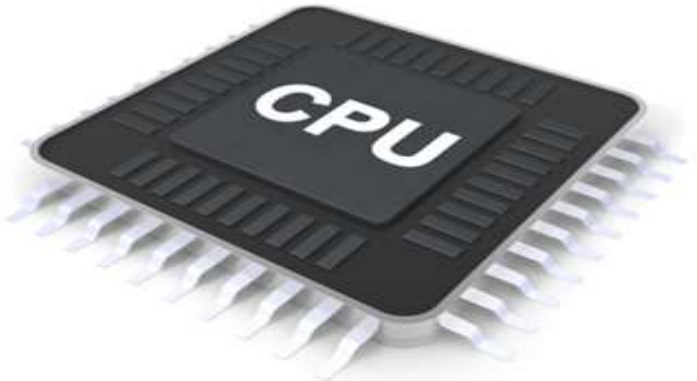


Power Management

ENEE 3587

Microp Interfacing

Power Consumption

- MCU fabricated using CMOS
  - If transistors are not switching they don't consume power
- Atmega supports 6 different sleep modes
  - Idle
  - ADCNRM
  - Power-down
  - Power-save
  - Standby
  - Extended Standby
- Sleep modes are controlled by the SMCR register

Sleep mode control register (SMCR)

7	6	5	4	3	2	1	0	
—	—	—	—	SM2	SM1	SM0	SE	Reset value = 0x00
R	R	R	R	R/W	R/W	R/W	R/W	

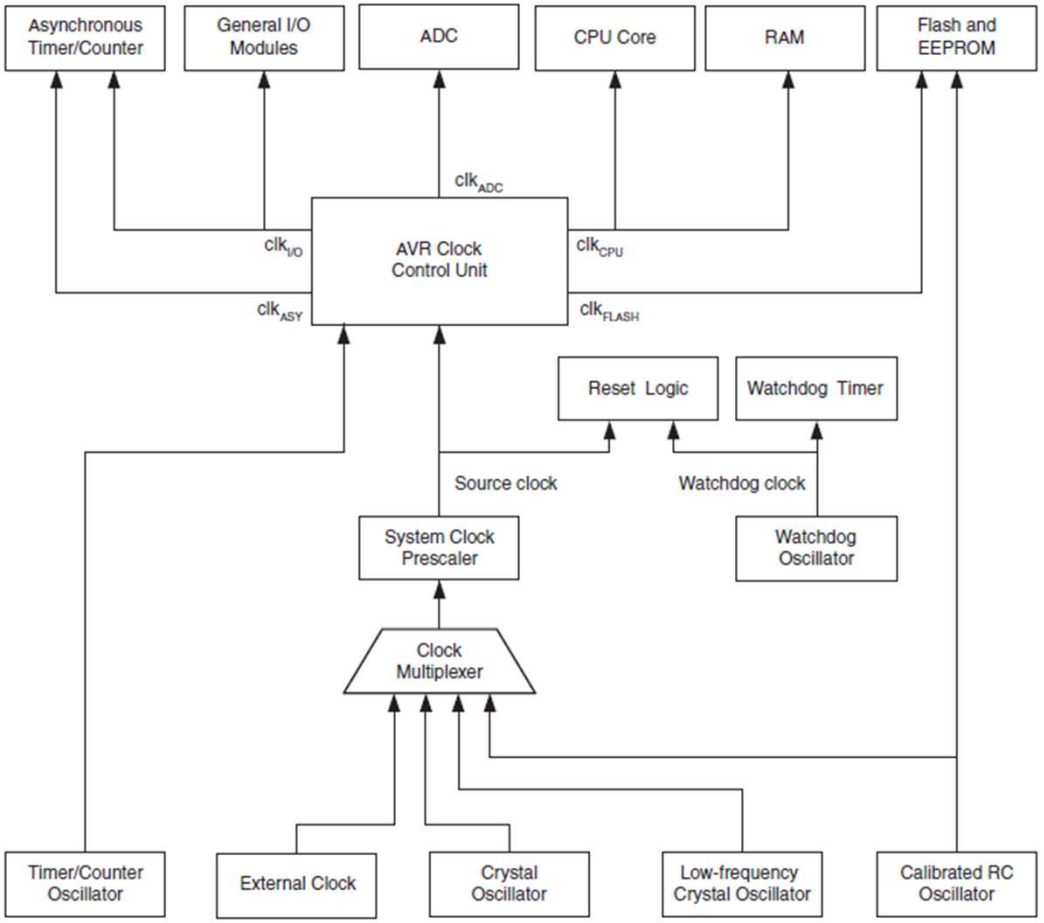
- **SM2-SM0**: Sleep mode select bits
  - 000 = Idle mode
  - 001 = ADC noise reduction
  - 010 = Power-down
  - 011 = Power save
  - 110 = Standby (recommended for external crystals or oscillators)
  - 111 = Extended standby (recommended for external crystals or oscillators)
  - 100-101 = Reserved
- **SE**: Sleep enable
  - 0 = Disable sleep mode
  - 1 = Enable sleep mode

Summary of Effects of Different Sleep Modes

	Active Clock Domains					Oscillators		Wake-up Sources						
Sleep Mode	clk_{CPU}	clk_{FLASH}	clk_{IO}	clk_{ADC}	clk_{ASY}	Main Clock Source Enabled	Timer Osc Enabled	INT7:0 and Pin Change	TWI Address Match	Timer2	SPM/ EEPROM Ready	ADC	WDT Interrupt	Other I/O
Idle			X	X	X	X	X(2)	X	X	X	X	X	X	X
ADCNRM				X	X	X	X(2)	X(3)	X	X(2)	X	X	X	
Power-down								X(3)	X				X	
Power-save					X		X(2)	X(3)	X	X			X	
Standby(1)						X		X(3)	X				X	
Extended Standby					X(2)	X	X(2)	X(3)	X	X			X	

Note:
1. Only recommended with external crystal or resonator selected as clock source.
2. If Timer/Counter2 is running in asynchronous mode.
3. For INT7:4, only level interrupt.

Clock Distribution



Clock Sources

- Calibrated RC oscillator: 1 MHz
  - 8.0 MHz and with the CKDIV8 fuse (/8)
- External Clock:
  - Connected to XTAL1 pin
- Watchdog oscillator: 128 kHz
- Low-Frequency oscillator: 32.768 kHz
- Timer/Counter oscillator:
  - Timer2
- System Clock Prescaler (CLKPR):
  - Increases the clock period.

Clock Prescale Register (CLKPR)

7	6	5	4	3	2	1	0	
CLKPCE	—	—	—	CLKPS3	CLKPS2	CLKPS1	CLKPS0	Reset value = 0x0x
R/W	R	R	R	R/W	R/W	R/W	R/W	

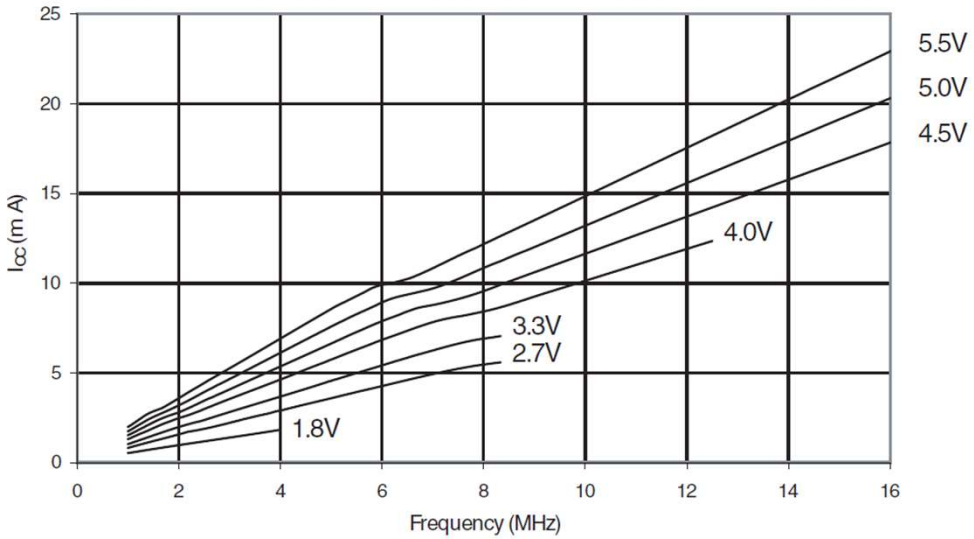
- CLKPCE: Clock prescaler change enable
  - 1: to enable changes to CLKPS bites
  - cleared by hardware 4 cycles after it is written or when CLKPS bits are written.
- CLKPS3-0: Clock prescaler selects 3-0

CLKPS[3~0]	Clock division factor
0000	1
0001	2
0010	4
0011	8
0100	16
0101	32
0110	64
0111	128
1000	256
1001~1111	Reserved

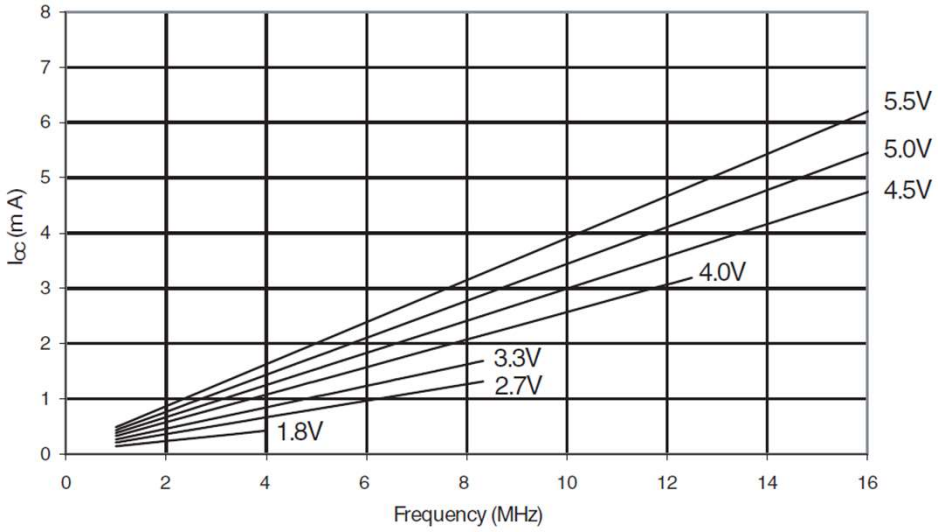
Clock Domains

- clk_{CPU}: used by CPU (aka AVR Core).
  - Used to execute instructions,
  - access: general purposes registers (r0-r31), status register, RAM memory
- clk_{FLASH}: controls operation of the Flash interface.
- clk_{IO}: used by
  - Timer/Counters, SPI, and USART
  - External Interrupt module (not asynchronous EINT)
- clk_{ASY}: asynchronous Timer clock
  - clocked directly from an external clock or an external 32kHz clock crystal.
- clk_{ADC}: for ADC module

Active vs Idle: Voltage & Current Characteristics



Active



Ide

Power Reduction

- Disable the clock input to modules that are not needed in the application
- Power Reduction Registers 0 used to shut-down:
  - Timer2, Timer0, Timer1,
    - Re-enabling continues operation from before shutdown
  - TWI, SPI, USART0, ADC.
    - Re-enabling re-initializes module
- Power Reduction Registers 1 used to shut-down:
  - Timer5, 4, 3
    - Re-enabling continues operation from before shutdown
  - USART3, 2, 0
    - Re-enabling re-initializes module

Power Reduction Register 0 (PRR0)

7	6	5	4	3	2	1	0	
PRTWI	PRTIM2	PRTIM0	—	PRTIM1	PRSPI	PRUSART0	PRADC	Reset value = 0x00
R	R	R	R	R/W	R/W	R/W	R/W	

- **PRTWI** = 1: shuts down the TWI module.
- **PRTIM2** = 1: shuts down the Timer/Counter2 module.
- **PRTIM0** = 1: shuts down the Timer/Counter0 module.
- **PRTIM1** = 1: shuts down the Timer/Counter1 module.
- **PRSPI** = 1: shuts down the SPI module.
- **PRUSART0** = 1: shuts down the USART0 by module.
- **PRADC** = 1: shuts down the ADC.
  - ADC must be disabled before shut down.

Power Reduction Register 1 (PRR1)

7	6	5	4	3	2	1	0	
—	—	PRTIM5	PRTIM4	PRTIM3	PRUART3	PRUSART2	PRUSART1	Reset value = 0x00
R	R	R	R	R/W	R/W	R/W	R/W	

- **PRTIM5** = 1: shuts down the Timer/Counter0 module.
- **PRTIM4** = 1: shuts down the Timer/Counter4 module.
- **PRTIM3** = 1: shuts down the Timer/Counter3 module.
- **PRUSART3** = 1: shuts down the USART3 by module.
- **PRUSART2** = 1: shuts down the USART2 by module.
- **PRUSART1** = 1: shuts down the USART1 by module.