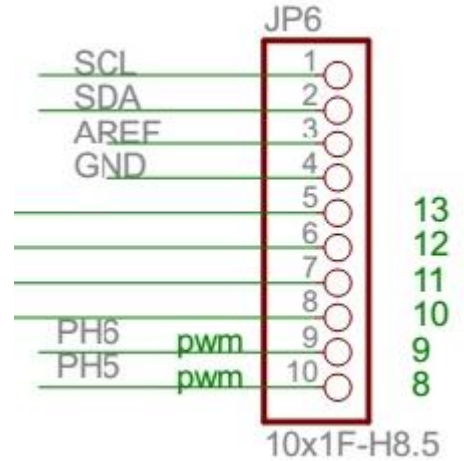
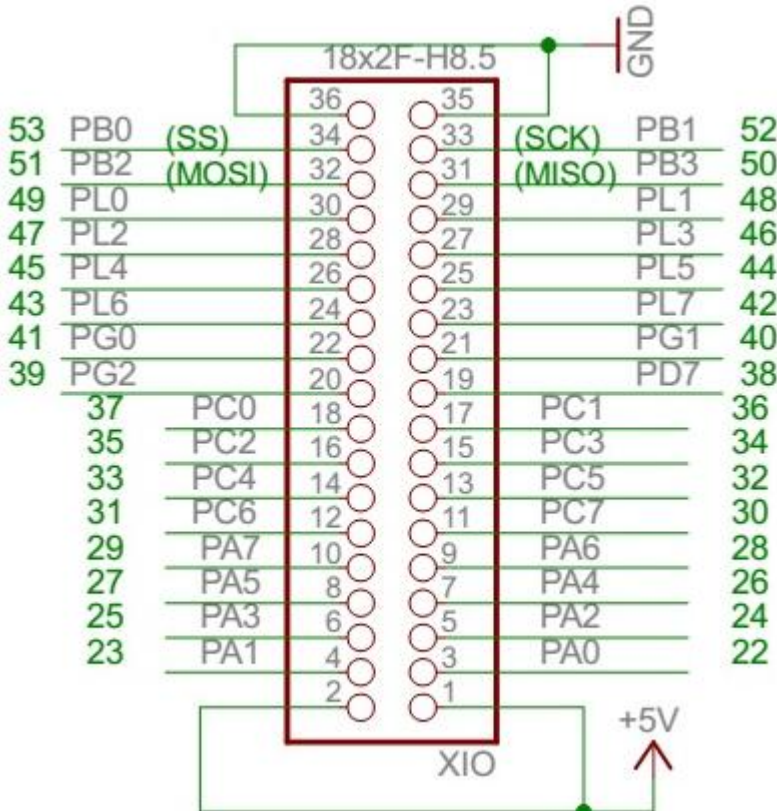


ADCH

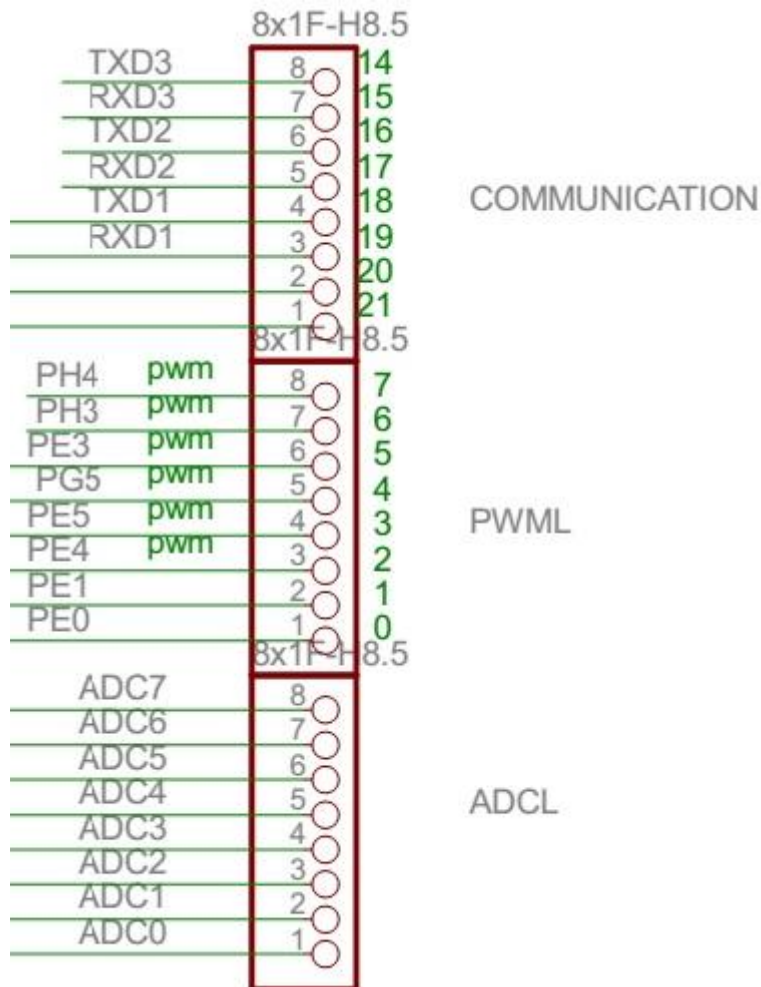


/

PB7 – 13, PB6 – 12, PB5 – 11, PB4 – 10



SDA – 20, SCL – 21



```
int timeM = 100;

void setup() {
    //          LED_BUILTIN
    pinMode( LED_BUILTIN, OUTPUT );
}

void loop() {
    digitalWrite( LED_BUILTIN, HIGH ); //          LED (HIGH voltage level)
    delay( timeM ); //          10          . .
    digitalWrite( LED_BUILTIN, LOW ); //          LED (voltage LOW)
    delay( timeM ); //          10          . .
    timeM += 100;
    if ( timeM == 3000 ) {
        timeM = 100;
        delay( 3000 );
    }
}
```

1

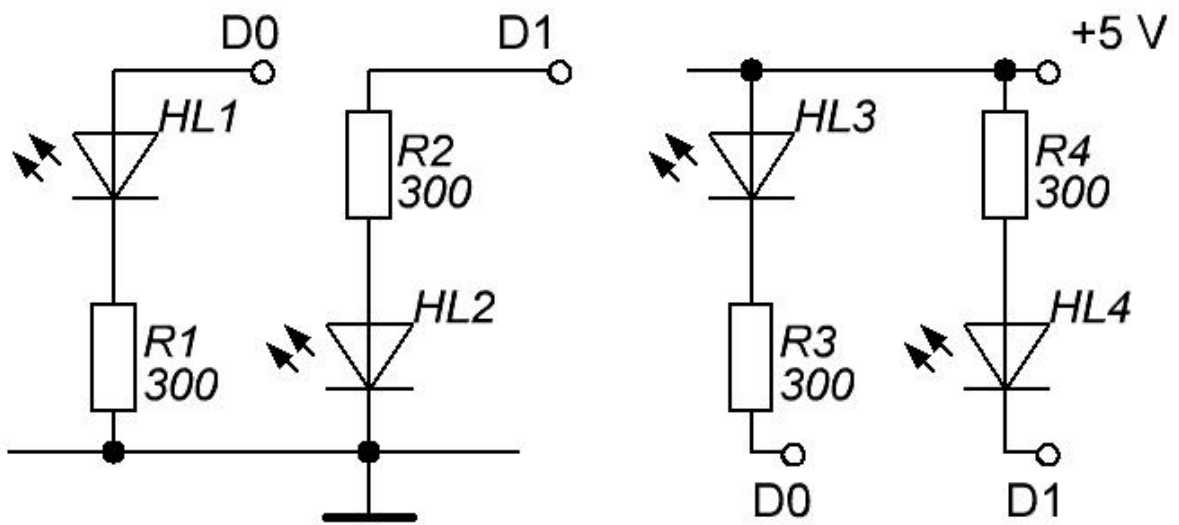
(PB7 - 13)

(1 +

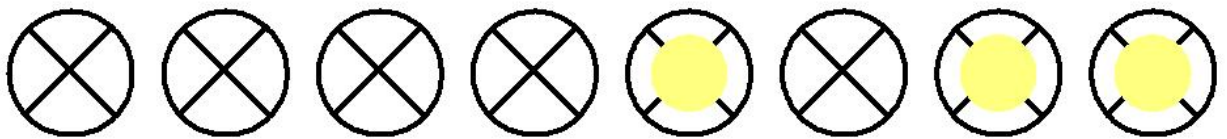
),
- 0,5, 1,0 2

2

8
XX XXX XXXX XXXXX XXXXXX XX XXX XX X XXXX X



8



30

15

:020000020000FC

:100000008FEF87B98BE0112488B940E054ED60E3AD

:0E001000415051096109E1F7880F811DF5CFBC

:00000001FF

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