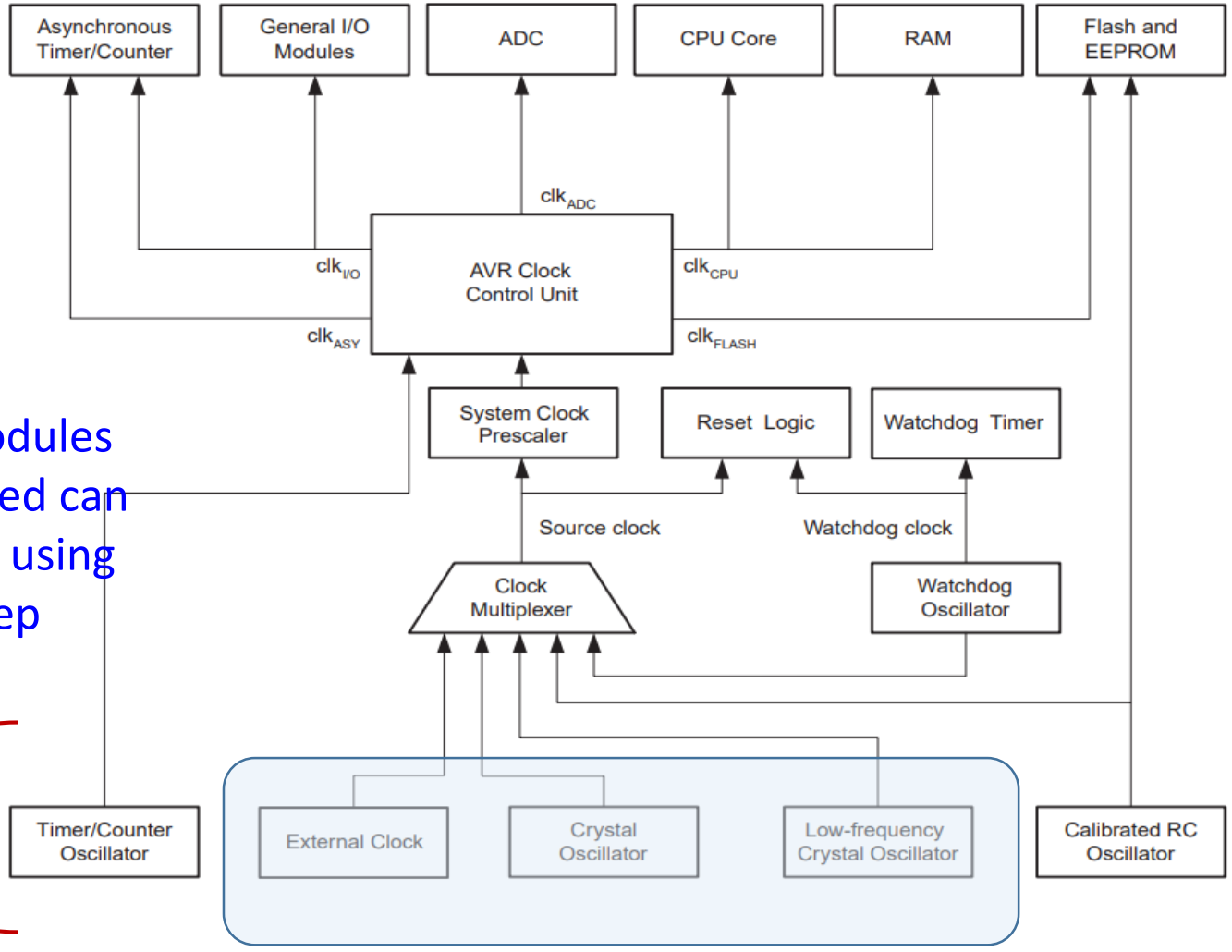
System clock and options

AVR Clock system

Source: Microchip

Figure 9-1. Clock Distribution



Clock network

Clocks to modules not being used can be halted by using different sleep modes.

Clock sources

AVR Clock system: Sources

Source: Microchip

Table 9-1. Device Clocking Options Select[1]

Device Clocking Option	CKSEL3...0
Low Power Crystal Oscillator [0.4-16] MHz	1111 - 1000
Full Swing Crystal Oscillator [0.4-20] MHz	0111 - 0110
Low Frequency Crystal Oscillator	0101 - 0100
Internal 128kHz RC Oscillator	0011
Calibrated Internal RC Oscillator	0010
External Clock	0000
Reserved	0001

8 MHz – MCU Default

16 MHz Crystal –Arduino UNO

CKSEL → Fuse bits, a programmer is required to modify them.

OSCCAL – RC Oscillator Calibration Register

CLKPR – Clock Prescale Register

Power management and sleeep modes

AVR Sleep modes

- Sleep modes enable the application to shut down unused modules in the MCU, thereby saving power.
- Six sleep modes:
  - Idle
  - ADC Noise Reduction
  - Power-down
  - Power-save
  - Standby
  - Extended standby
- Setup:
  - SMCR register
  - Sleep instruction
- Interrupt occurs in a sleep mode → MCU wakes up

AVR Sleep modes

Source: Microchip

Table 10-1. Active Clock Domains and Wake-up Sources in the Different Sleep Modes

	Active Clock Domains					Oscillators			Wake-up Sources						
	clk_{CPU}	clk_{FLASH}	clk_{IO}	clk_{ADC}	clk_{ASY}	Main Clock Source Enabled	Timer Oscillator Enabled	INT1, INT0 and Pin Change	TWI Address Match	Timer2	SPM/EEPROM Ready	ADC	WDT	Other I/O	Software BOD Disable
Idle	STOP		X	X	X	X	X(2)	X	X	X	X	X	X	X	
ADC Noise Reduction	STOP			X	X	X	X(2)	X(3)	X	X(2)	X	X	X	NO Wake-up	
Power-down	STOP							X(3)	X	NO Wake-up			X		X
Power-save	STOP				X		X(2)	X(3)	X	X	NO Wake-up		X		X
Standby(1)	STOP					X		X(3)	X	NO Wake-up			X		X
Extended Standby	STOP				X(2)	X	X(2)	X(3)	X	X	NO Wake-up		X		X

Notes:
1. Only recommended with external crystal or resonator selected as clock source.
2. If Timer/Counter2 is running in asynchronous mode.
3. For INT1 and INT0, only level interrupt.

Related to clock-system figure (S26)

AVR Sleep modes

Source: Microchip

Idle Mode

- Analog Comparator can be powered down

ADC Noise Reduction Mode

- An ADC conversión starts

Power-down Mode

- Halts all generated clocks, allowing operation of asynchronous modules only.

Power-save Mode

- Identical to Power-down
- Timer/Counter2 will keep running during sleep

Stand by Mode

- Identical to Power-down
- An external crystal/resonator clock option is selected

Extended standby

- Identical to Power-save

AVR Sleep modes: Registers

Sleep Mode Control Register

Source: Microchip

Bit	7	6	5	4	3	2	1	0	
0x33 (0x53)	–	–	–	–	SM2	SM1	SM0	SE	SMCR
Read/Write	R	R	R	R	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Enable/Disable

Table 10-2. Sleep Mode Select

SM2	SM1	SM0	Sleep Mode
0	0	0	Idle
0	0	1	ADC Noise Reduction
0	1	0	Power-down
0	1	1	Power-save
1	0	0	Reserved
1	0	1	Reserved
1	1	0	Standby(1)
1	1	1	External Standby(1)

Note: 1. Standby mode is only recommended for use with external crystals or resonators.

AVR Sleep modes: Registers

PRR – Power Reduction Register

Source: Microchip

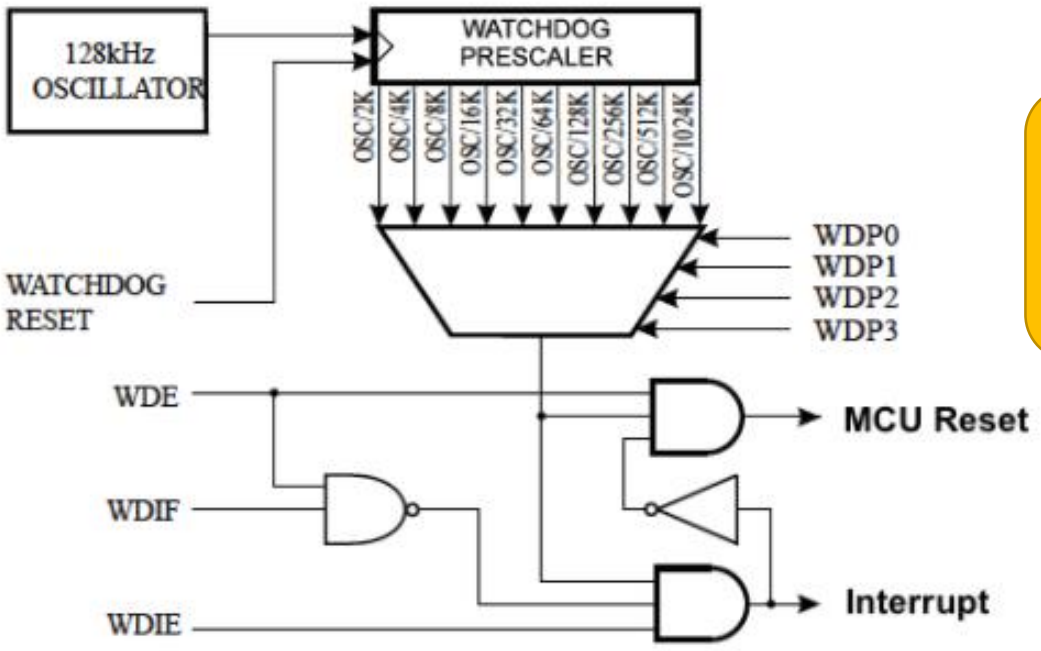
Bit	7	6	5	4	3	2	1	0	
(0x64)	PRTWI	PRTIM2	PRTIM0	–	PRTIM1	PRSPI	PRUSART0	PRADC	PRR
Read/Write	R/W	R/W	R/W	R	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

- Stops the clock to individual peripherals to reduce power consumption
- Module shutdown can be used in Idle mode and Active mode. In all other sleep modes, the clock is already stopped.

Watchdog

AVR Watchdog Timer

Source: Microchip



Used as a safety measure

- WDT is a counter that forces an interrupt or a system reset when the counter reaches a given time-out value.
- The code must restart the Watchdog Timer Reset (WDR) instruction to restart before the time-out value is reached.
- Otherwise, an interrupt or system reset will occur.

AVR Watchdog Timer: Features

Source: Microchip

- Clocked from separate On-chip Oscillator. (128KHz)

- Three operating modes:
  - Interrupt → to wake up the device
    → to limit máximum time allowed for…
  - System Reset → to prevent hang-up
  - Interrupt and System Reset → time to save critical parameters before a system reset

- Time-out → from 16 milliseconds to 8 seconds.
- Enabled by:
  - Fuses
  - Program instructions

AVR Watchdog Timer: WDT instructions

Source: Microchip

- WDT Instructions:
  - enable the WDT
  - disable the WDT
  - set the prescaler
  - Reset WDT:

  Reset the watchdog timer regularly to avoid a watchdog reset.