

Power Management and Sleep Modes

A key feature of many microcontrollers is low power consumption.

The principle way to reduce power consumption is to stop the clock.

Quiescent CMOS consumes essentially no power at feature sizes $> .35\mu$

CMOS power dissipation is mostly due to dynamic power dissipation, i.e., power dissipation caused by signals transitioning.

For example, in the DEC Alpha microprocessor (~ 1995) approximately 50% of the 30W dissipated was spent in simply driving the clock tree.

Rough figure for power dissipation in CMOS: (neglecting leakage)

$$P_d = CV^2f$$

where C = capacitance, V = voltage, f = frequency of operation

Power Management and Sleep Modes

To save power in the AVR: cut off the clock to unused modules

The MCU Control Register holds the power management settings.

MCU Control Register

Bit	7	6	5	4	3	2	1	0	
	SRE	SRW10	SE	SM1	SM0	SM2	IVSEL	IVCE	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	

sleep enable: if set, the MCU will enter sleep mode when the SLEEP instruction is executed

SM2	SM1	SM0	
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	Extended Standby

Power Management and Sleep Modes

Sleep Modes:

Idle Mode:

- Stopped: CPU, Flash memory
- Running: SPI, USART, Comparator, ADC, TWI, TCNT0-3, Watchdog
- Wakeup: external and internal interrupts

ADC Noise Reduction Mode

- Stopped: All above plus the I/O clocks
- Running: ADC, TWI, TCNT0, Watchdog
- Wakeup: external and internal interrupts

Power-down Mode:

- Stopped: All the above plus the external oscillator
- Running: External interrupts, TWI address match, Watchdog
- Wakeup: Watchdog, or brown out reset, external interrupt

Power Management and Sleep Modes

Sleep Modes:

Power Save Mode: (identical to Power-down, except:)

- Running: TCNT0 also if clocked externally (asynchronous mode)
- Wakeup: can also wakeup from TCNT0 interrupts

Standby Mode: (identical to Power-down except:)

- Running: External crystal clock oscillator still running
- Wakeup: just like Power-down, except wakes up in 6 clock cycles

Extended Standby Mode: (identical to Power-save except:)

- Running: External crystal clock oscillator still running
- Wakeup: just like Power-save, except wakes up in 6 clock cycles