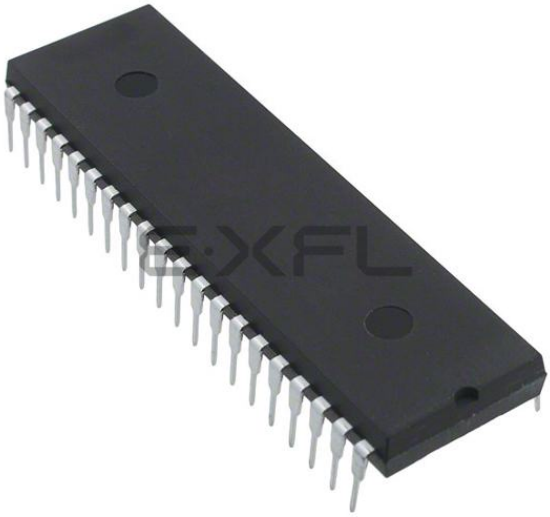

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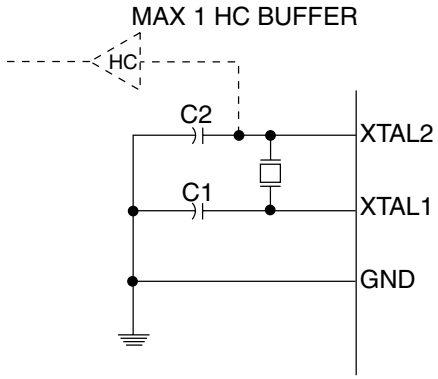
Applications of "Embedded - Microcontrollers"

Details	
Product Status	Obsolete
Core Processor	AVR
Core Size	8-Bit
Speed	8MHz
Connectivity	SPI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	32
Program Memory Size	8KB (4K x 16)
Program Memory Type	FLASH
EEPROM Size	512 x 8
RAM Size	512 x 8
Voltage - Supply (Vcc/Vdd)	4V ~ 6V
Data Converters	-
Oscillator Type	Internal
Operating Temperature	0°C ~ 70°C (TA)
Mounting Type	Through Hole
Package / Case	40-DIP (0.600", 15.24mm)
Supplier Device Package	40-PDIP
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/at90s8515-8pc

Crystal Oscillator

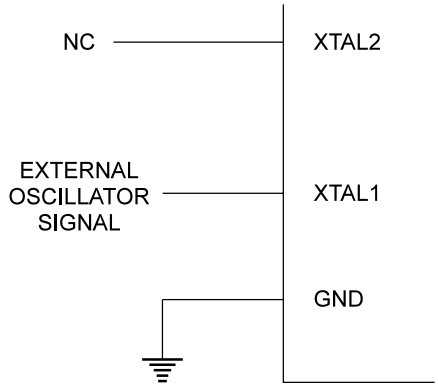
XTAL1 and XTAL2 are input and output, respectively, of an inverting amplifier that can be configured for use as an on-chip oscillator, as shown in Figure 2. Either a quartz crystal or a ceramic resonator may be used. To drive the device from an external clock source, XTAL2 should be left unconnected while XTAL1 is driven as shown in Figure 3.

Figure 2. Oscillator Connections



Note: When using the MCU oscillator as a clock for an external device, an HC buffer should be connected as indicated in the figure.

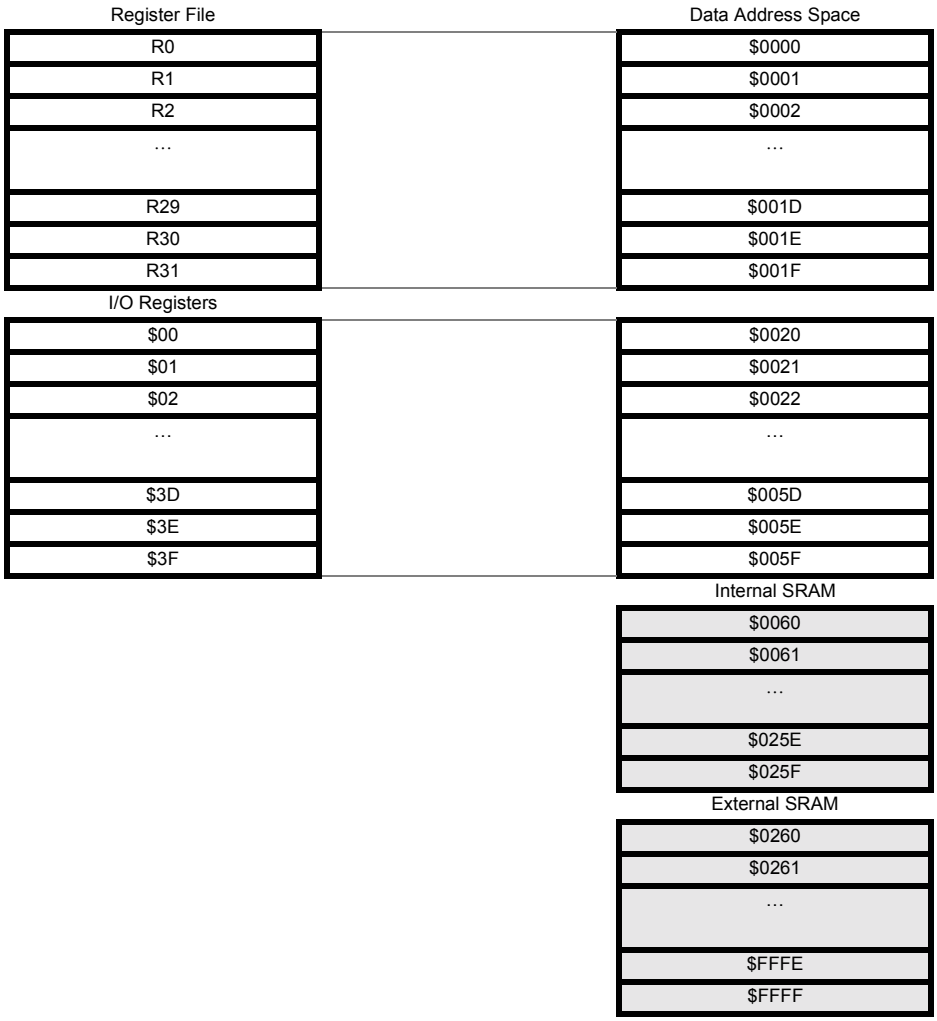
Figure 3. External Clock Drive Configuration



SRAM Data Memory – Internal and External

Figure 8 shows how the AT90S8515 SRAM memory is organized.

Figure 8. SRAM Organization



The lower 608 data memory locations address the Register file, the I/O memory and the internal data SRAM. The first 96 locations address the Register file + I/O memory, and the next 512 locations address the internal data SRAM. An optional external data SRAM can be placed in the same SRAM memory space. This SRAM will occupy the location following the internal SRAM and up to as much as 64K - 1, depending on SRAM size.

When the addresses accessing the data memory space exceed the internal data SRAM locations, the external data SRAM is accessed using the same instructions as for the internal data SRAM access. When the internal data space is accessed, the read and write strobe pins ($\overline{RD}$ and $\overline{WR}$) are inactive during the whole access cycle. External SRAM operation is enabled by setting the SRE bit in the MCUCR register. See page 29 for details.

Accessing external SRAM takes one additional clock cycle per byte compared to access of the internal SRAM. This means that the commands LD, ST, LDS, STS, PUSH and POP take one additional clock cycle. If the stack is placed in external SRAM, interrupts, subroutine calls and returns take two clock cycles extra because the 2-byte program counter is pushed and popped. When external SRAM interface is used with wait state,

External Interrupts

The external interrupts are triggered by the INT1 and INT0 pins. Observe that, if enabled, the interrupts will trigger even if the INT0/INT1 pins are configured as outputs. This feature provides a way of generating a software interrupt. The external interrupts can be triggered by a falling or rising edge or a low level. This is set up as indicated in the specification for the MCU Control Register (MCUCR). When the external interrupt is enabled and is configured as level-triggered, the interrupt will trigger as long as the pin is held low.

The external interrupts are set up as described in the specification for the MCU Control Register (MCUCR).

Interrupt Response Time

The interrupt execution response for all the enabled AVR interrupts is four clock cycles minimum. Four clock cycles after the interrupt flag has been set, the program vector address for the actual interrupt handling routine is executed. During this 4-clock-cycle period, the Program Counter (2 bytes) is pushed onto the stack and the Stack Pointer is decremented by 2. The vector is normally a relative jump to the interrupt routine, and this jump takes two clock cycles. If an interrupt occurs during execution of a multi-cycle instruction, this instruction is completed before the interrupt is served.

A return from an interrupt handling routine (same as for a subroutine call routine) takes four clock cycles. During these four clock cycles, the Program Counter (2 bytes) is popped back from the stack, the Stack Pointer is incremented by 2 and the I-flag in SREG is set. When the AVR exits from an interrupt, it will always return to the main program and execute one more instruction before any pending interrupt is served.

Note that the Status Register (SREG) is not handled by the AVR hardware, for neither interrupts nor subroutines. For the interrupt handling routines requiring a storage of the SREG, this must be performed by user software.

For interrupts triggered by events that can remain static (e.g., the Output Compare Register1 A matching the value of Timer/Counter1), the interrupt flag is set when the event occurs. If the interrupt flag is cleared and the interrupt condition persists, the flag will not be set until the event occurs the next time. Note that an external level interrupt will only be remembered for as long as the interrupt condition is active.

MCU Control Register – MCUCR

The MCU Control Register contains control bits for general MCU functions.

Bit	7	6	5	4	3	2	1	0	
$35 ($55)	SRE	SRW	SE	SM	ISC11	ISC10	ISC01	ISC00	MCUCR
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

- **Bit 7 – SRE: External SRAM Enable**

When the SRE bit is set (one), the external data SRAM is enabled and the pin functions AD0 - 7 (Port A), A8 - 15 (Port C), $\overline{WR}$ and $\overline{RD}$ (Port D) are activated as the alternate pin functions. Then the SRE bit overrides any pin direction settings in the respective data direction registers. See “SRAM Data Memory – Internal and External” on page 12 for a description of the external SRAM pin functions. When the SRE bit is cleared (zero), the external data SRAM is disabled and the normal pin and data direction settings are used.

- **Bit 6 – SRW: External SRAM Wait State**

When the SRW bit is set (one), a one-cycle wait state is inserted in the external data SRAM access cycle. When the SRW bit is cleared (zero), the external data SRAM access is executed with the normal three-cycle scheme. See Figure 43 and Figure 44.

Sleep Modes

To enter the sleep modes, the SE bit in MCUCR must be set (one) and a SLEEP instruction must be executed. If an enabled interrupt occurs while the MCU is in a sleep mode, the MCU awakes, executes the interrupt routine and resumes execution from the instruction following SLEEP. The contents of the register file, SRAM and I/O memory are unaltered. If a reset occurs during Sleep Mode, the MCU wakes up and executes from the Reset vector.

Idle Mode

When the SM bit is cleared (zero), the SLEEP instruction forces the MCU into the Idle Mode, stopping the CPU but allowing Timer/Counters, Watchdog and the interrupt system to continue operating. This enables the MCU to wake up from external triggered interrupts as well as internal ones like Timer Overflow interrupt and Watchdog reset. If wake-up from the Analog Comparator interrupt is not required, the Analog Comparator can be powered down by setting the ACD-bit in the Analog Comparator Control and Status Register (ACSR). This will reduce power consumption in Idle Mode. When the MCU wakes up from Idle Mode, the CPU starts program execution immediately.

Power-down Mode

When the SM bit is set (one), the SLEEP instruction forces the MCU into the Power-down mode. In this mode, the external oscillator is stopped, while the external interrupts and the Watchdog (if enabled) continue operating. Only an external reset, a Watchdog reset (if enabled), or an external level interrupt on INT0 or INT1 can wake up the MCU.

Note that when a level-triggered interrupt is used for wake-up from power-down, the low level must be held for a time longer than the reset delay Time-out period t_{TOUT}. Otherwise, the MCU will fail to wake up.

(TCCR1A and TCCR1B). The interrupt enable/disable settings for Timer/Counter1 are found in the Timer/Counter Interrupt Mask Register (TIMSK).

When Timer/Counter1 is externally clocked, the external signal is synchronized with the oscillator frequency of the CPU. To assure proper sampling of the external clock, the minimum time between two external clock transitions must be at least one internal CPU clock period. The external clock signal is sampled on the rising edge of the internal CPU clock.

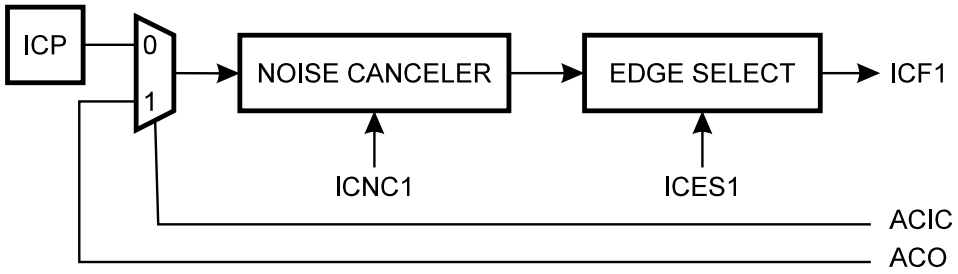
The 16-bit Timer/Counter1 features both a high-resolution and a high-accuracy usage with the lower prescaling opportunities. Similarly, the high prescaling opportunities make the Timer/Counter1 useful for lower speed functions or exact timing functions with infrequent actions.

The Timer/Counter1 supports two Output Compare functions using the Output Compare Register 1 A and B (OCR1A and OCR1B) as the data sources to be compared to the Timer/Counter1 contents. The Output Compare functions include optional clearing of the counter on compareA match and actions on the Output Compare pins on both compare matches.

Timer/Counter1 can also be used as an 8-, 9- or 10-bit Pulse Width Modulator. In this mode, the counter and the OCR1A/OCR1B registers serve as a dual, glitch-free, standalone PWM with centered pulses. Refer to page 47 for a detailed description of this function.

The Input Capture function of Timer/Counter1 provides a capture of the Timer/Counter1 contents to the Input Capture Register (ICR1), triggered by an external event on the input capture pin (ICP). The actual capture event settings are defined by the Timer/Counter1 Control Register (TCCR1B). In addition, the Analog Comparator can be set to trigger the Input Capture. Refer to “Analog Comparator” on page 59 for details on this. The ICP pin logic is shown in Figure 31.

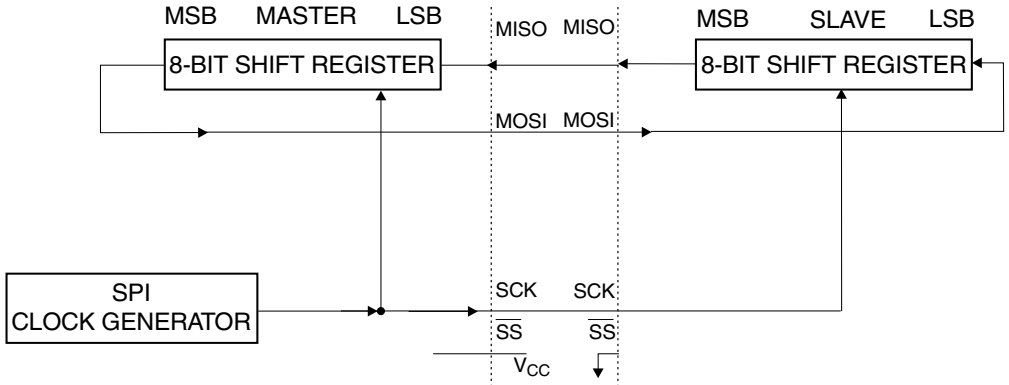
Figure 31. ICP Pin Schematic Diagram



ACIC: COMPARATOR IC ENABLE
ACO: COMPARATOR OUTPUT

If the Noise Canceler function is enabled, the actual trigger condition for the capture event is monitored over four samples and all four must be equal to activate the capture flag.

Figure 35. SPI Master-slave Interconnection



The system is single-buffered in the transmit direction and double-buffered in the receive direction. This means that bytes to be transmitted cannot be written to the SPI Data Register before the entire shift cycle is completed. When receiving data, however, a received byte must be read from the SPI Data Register before the next byte has been completely shifted in. Otherwise, the first byte is lost.

When the SPI is enabled, the data direction of the MOSI, MISO, SCK and $\overline{SS}$ pins is overridden according to Table 15.

Table 15. SPI Pin Overrides

Pin	Direction, Master SPI	Direction, Slave SPI
MOSI	User Defined	Input
MISO	Input	User Defined
SCK	User Defined	Input
$\overline{SS}$	User Defined	Input

Note: See “Alternate Functions of Port B” on page 66 for a detailed description of how to define the direction of the user-defined SPI pins.

$\overline{SS}$ Pin Functionality

When the SPI is configured as a master (MSTR in SPCR is set), the user can determine the direction of the $\overline{SS}$ pin. If $\overline{SS}$ is configured as an output, the pin is a general output pin, which does not affect the SPI system. If $\overline{SS}$ is configured as an input, it must be held high to ensure master SPI operation. If the $\overline{SS}$ pin is driven low by peripheral circuitry when the SPI is configured as master with the $\overline{SS}$ pin defined as an input, the SPI system interprets this as another master selecting the SPI as a slave and starts to send data to it. To avoid bus contention, the SPI system takes the following actions:

1. The MSTR bit in SPCR is cleared and the SPI system becomes a slave. As a result of the SPI becoming a slave, the MOSI and SCK pins become inputs.
2. The SPIF flag in SPSR is set, and if the SPI interrupt is enabled and the I-bit in SREG is set, the interrupt routine will be executed.

Thus, when interrupt-driven SPI transmittal is used in Master Mode and there exists a possibility that $\overline{SS}$ is driven low, the interrupt should always check that the MSTR bit is still set. Once the MSTR bit has been cleared by a slave select, it must be set by the user to re-enable SPI Master Mode.

When the SPI is configured as a slave, the $\overline{SS}$ pin is always input. When $\overline{SS}$ is held low, the SPI is activated and MISO becomes an output if configured so by the user. All other

If the 10(11)-bit Transmitter shift register is empty, data is transferred from UDR to the shift register. At this time the UDRE (UART Data Register Empty) bit in the UART Status Register, USR, is set. When this bit is set (one), the UART is ready to receive the next character. At the same time as the data is transferred from UDR to the 10(11)-bit shift register, bit 0 of the shift register is cleared (start bit) and bit 9 or 10 is set (stop bit). If 9-bit data word is selected (the CHR9 bit in the UART Control Register, UCR is set), the TXB8 bit in UCR is transferred to bit 9 in the Transmit shift register.

On the baud rate clock following the transfer operation to the shift register, the start bit is shifted out on the TXD pin. Then follows the data, LSB first. When the stop bit has been shifted out, the shift register is loaded if any new data has been written to the UDR during the transmission. During loading, UDRE is set. If there is no new data in the UDR register to send when the stop bit is shifted out, the UDRE flag will remain set until UDR is written again. When no new data has been written and the stop bit has been present on TXD for one bit length, the TX Complete flag (TXC) in USR is set.

The TXEN bit in UCR enables the UART Transmitter when set (one). When this bit is cleared (zero), the PD1 pin can be used for general I/O. When TXEN is set, the UART Transmitter will be connected to PD1, which is forced to be an output pin regardless of the setting of the DDD1 bit in DDRD.

Data Reception

Figure 39 shows a block diagram of the UART Receiver.

Figure 39. UART Receiver

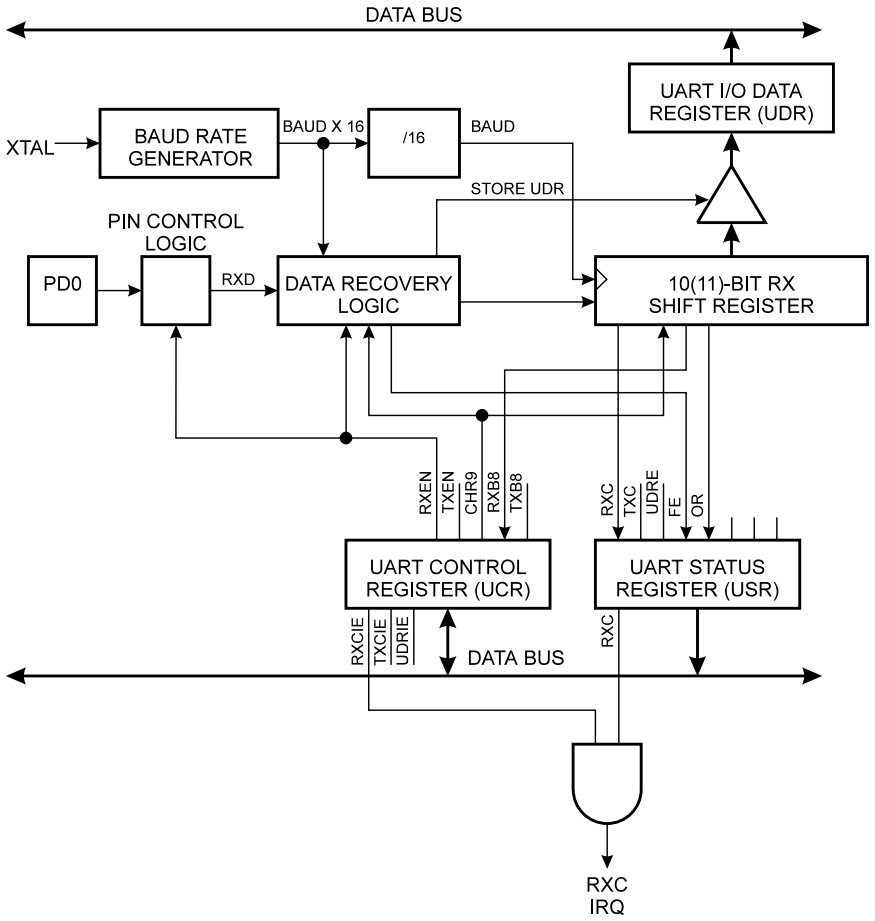


Table 17. UBRR Settings at Various Crystal Frequencies

Baud Rate	1 MHz		%Error	1.8432 MHz		%Error	2 MHz		%Error	2.4576 MHz		%Error
2400	UBRR=	**25**	**0.2**	UBRR=	**47**	**0.0**	UBRR=	**51**	**0.2**	UBRR=	**63**	**0.0**
4800	UBRR=	**12**	**0.2**	UBRR=	**23**	**0.0**	UBRR=	**25**	**0.2**	UBRR=	**31**	**0.0**
9600	UBRR=	6	7.5	UBRR=	**11**	**0.0**	UBRR=	**12**	**0.2**	UBRR=	**15**	**0.0**
14400	UBRR=	3	7.8	UBRR=	**7**	**0.0**	UBRR=	8	3.7	UBRR=	10	3.1
19200	UBRR=	2	7.8	UBRR=	**5**	**0.0**	UBRR=	6	7.5	UBRR=	**7**	**0.0**
28800	UBRR=	1	7.8	UBRR=	**3**	**0.0**	UBRR=	3	7.8	UBRR=	4	6.3
38400	UBRR=	1	22.9	UBRR=	**2**	**0.0**	UBRR=	2	7.8	UBRR=	**3**	**0.0**
57600	UBRR=	0	7.8	UBRR=	**1**	**0.0**	UBRR=	1	7.8	UBRR=	2	12.5
76800	UBRR=	0	22.9	UBRR=	1	33.3	UBRR=	1	22.9	UBRR=	**1**	**0.0**
115200	UBRR=	0	84.3	UBRR=	**0**	**0.0**	UBRR=	0	7.8	UBRR=	0	25.0

Baud Rate	3.2768 MHz		%Error	3.6864 MHz		%Error	4 MHz		%Error	4.608 MHz		%Error
2400	UBRR=	**84**	**0.4**	UBRR=	**95**	**0.0**	UBRR=	**103**	**0.2**	UBRR=	**119**	**0.0**
4800	UBRR=	**42**	**0.8**	UBRR=	**47**	**0.0**	UBRR=	**51**	**0.2**	UBRR=	**59**	**0.0**
9600	UBRR=	**20**	**1.6**	UBRR=	**23**	**0.0**	UBRR=	**25**	**0.2**	UBRR=	**29**	**0.0**
14400	UBRR=	**13**	**1.6**	UBRR=	**15**	**0.0**	UBRR=	16	2.1	UBRR=	**19**	**0.0**
19200	UBRR=	10	3.1	UBRR=	**11**	**0.0**	UBRR=	**12**	**0.2**	UBRR=	**14**	**0.0**
28800	UBRR=	**6**	**1.6**	UBRR=	**7**	**0.0**	UBRR=	8	3.7	UBRR=	**9**	**0.0**
38400	UBRR=	4	6.3	UBRR=	**5**	**0.0**	UBRR=	6	7.5	UBRR=	7	6.7
57600	UBRR=	3	12.5	UBRR=	**3**	**0.0**	UBRR=	3	7.8	UBRR=	**4**	**0.0**
76800	UBRR=	2	12.5	UBRR=	**2**	**0.0**	UBRR=	2	7.8	UBRR=	3	6.7
115200	UBRR=	1	12.5	UBRR=	**1**	**0.0**	UBRR=	1	7.8	UBRR=	2	20.0

Baud Rate	7.3728 MHz		%Error	8 MHz		%Error	9.216 MHz		%Error	11.059 MHz		%Error
2400	UBRR=	**191**	**0.0**	UBRR=	**207**	**0.2**	UBRR=	**239**	**0.0**	UBRR=	287	-
4800	UBRR=	**95**	**0.0**	UBRR=	**103**	**0.2**	UBRR=	**119**	**0.0**	UBRR=	**143**	**0.0**
9600	UBRR=	**47**	**0.0**	UBRR=	**51**	**0.2**	UBRR=	**59**	**0.0**	UBRR=	**71**	**0.0**
14400	UBRR=	**31**	**0.0**	UBRR=	**34**	**0.8**	UBRR=	**39**	**0.0**	UBRR=	**47**	**0.0**
19200	UBRR=	**23**	**0.0**	UBRR=	**25**	**0.2**	UBRR=	**29**	**0.0**	UBRR=	**35**	**0.0**
28800	UBRR=	**15**	**0.0**	UBRR=	16	2.1	UBRR=	**19**	**0.0**	UBRR=	**23**	**0.0**
38400	UBRR=	**11**	**0.0**	UBRR=	**12**	**0.2**	UBRR=	**14**	**0.0**	UBRR=	**17**	**0.0**
57600	UBRR=	**7**	**0.0**	UBRR=	8	3.7	UBRR=	**9**	**0.0**	UBRR=	**11**	**0.0**
76800	UBRR=	**5**	**0.0**	UBRR=	6	7.5	UBRR=	7	6.7	UBRR=	**8**	**0.0**
115200	UBRR=	**3**	**0.0**	UBRR=	3	7.8	UBRR=	**4**	**0.0**	UBRR=	**5**	**0.0**

UART BAUD Rate Register – UBRR

Bit	7	6	5	4	3	2	1	0	
$09 ($29)	**MSB**							**LSB**	**UBRR**
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

The UBRR register is an 8-bit read/write register that specifies the UART Baud Rate according to the equation on the previous page.

Default, the external SRAM access, is a 3-cycle scheme as depicted in Figure 43. When one extra wait state is needed in the access cycle, set the SRW bit (one) in the MCUCR register. The resulting access scheme is shown in Figure 44. In both cases, note that PORTA is data bus in one cycle only. As soon as the data access finishes, PORTA becomes a low-order address bus again.

For details of the timing for the SRAM interface, please refer to Figure 68, Table 37, Table 38, Table 39 and Table 40, beginning on page 92. Refer to “Architectural Overview” on page 7 for a description of the memory map, including address space for SRAM.

Figure 42. External SRAM Connected to the AVR

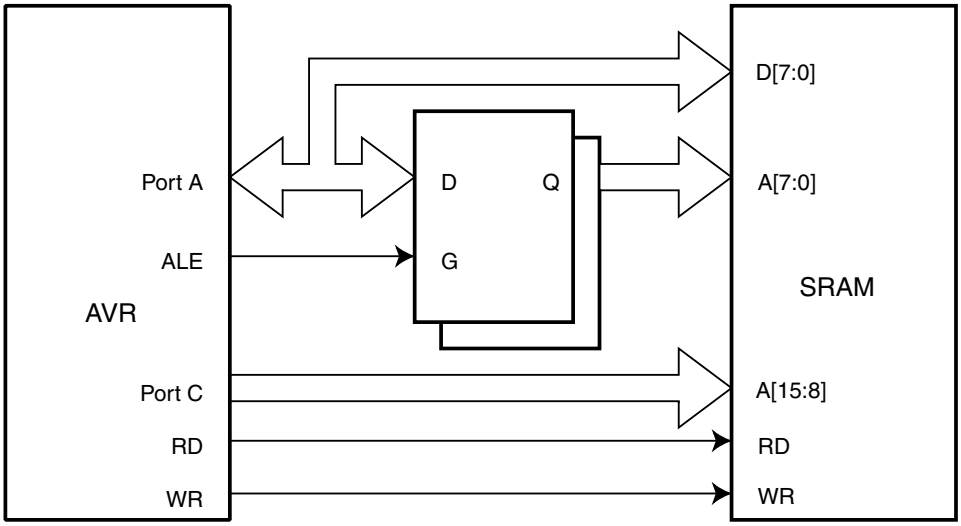
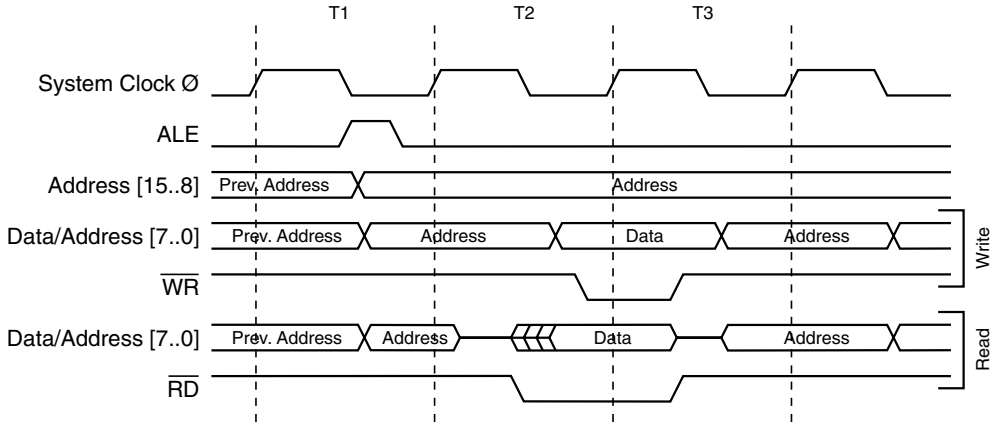


Figure 43. External Data SRAM Memory Cycles without Wait State



I/O Ports

All AVR ports have true read-modify-write functionality when used as general digital I/O ports. This means that the direction of one port pin can be changed without unintentionally changing the direction of any other pin with the SBI and CBI instructions. The same applies for changing drive value (if configured as output) or the enabling/disabling of pull-up resistors (if configured as input).

Port A

Port A is an 8-bit bi-directional I/O port.

Three I/O memory address locations are allocated for the Port A, one each for the Data Register – PORTA, $1B($3B), Data Direction Register – DDRA, $1A($3A) and the Port A Input Pins – PINA, $19($39). The Port A Input Pins address is read-only, while the Data Register and the Data Direction Register are read/write.

All port pins have individually selectable pull-up resistors. The Port A output buffers can sink 20 mA and thus drive LED displays directly. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated.

The Port A pins have alternate functions related to the optional external data SRAM. Port A can be configured to be the multiplexed low-order address/data bus during accesses to the external data memory. In this mode, Port A has internal pull-up resistors.

When Port A is set to the alternate function by the SRE (external SRAM enable) bit in the MCUCR (MCU Control Register), the alternate settings override the Data Direction Register.

Port A Data Register – PORTA

Bit	7	6	5	4	3	2	1	0	
$1B ($3B)	PORTA7	PORTA6	PORTA5	PORTA4	PORTA3	PORTA2	PORTA1	PORTA0	PORTA
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Port A Data Direction Register – DDRA

Bit	7	6	5	4	3	2	1	0	
$1A ($3A)	DDA7	DDA6	DDA5	DDA4	DDA3	DDA2	DDA1	DDA0	DDRA
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Port A Input Pins Address – PINA

Bit	7	6	5	4	3	2	1	0	
$19 ($39)	PINA7	PINA6	PINA5	PINA4	PINA3	PINA2	PINA1	PINA0	PINA
Read/Write	R	R	R	R	R	R	R	R	
Initial Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

The Port A Input Pins address (PINA) is not a register; this address enables access to the physical value on each Port A pin. When reading PORTA, the Port A Data Latch is read and when reading PINA, the logical values present on the pins are read.

Port A as General Digital I/O

All eight pins in Port A have equal functionality when used as digital I/O pins.

PAn, general I/O pin: The DDAn bit in the DDRA register selects the direction of this pin. If DDAn is set (one), PAn is configured as an output pin. If DDAn is cleared (zero), PAn is configured as an input pin. If PORTAn is set (one) when the pin is configured as an input pin, the MOS pull-up resistor is activated. To switch the pull-up resistor off, the

PORTAn has to be cleared (zero) or the pin has to be configured as an output pin. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not active..

Table 19. DDAn Effects on Port A Pins

DDAn	PORTAn	I/O	Pull-up	Comment
0	0	Input	No	Tri-state (high-Z)
0	1	Input	Yes	PAn will source current if ext. pulled low.
1	0	Output	No	Push-pull Zero Output
1	1	Output	No	Push-pull One Output

Note: n: 7,6…0, pin number.

Port A Schematics

Note that all port pins are synchronized. The synchronization latch is, however, not shown in the figure.

Figure 45. Port A Schematic Diagrams (Pins PA0 - PA7)

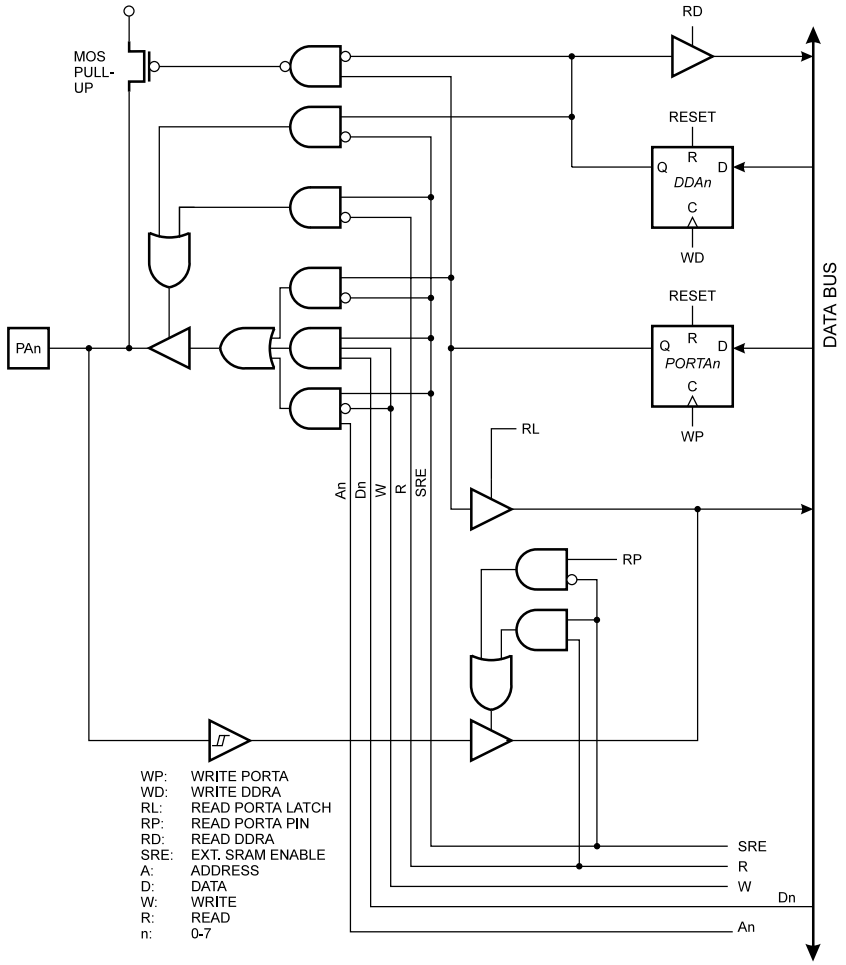


Figure 47. Port B Schematic Diagram (Pins PB2 and PB3)

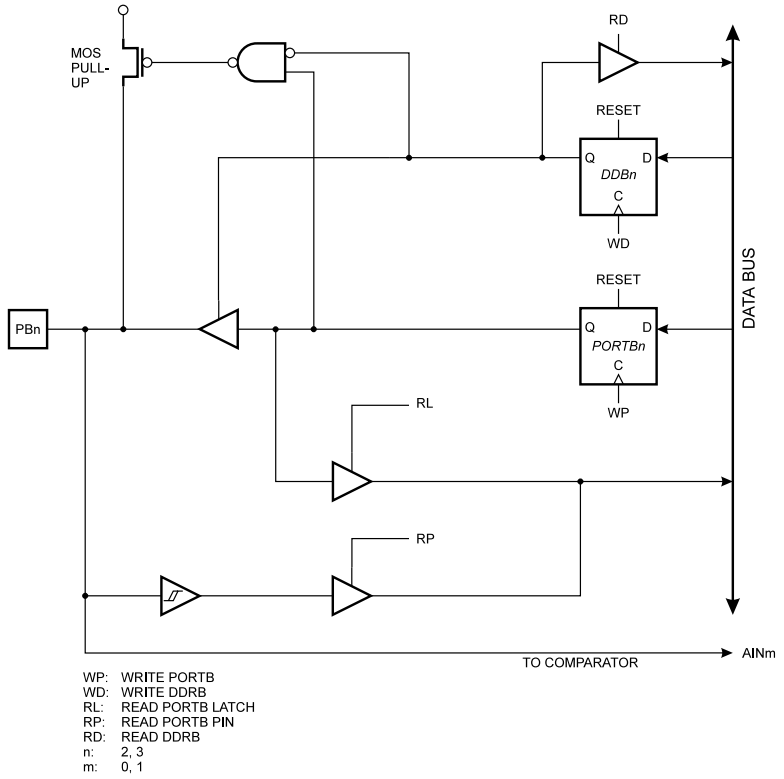


Figure 48. Port B Schematic Diagram (Pin PB4)

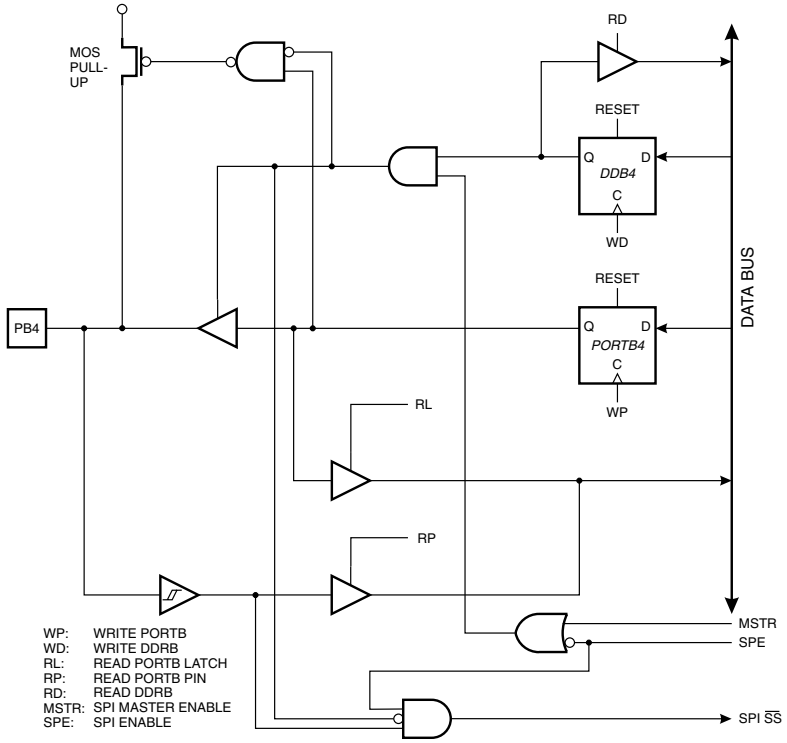
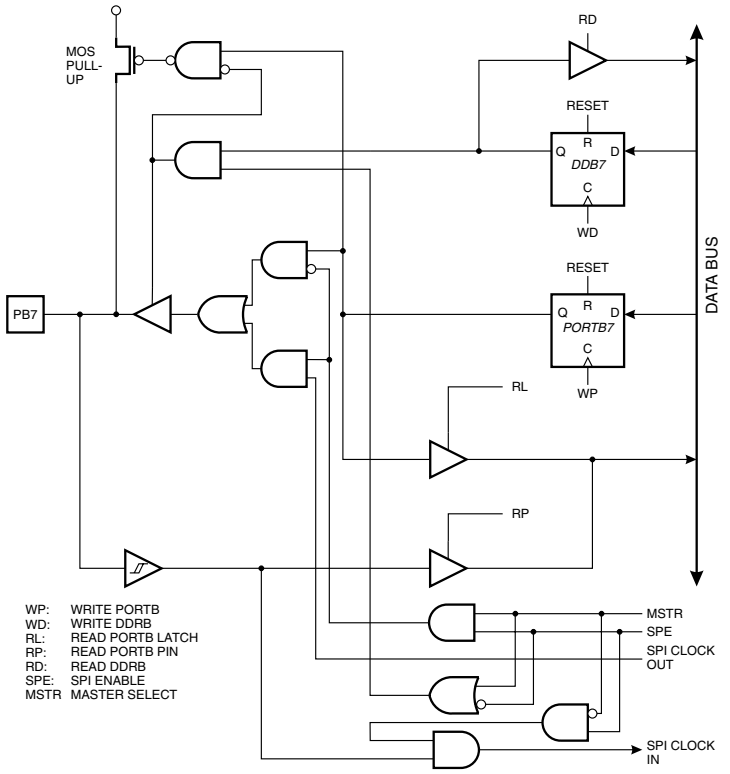


Figure 51. Port B Schematic Diagram (Pin PB7)



Port C

Port C is an 8-bit bi-directional I/O port. Three I/O memory address locations are allocated for the Port C, one each for the Data Register – PORTC, $15($35), Data Direction Register – DDRC, $14($34) and the Port C Input Pins – PINC, $13($33). The Port C Input Pins address is read-only, while the Data Register and the Data Direction Register are read/write.

All port pins have individually selectable pull-up resistors. The Port C output buffers can sink 20 mA and thus drive LED displays directly. When pins PC0 to PC7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated.

The Port C pins have alternate functions related to the optional external data SRAM. Port C can be configured to be the high-order address byte during accesses to external data memory. When Port C is set to the alternate function by the SRE (external SRAM enable) bit in the MCUCR (MCU Control Register), the alternate settings override the Data Direction Register.

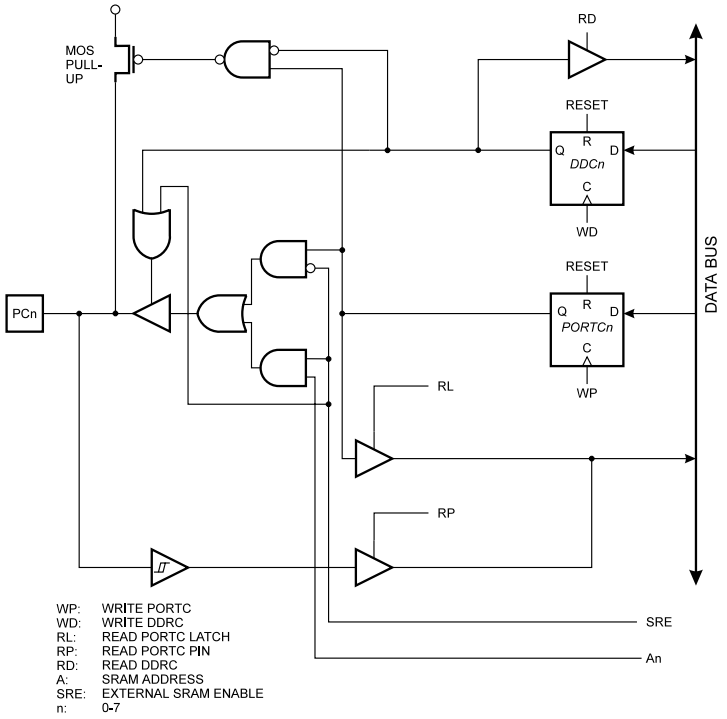
Port C Data Register – PORTC

Bit	7	6	5	4	3	2	1	0	
$15 ($35)	PORTC7	PORTC6	PORTC5	PORTC4	PORTC3	PORTC2	PORTC1	PORTC0	PORTC
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Port C Schematics

Note that all port pins are synchronized. The synchronization latch is, however, not shown in the figure.

Figure 52. Port C Schematic Diagram (Pins PC0 - PC7)



Port D

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors.

Three I/O memory address locations are allocated for the Port D, one each for the Data Register – PORTD, $12($32), Data Direction Register – DDRD, $11($31) and the Port D Input Pins – PIND, $10($30). The Port D Input Pins address is read-only, while the Data Register and the Data Direction Register are read/write.

The Port D output buffers can sink 20 mA. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated.

Some Port D pins have alternate functions as shown in Table 23.

Table 23. Port D Pin Alternate Functions

Port Pin	Alternate Function
PD0	RXD (UART Input Line)
PD1	TXD (UART Output Line)
PD2	INT0 (External interrupt 0 Input)
PD3	INT1 (External interrupt 1 Input)
PD5	OC1A (Timer/Counter1 Output CompareA Match Output)
PD6	$\overline{WR}$ (Write Strobe to External Memory)
PD7	$\overline{RD}$ (Read Strobe to External Memory)

When the pins are used for the alternate function, the DDRD and PORTD registers have to be set according to the alternate function description.

Port D Data Register – PORTD

Bit	7	6	5	4	3	2	1	0	
$12 ($32)	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0	PORTD
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Port D Data Direction Register – DDRD

Bit	7	6	5	4	3	2	1	0	
$11 ($31)	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0	DDRD
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Port D Input Pins Address – PIND

Bit	7	6	5	4	3	2	1	0	
$10 ($30)	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0	PIND
Read/Write	R	R	R	R	R	R	R	R	
Initial Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

The Port D Input Pins address (PIND) is not a register; this address enables access to the physical value on each Port D pin. When reading PORTD, the Port D Data Latch is read and when reading PIND, the logical values present on the pins are read.

Port D as General Digital I/O

PDn, general I/O pin: The DDDn bit in the DDRD register selects the direction of this pin. If DDDn is set (one), PDn is configured as an output pin. If DDDn is cleared (zero), PDn is configured as an input pin. If PDn is set (one) when configured as an input pin, the MOS pull-up resistor is activated. To switch the pull-up resistor off the PDn has to be cleared (zero) or the pin has to be configured as an output pin. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not active.

Table 24. DDDn Bits on Port D Pins

DDDn	PORTDn	I/O	Pull-up	Comment
0	0	Input	No	Tri-state (high-Z)
0	1	Input	Yes	PDn will source current if ext. pulled low.
1	0	Output	No	Push-pull Zero Output
1	1	Output	No	Push-pull One Output

Note: n: 7,6…0, pin number.

Alternate Functions of Port D

- **$\overline{RD}$ – Port D, Bit 7**

$\overline{RD}$ is the external data memory read control strobe. See “Interface to External SRAM” on page 60 for detailed information.

- **$\overline{WR}$ – Port D, Bit 6**

$\overline{WR}$ is the external data memory write control strobe. See “Interface to External SRAM” on page 60 for detailed information.

- **OC1A – Port D, Bit 5**

OC1A: Output compare match output. The PD5 pin can serve as an external output when the Timer/Counter1 compare matches. The PD5 pin has to be configured as an output (DDD5 set [one]) to serve this function. See the Timer/Counter1 description for further details and how to enable the output. The OC1A pin is also the output pin for the PWM mode timer function.

1. Set BS to “1”. This selects high data.
2. Give $\overline{WR}$ a negative pulse. This starts programming of the data byte. RDY/$\overline{BSY}$ goes low.
3. Wait until RDY/$\overline{BSY}$ goes high to program the next byte.

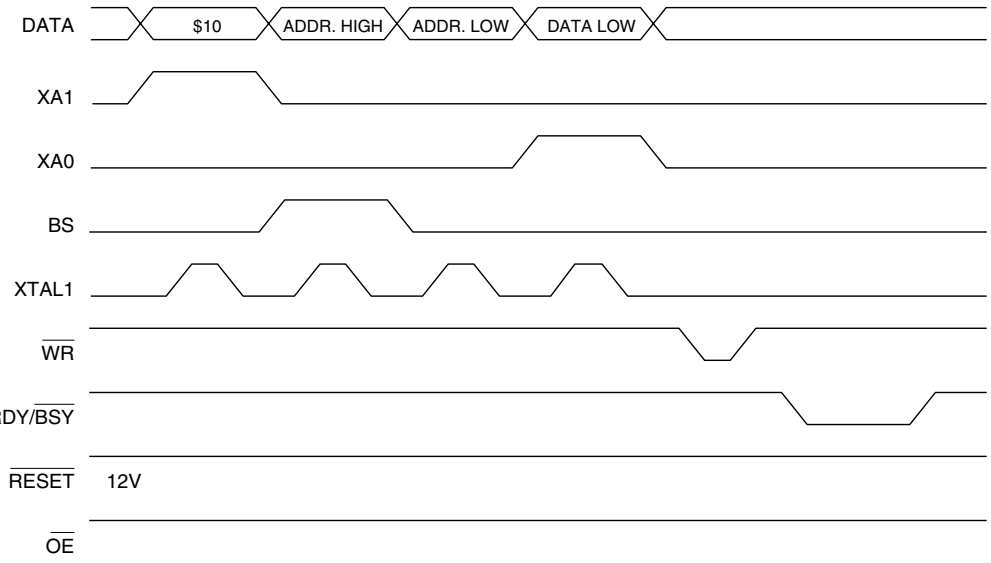
(See Figure 62 for signal waveforms.)

The loaded command and address are retained in the device during programming. For efficient programming, the following should be considered:

- The command needs only be loaded once when writing or reading multiple memory locations.
- Address high byte needs only be loaded before programming a new 256-word page in the Flash.
- Skip writing the data value $FF, that is, the contents of the entire Flash and EEPROM after a Chip Erase.

These considerations also apply to EEPROM programming and Flash, EEPROM and signature byte reading.

Figure 61. Programming the Flash Waveforms



Serial Programming Characteristics

Figure 66. Serial Programming Timing

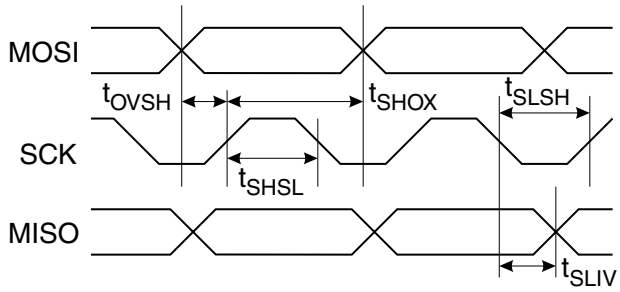


Table 33. Serial Programming Characteristics, T_A = -40°C to 85°C, V_{CC} = 2.7V - 6.0V (unless otherwise noted)

Symbol	Parameter	Min	Typ	Max	Units
$1/t_{CLCL}$	Oscillator Frequency (V_{CC} = 2.7 - 4.0V)	0		4.0	MHz
t_{CLCL}	Oscillator Period (V_{CC} = 2.7 - 4.0V)	250.0			ns
$1/t_{CLCL}$	Oscillator Frequency (V_{CC} = 4.0 - 6.0V)	0		8.0	MHz
t_{CLCL}	Oscillator Period (V_{CC} = 4.0 - 6.0V)	125.0			ns
t_{SHSL}	SCK Pulse Width High	2.0 t_{CLCL}			ns
t_{SLSH}	SCK Pulse Width Low	2.0 t_{CLCL}			ns
t_{OVSH}	MOSI Setup to SCK High	t_{CLCL}			ns
t_{SHOX}	MOSI Hold after SCK High	2.0 t_{CLCL}			ns
t_{SLIV}	SCK Low to MISO Valid	10.0	16.0	32.0	ns

Table 34. Minimum Wait Delay after the Chip Erase Instruction

Symbol	3.2V	3.6V	4.0V	5.0V
t_{WD_ERASE}	18 ms	14 ms	12 ms	8 ms

Table 35. Minimum Wait Delay after Writing a Flash or EEPROM Location

Symbol	3.2V	3.6V	4.0V	5.0V
t_{WD_PROG}	9 ms	7 ms	6 ms	4 ms

Figure 70. Active Supply Current vs. V_{CC}

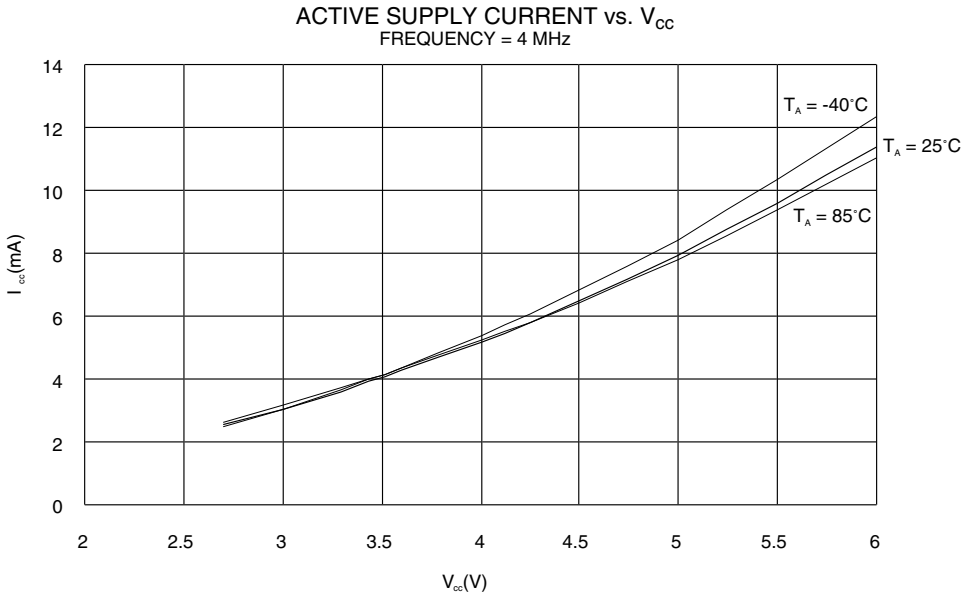
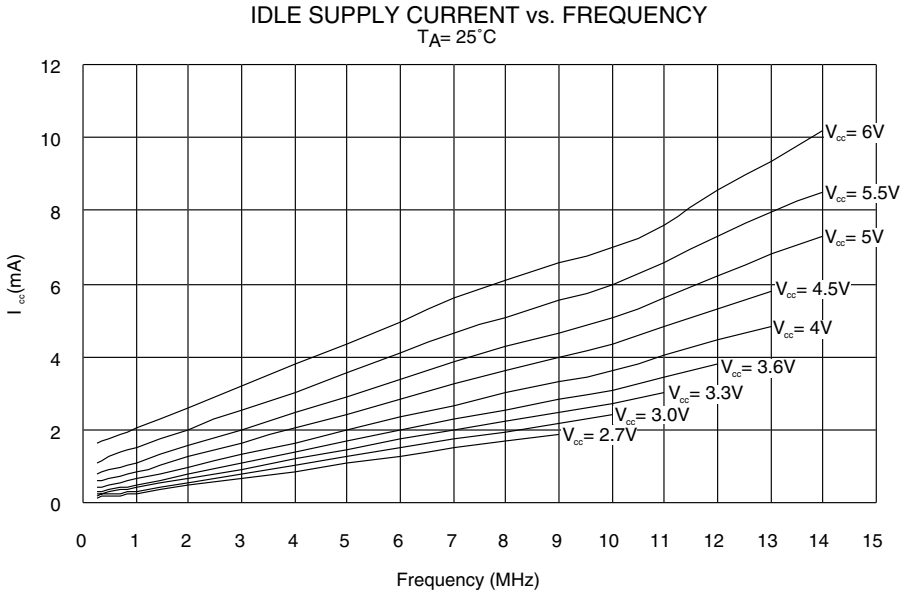


Figure 71. Idle Supply Current vs. Frequency



Sink and source capabilities of I/O ports are measured on one pin at a time.

Figure 80. Pull-up Resistor Current vs. Input Voltage

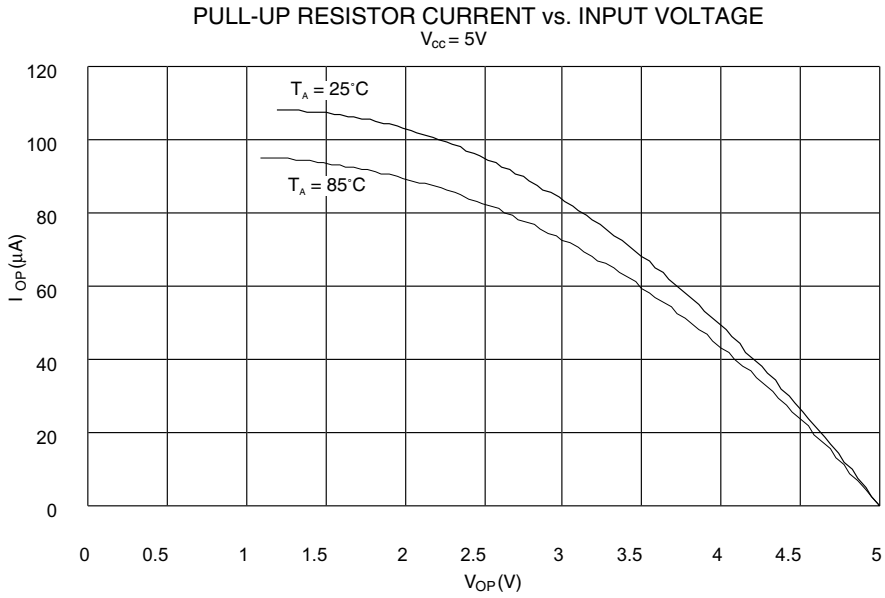
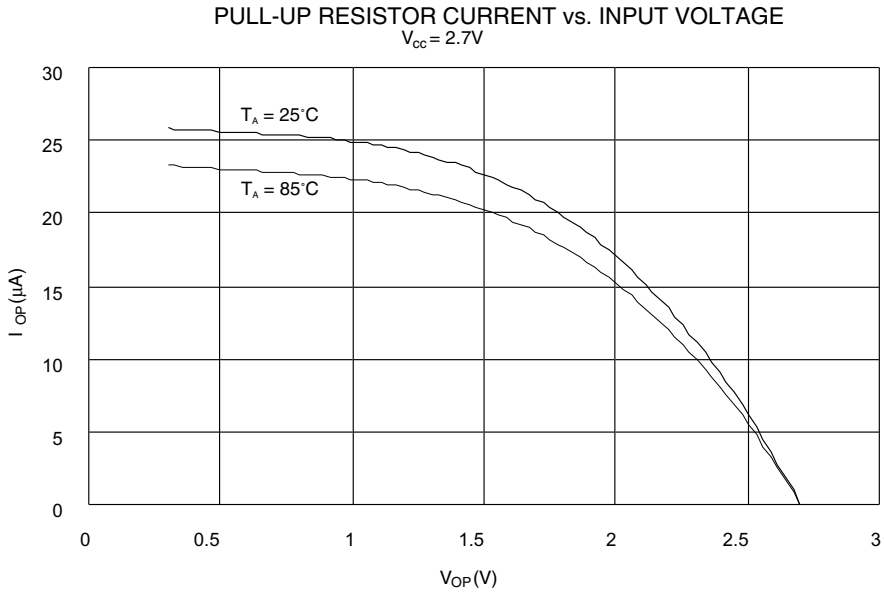


Figure 81. Pull-up Resistor Current vs. Input Voltage



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