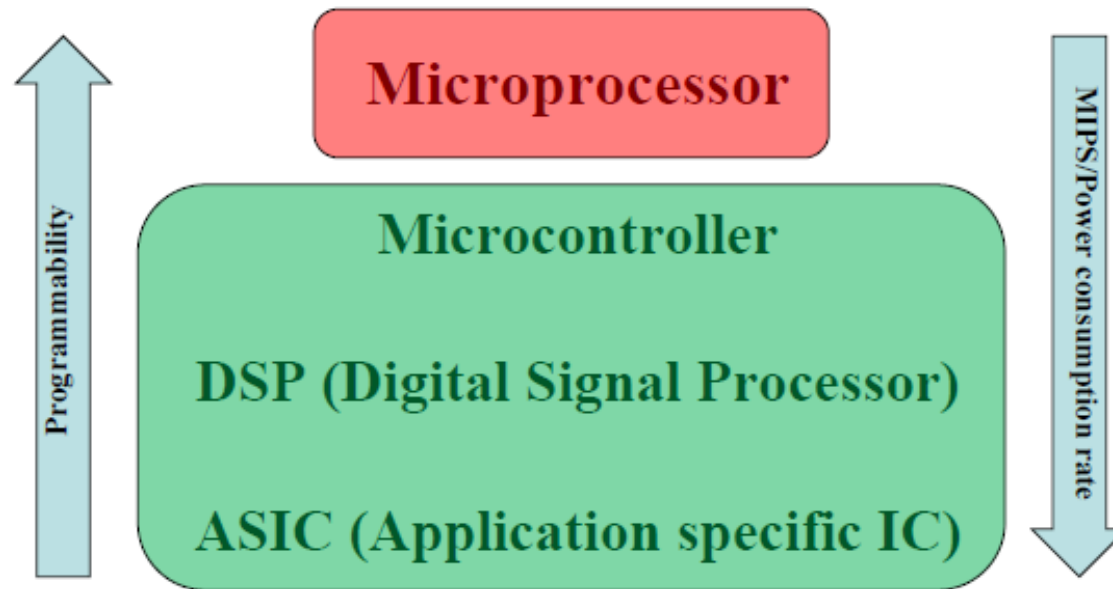




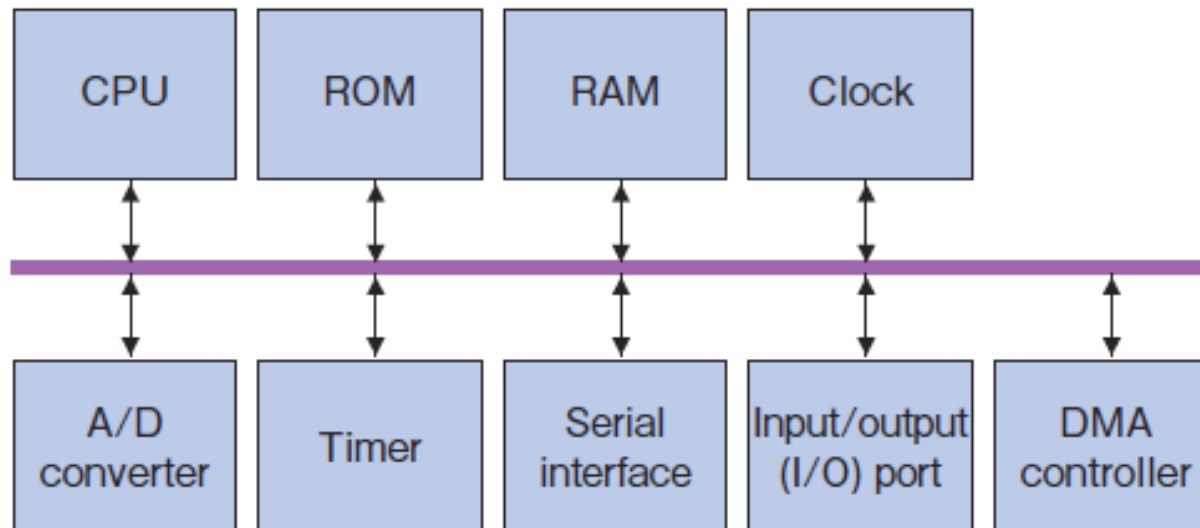
Microcontrollori



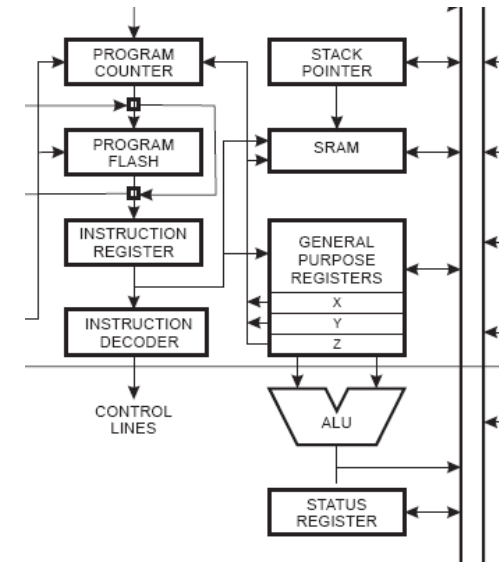
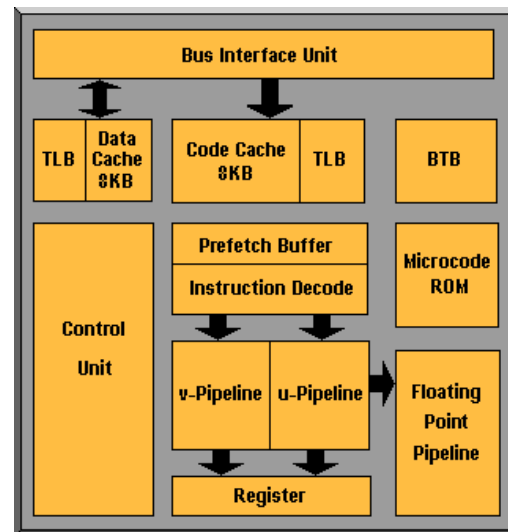
 General purpose

 Application specific

Microcontrollori



Microcontrollori – CPU



Instruction set

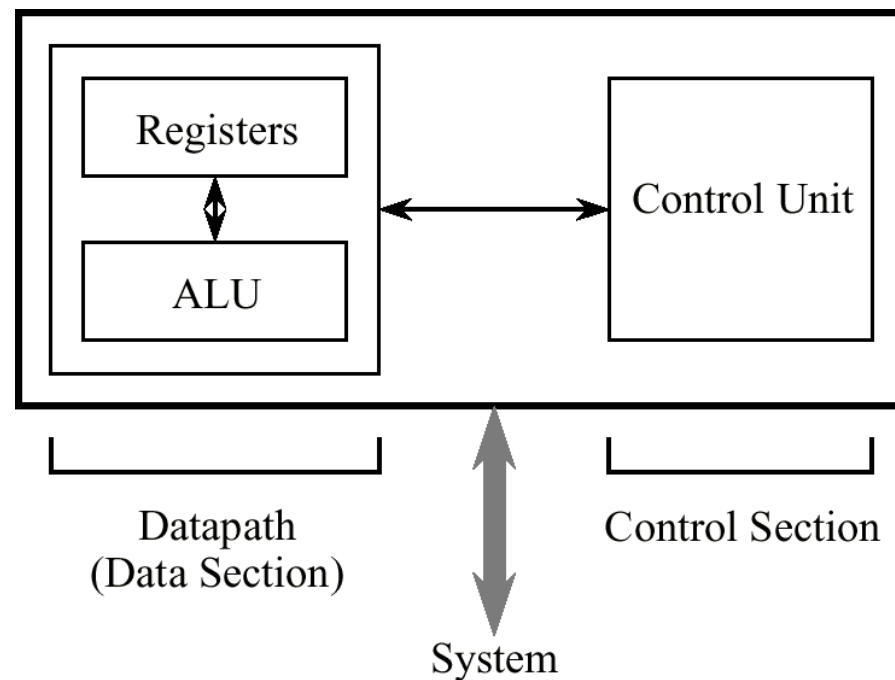
- CISC Complex Instruction Set Computing (Intel x86 family; Motorola 680x0)
- RISC Reduced Instruction Set computer (ARM family, ATMEL AVR Family)

Architecture (respect integer operand maximum dimension)

- 8 bit (Intel 8051, ATMEL AVR, PIC)
- 16 bit (Intel 8088, Motorola 68000, TI MSP430)
- 32 bit (x86 family, Motorola 680x0, ATMEL AVR32, Power PC)
- 64 bit (x86-64 family, Power PC)

Microcontrollori - CPU

Costituita da una unità aritmetica e una unità di controllo che interpreta le istruzioni e gestisce il trasferimento dei dati nei Registri.

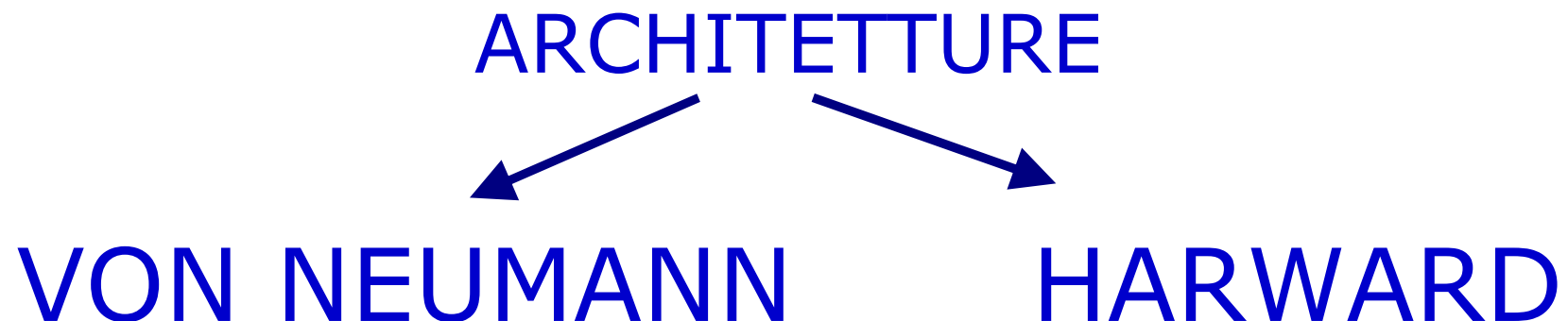




Microcontrollori - Architettura

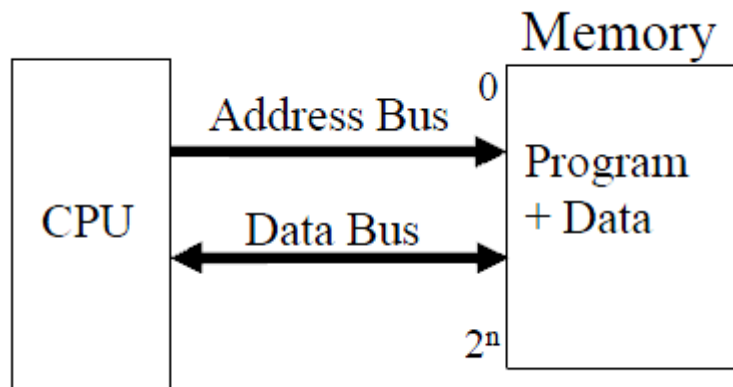
Informazioni presenti in un programma:

Codice di Istruzioni per l'esecuzione
Dati utilizzati dalle Istruzioni

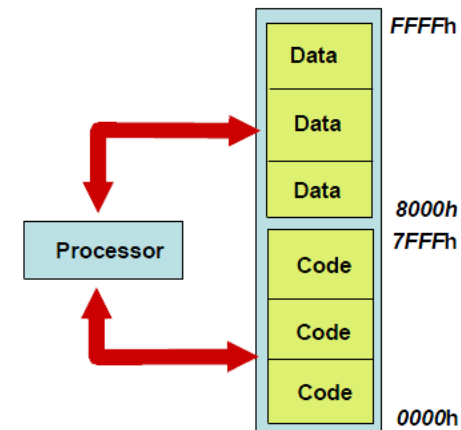
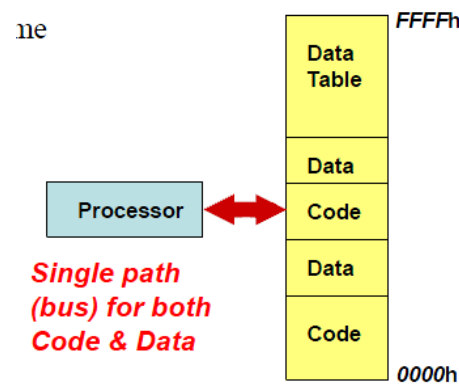
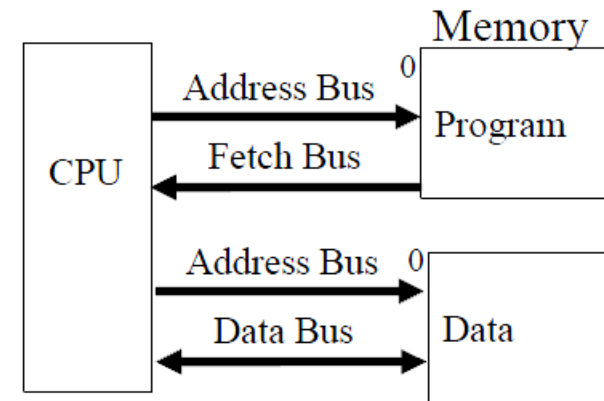


Microcontrollori - Memoria

VON NEUMANN

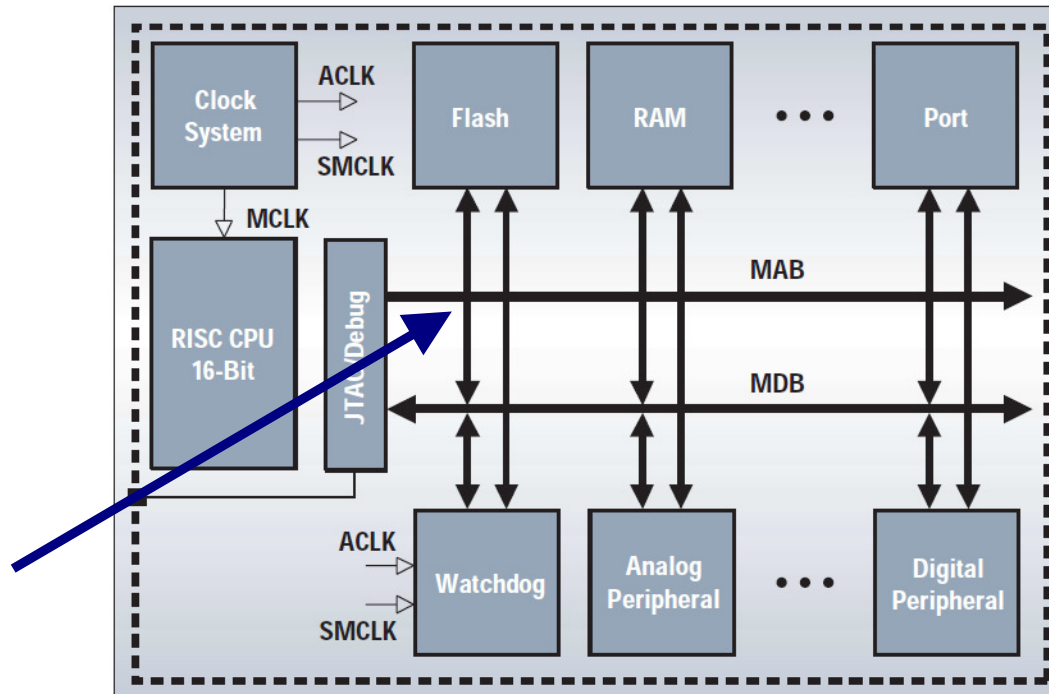


HARWARD



Microcontrollori - Architettura

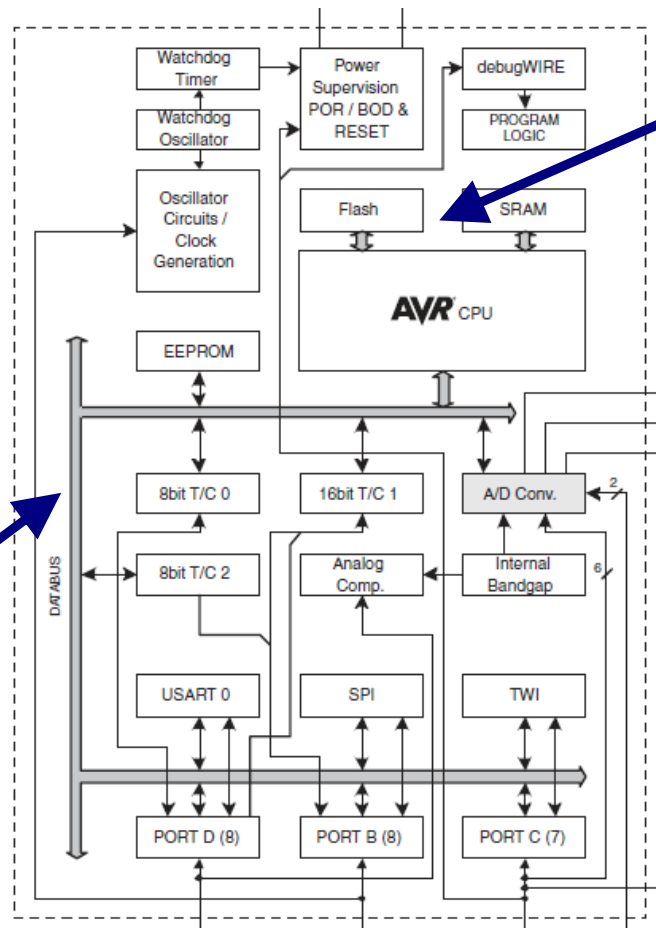
MSP 430 TEXAS INSTRUMENT



BUS PERIFERICHE
+ Memorie

Microcontrollori - Architettura

ATMEL AVR



BUS MEMORIE

BUS PERIFERICHE



Microcontrollori – Registri Interni

Registri dedicati:

- Program Counter (PC):

Puntatore alla prossima istruzione che deve essere letta ed eseguita dalla CPU.

- Stack Pointer (SP):

Utilizzato per memorizzare informazioni sullo stato delle istruzioni (instructions: store by PUSH, retrieve by POP);

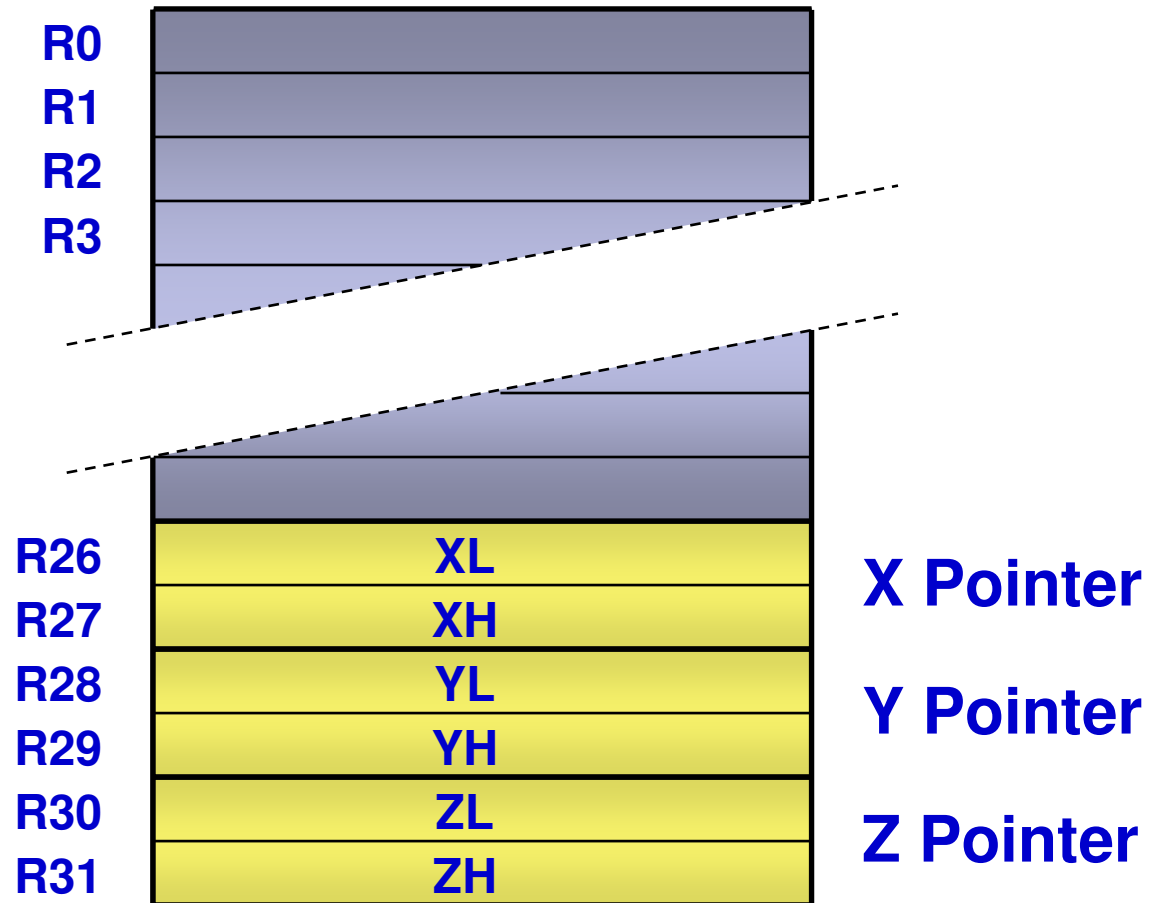
utilizzato per i parametri delle routine (PUSH, POP in calling routine)

usato dalle subroutine per memorizzare il punto di ritorno al programma (RET).

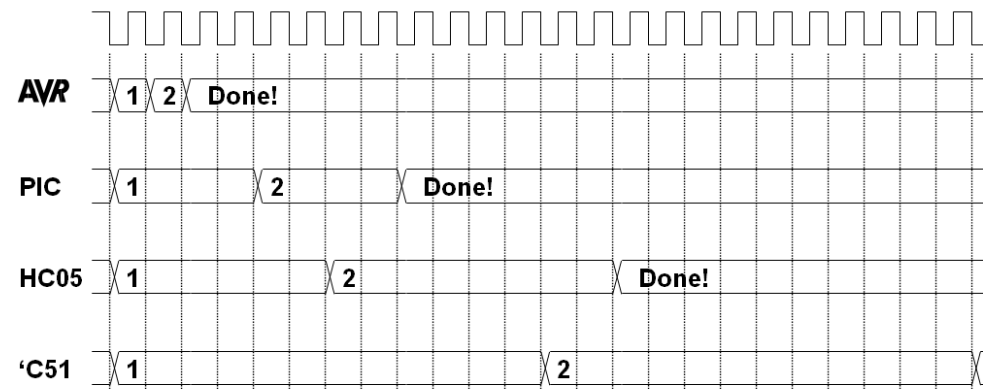
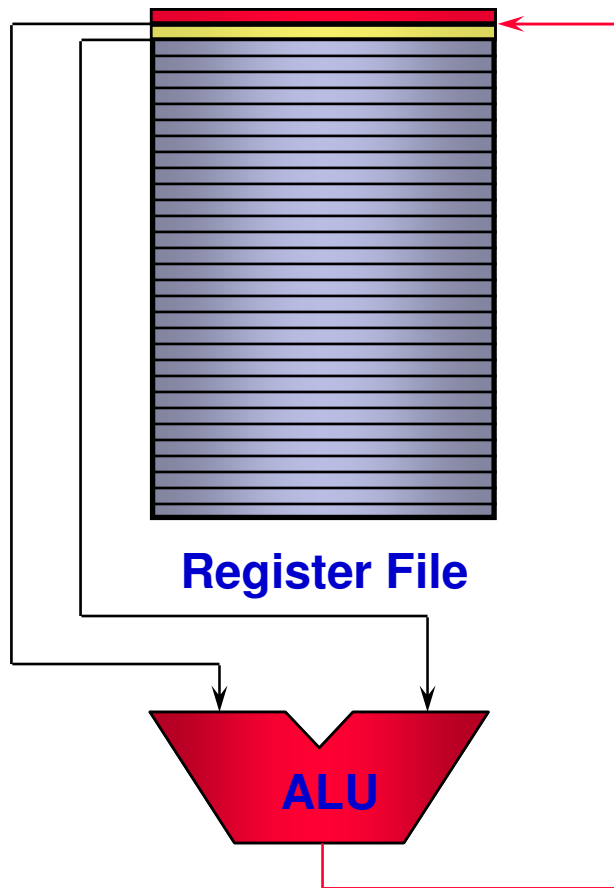
- Status Register (SR):

Registro di stato della CPU, aggiornato automaticamente dalla CPU.

Microcontrollori – General Purpose Register



Microcontrollori – General Purpose Register





Microcontrollori – Processor Size

- Unità di Misura: Bits
- Corrisponde alla dimensione massima dei dati che può elaborare la CPU
- Rispecchia la dimensione del bus interno e della memoria dei registri della CPU
- Architetture standard : 8 , 16, 32 Bits



Microcontrollori- Performance Metrics

Elaborazione:

- Clock Speed
- MIPS (instructions per sec)
- Latency
- Throughput

Elettriche:

- Power Consumptions
- Voltage Supply
- Noise Immunity
- Sensitivity



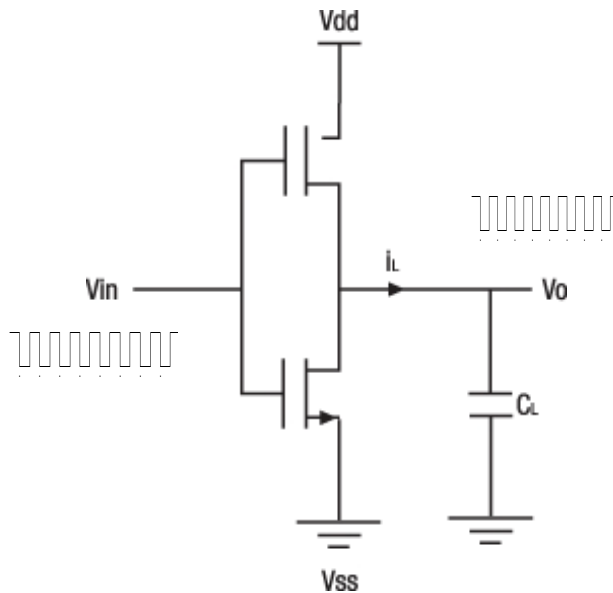
Microcontrollori- Power Consumption

Contributi al consumo di potenza nei dispositivi CMOS:

- Consumo dinamico (P_{DYN})
- Consumo di corto circuito (P_{SHORT})
- Consumi di Leakage (P_{LEAK})

$$P = P_{DYN} + P_{SHORT} + P_{LEAK}$$

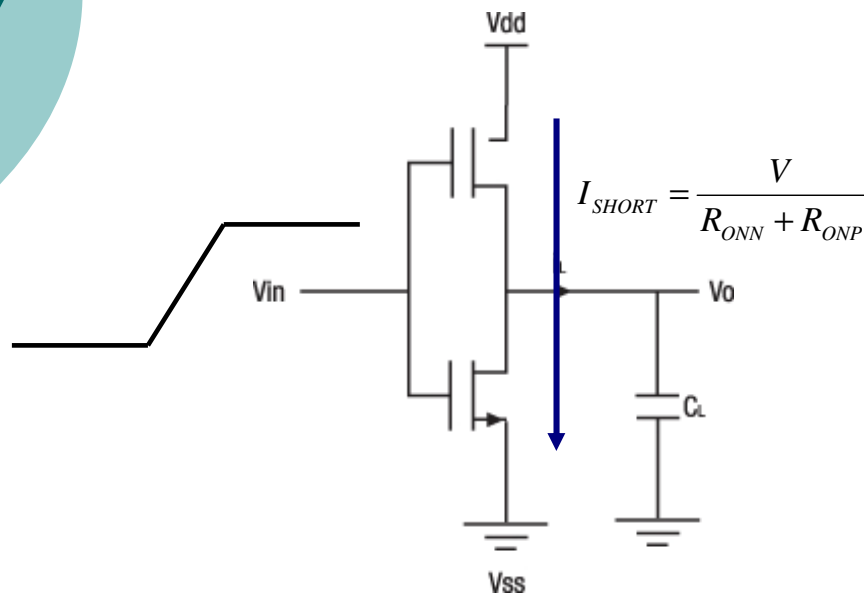
Microcontrollori- Power Consumption



$$P_{DYN} = A \cdot C \cdot V^2 \cdot f$$

A : Attività del Gate
 C : Capacità di carico
 V : Tensione di alimentazione
 f : Frequenza del clock

Microcontrollori- Power Consumption



$$P_{SHORT} = \tau \cdot A \cdot V \cdot I_{SHORT} \cdot f$$

t = Tempo di corto circuito

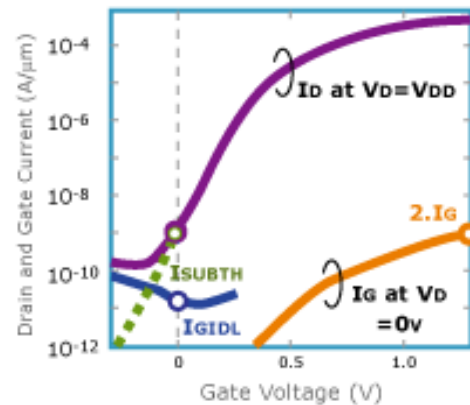
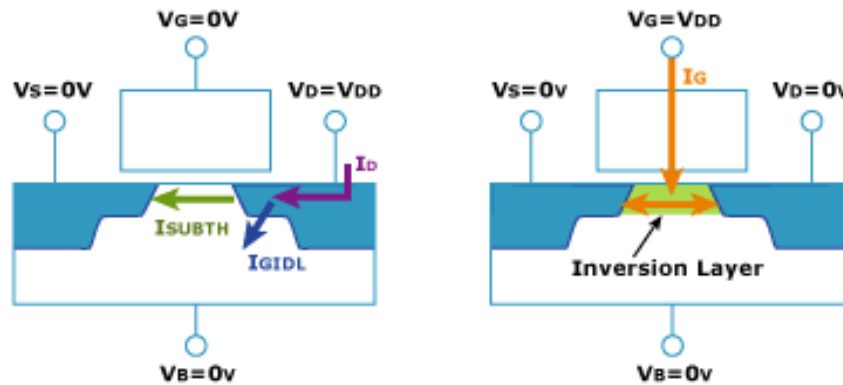
A : Attività del Gate

I_{SHORT} : Corrente di corto circuito

V : Tensione di alimentazione

f : Frequenza del clock

Microcontrollori- Power Consumption

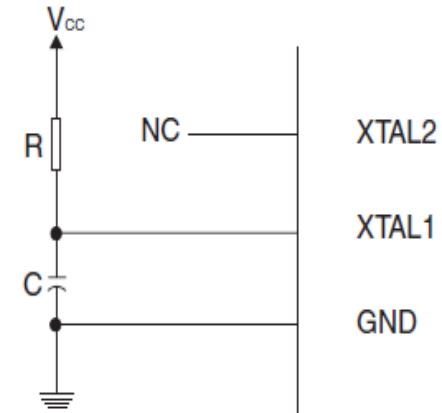
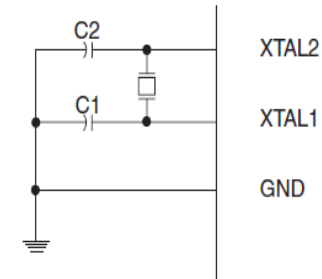
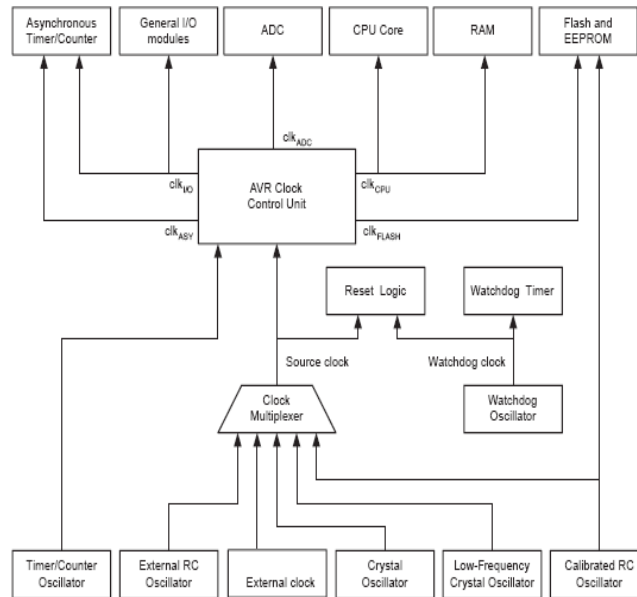


$$P_{LEAK} = V \cdot I_{LEAK}$$

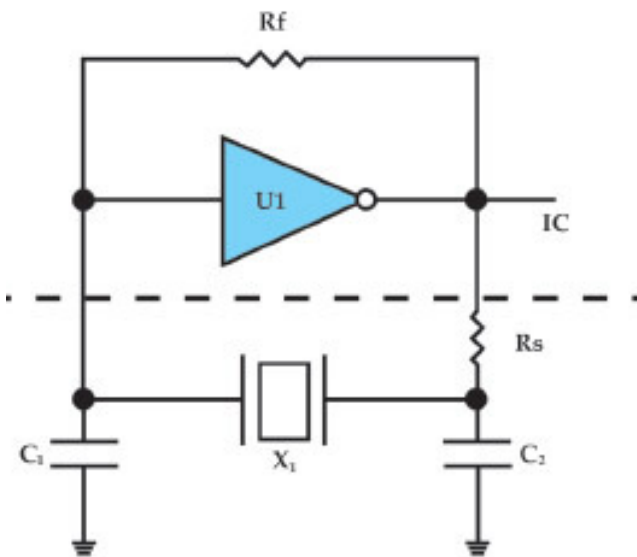
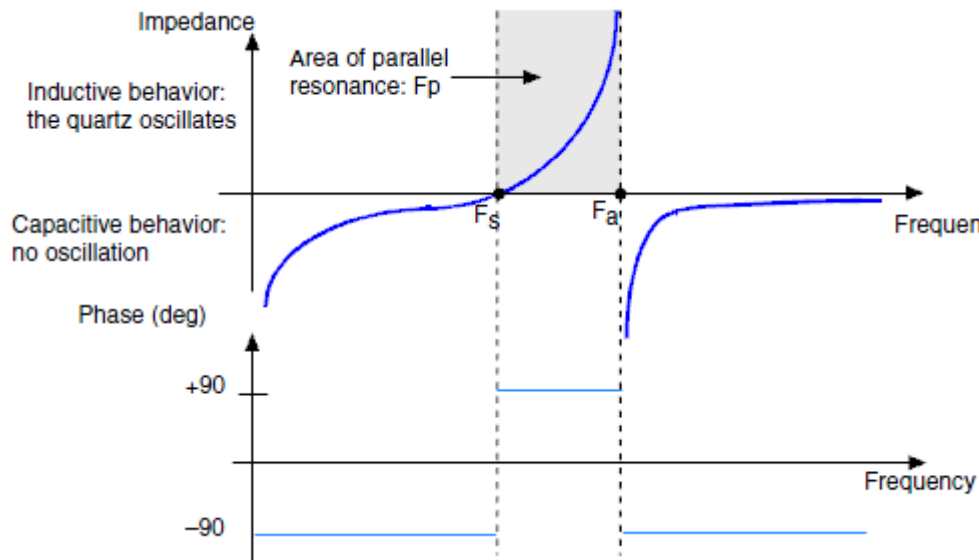
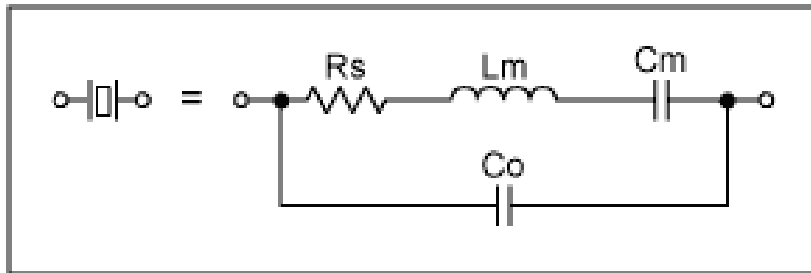
Microcontrollori- Power Consumption

Sleep Mode	Active Clock Domains					Oscillators		Wake Up Sources					
	clk _{CPU}	clk _{FLASH}	clk _{IO}	clk _{ADC}	clk _{ASY}	Main Clock Source Enabled	Timer Osc Enabled	INT7:0	TWI Address Match	Timer 0	SPM/EEPROM Ready	ADC	Other I/O
Idle			X	X	X	X	X ⁽²⁾	X	X	X	X	X	X
ADC Noise Reduction				X	X	X	X ⁽²⁾	X ⁽³⁾	X	X	X	X	
Power-down								X ⁽³⁾	X				
Power-save					X ⁽²⁾		X ⁽²⁾	X ⁽³⁾	X	X ⁽²⁾			
Standby ⁽¹⁾						X		X ⁽³⁾	X				
Extended Standby ⁽¹⁾					X ⁽²⁾	X	X ⁽²⁾	X ⁽³⁾	X	X ⁽²⁾			

Microcontrollori – Clock System



Microcontrollori - Crystal





Microcontrollori - Crystal

Specifiche:

Quality Factor

Rapporto fra l'energia immagazzinata e quella dissipata . Q alto → lentezza nella partenza

Load Capacitance

Capacità necessaria per far oscillare il quarzo

ESR

Resistenza serie equivalente

Frequency Stability

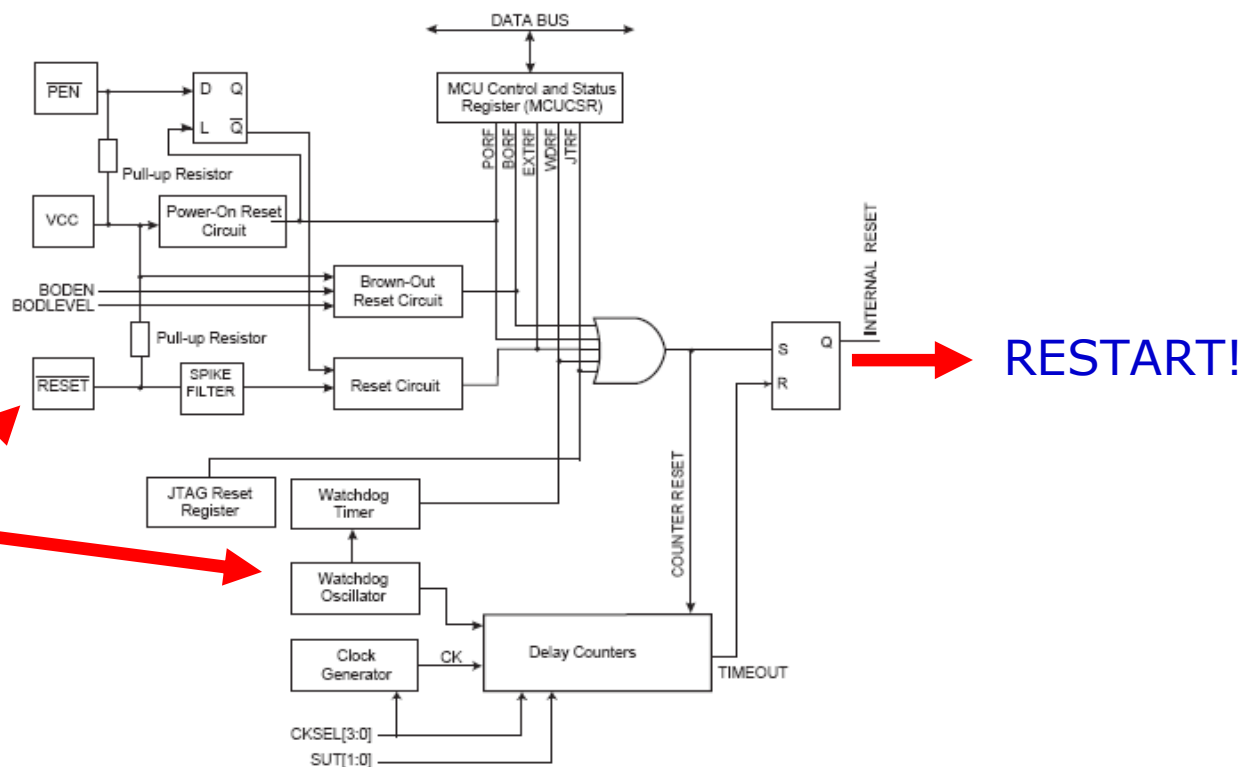
Massima deviazione della frequenza dalla specifica in un dato range di temperatura

Frequency Tolerance

Massima deviazione della frequenza dalla specifica a 25° C.

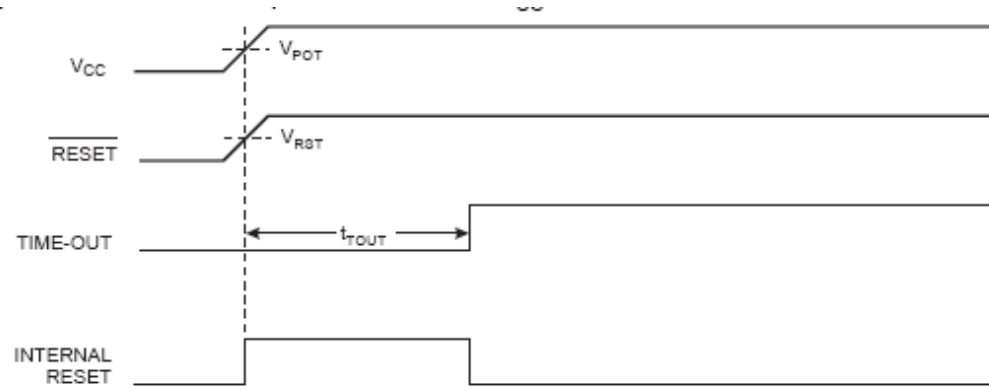
Microcontrollori – Reset Logic

EVENTI
Interni
Ed Esterni

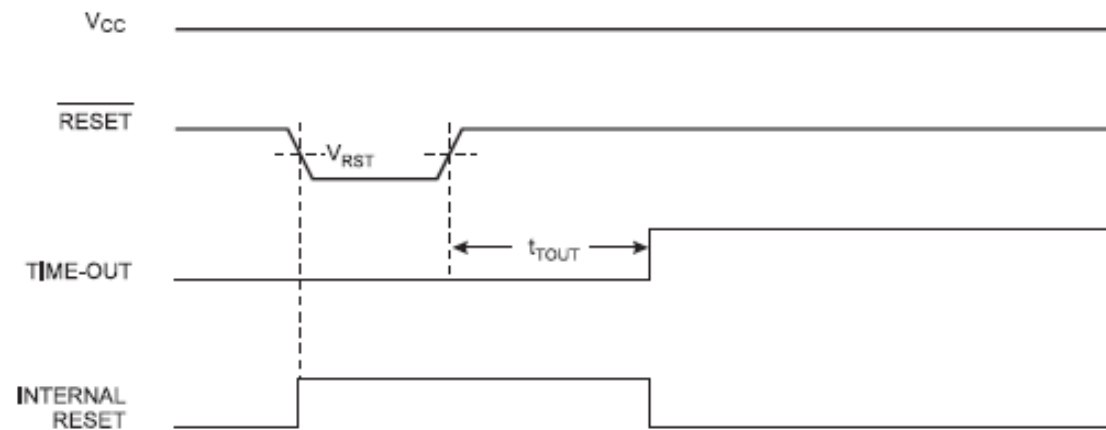


Microcontrollori – Reset Logic

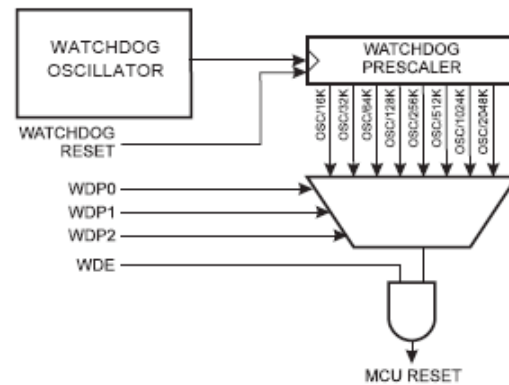
Start Up



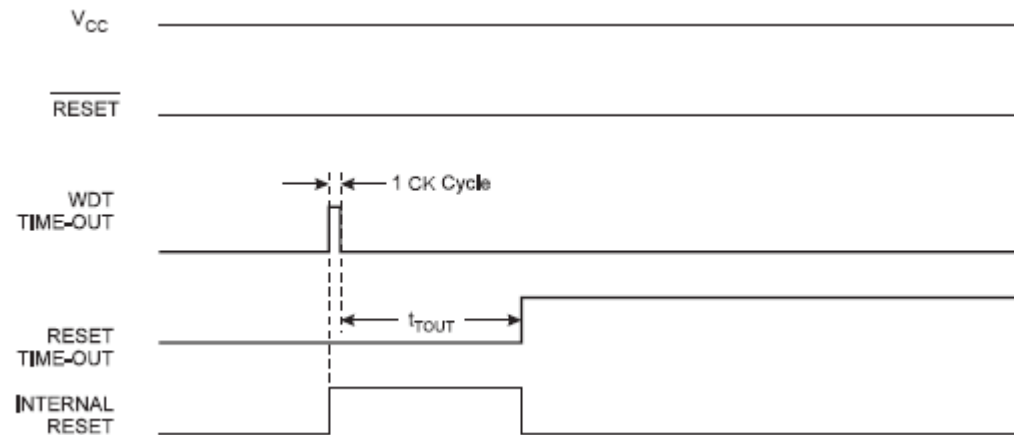
External Reset



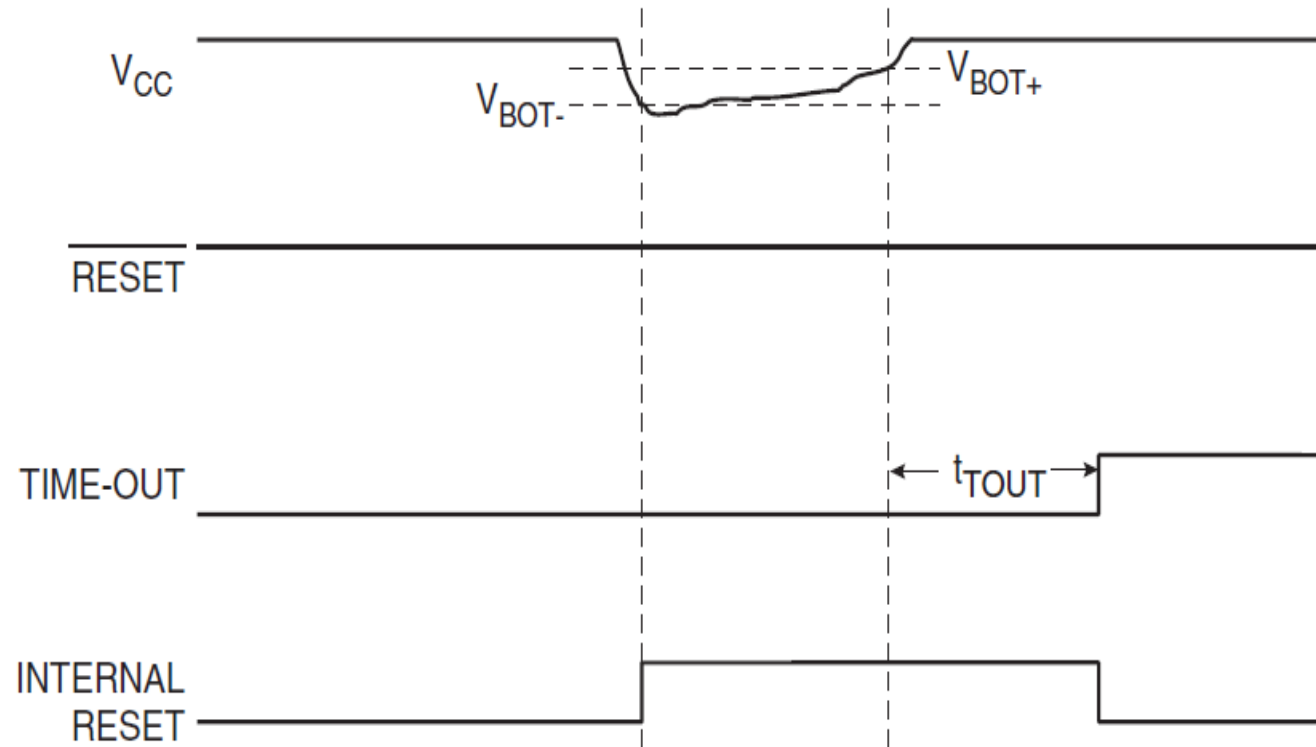
Microcontrollori – Reset Logic



Watch dog Reset



Microcontrollori – Reset Logic



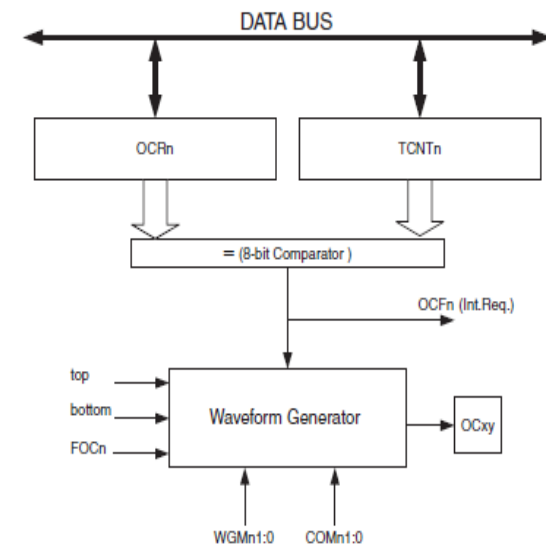
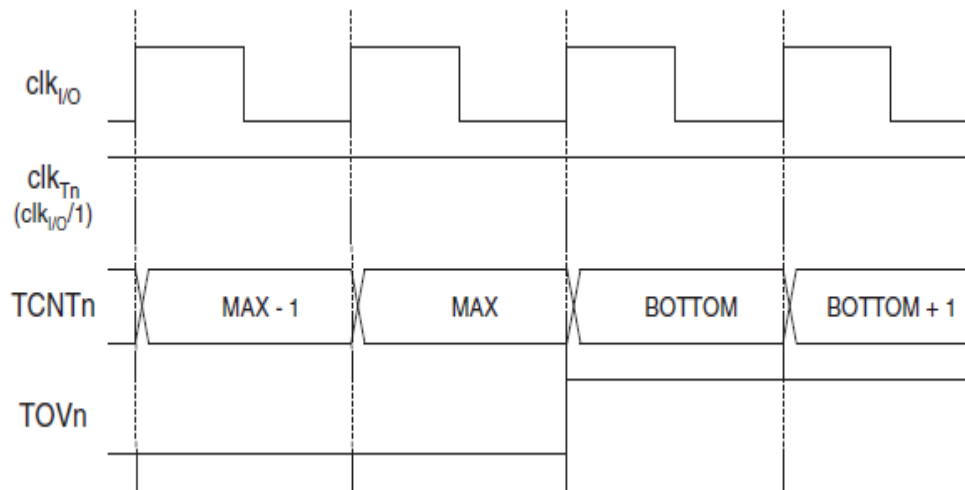
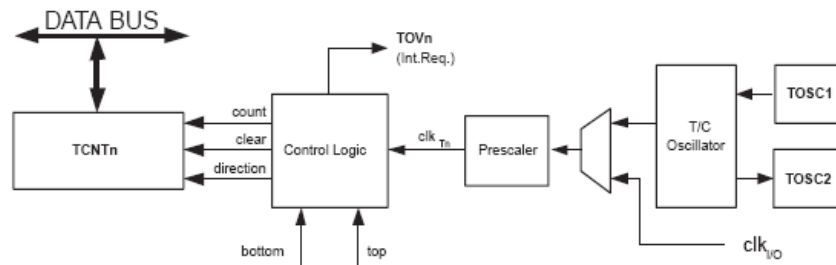
Brown Out Reset

Microcontrollori – Reset Logic

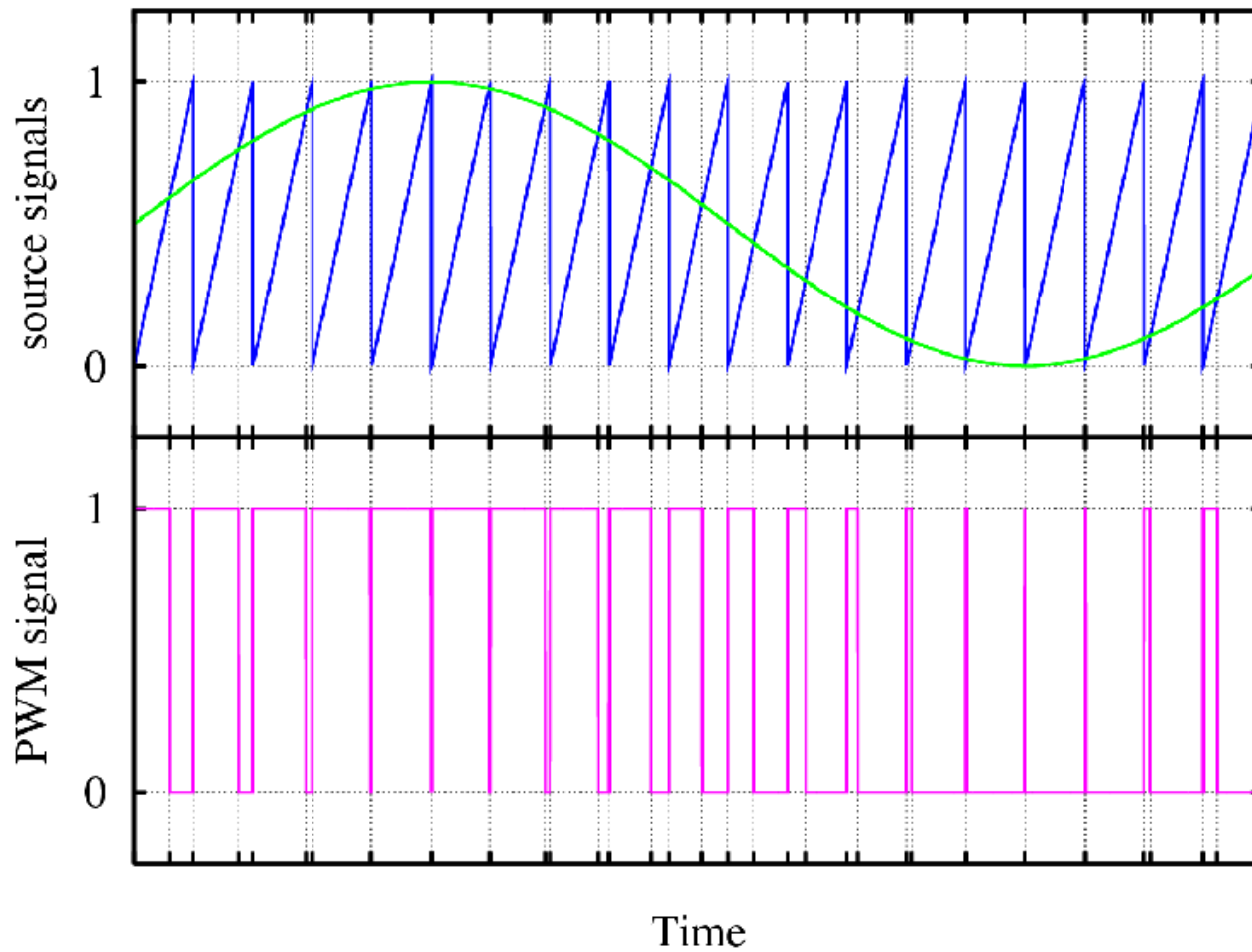
In quale stato riporta il dispositivo?

	Power-On Reset	External Reset	Watchdog Reset	BOD Reset	BOD33 Reset	CPU Error Reset	OCD Reset
CPU/HSB/PBA/PBB (excluding Power Manager)	Y	Y	Y	Y	Y	Y	Y
32 KHz oscillator	Y	N	N	N	N	N	N
RTC control register	Y	N	N	N	N	N	N
GPLP registers	Y	N	N	N	N	N	N
Watchdog control register	Y	Y	N	Y	Y	Y	Y
Voltage calibration register	Y	N	N	N	N	N	N
RCSYS Calibration register	Y	N	N	N	N	N	N
BOD control register	Y	Y	N	N	N	N	N
BOD33 control register	Y	Y	N	N	N	N	N
Bandgap control register	Y	Y	N	N	N	N	N
Clock control registers	Y	Y	Y	Y	Y	Y	Y
Osc0/Osc1 and control registers	Y	Y	Y	Y	Y	Y	Y
PLL0/PLL1 and control registers	Y	Y	Y	Y	Y	Y	Y
OCD system and OCD registers	Y	Y	N	Y	Y	Y	N

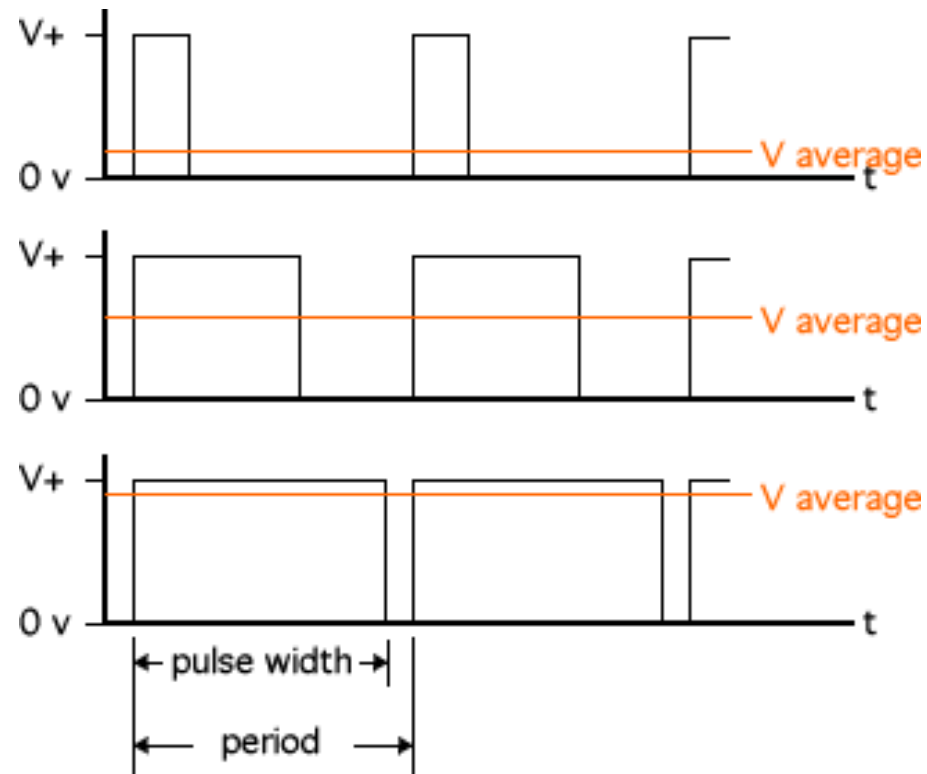
Microcontrollori - Timer



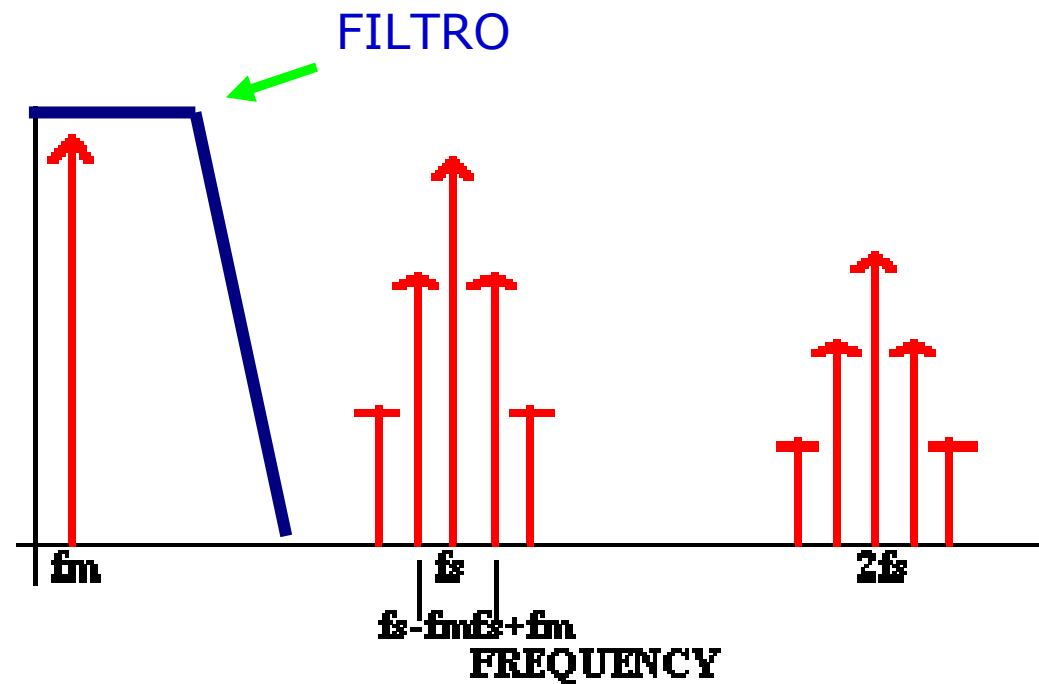
PWM – Pulse Width Modulation



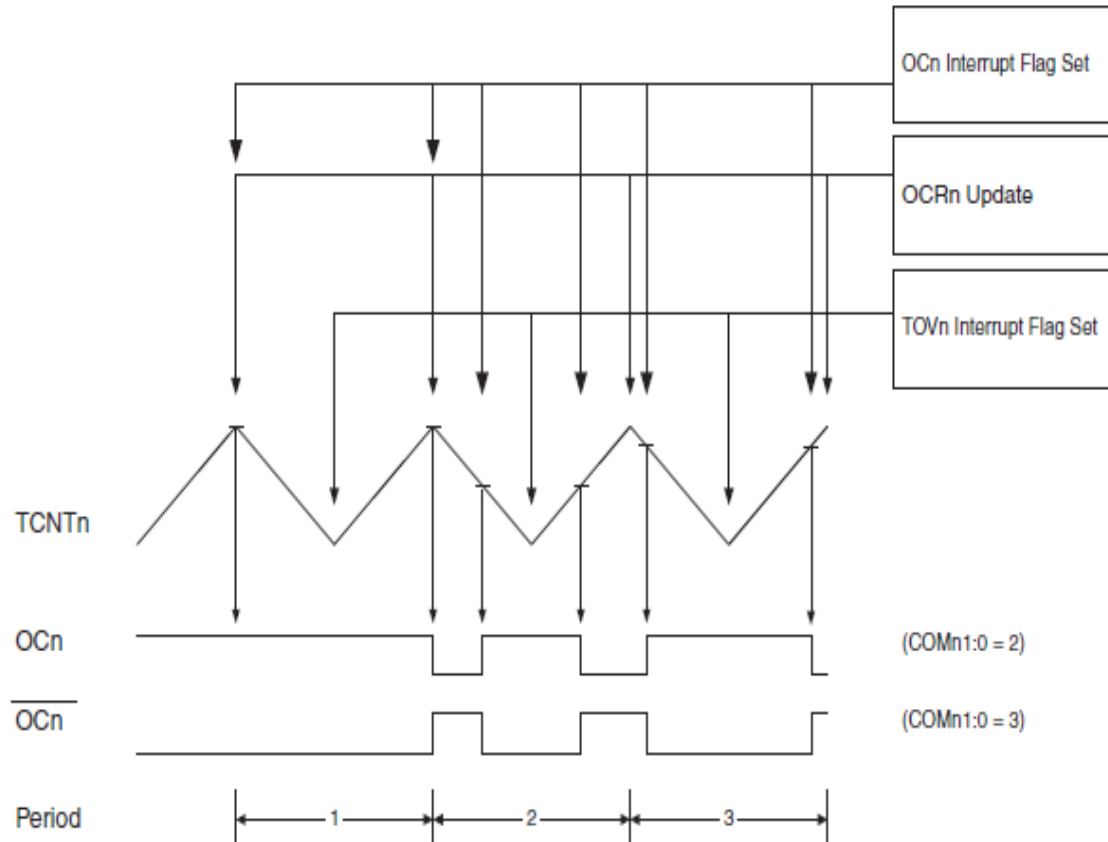
PWM – Pulse Width Modulation



PWM – Pulse Width Modulation



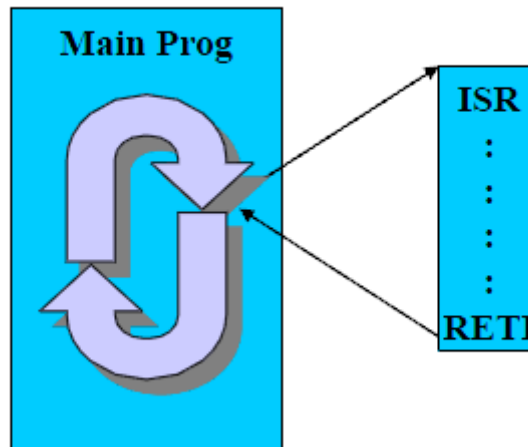
PWM – Pulse Width Modulation



Microcontrollori - Interrupt

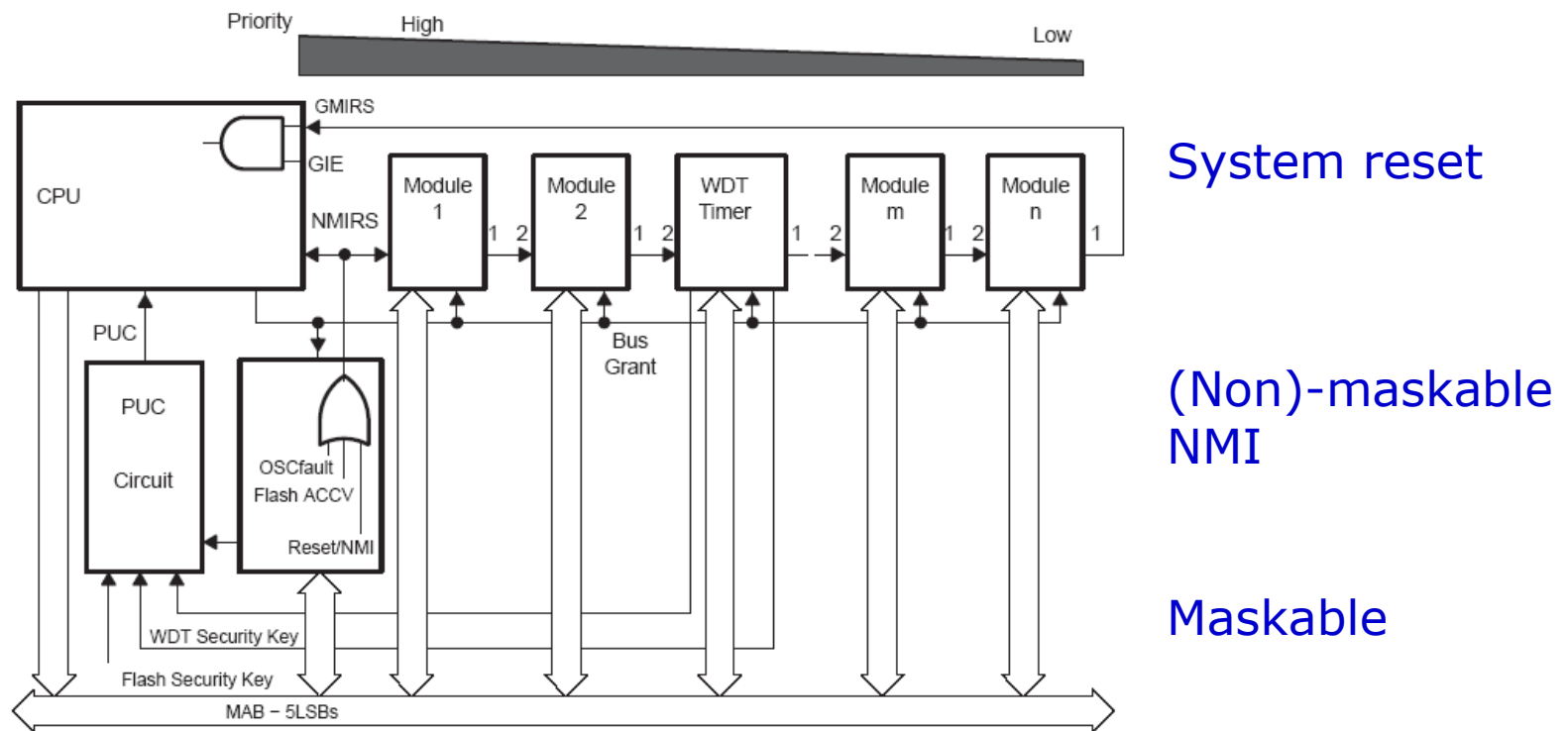
Permette di rispondere ad un evento "Esterno" senza polling

"Esterno": tutto ciò che è al di fuori del Core e
tutto ciò che può attivare i flag di interrupt



Microcontrollori - Interrupt

Figure 2-4. Interrupt Priority



Microcontrollori - Interrupt

Vector No.	Program Address ⁽²⁾	Source	Interrupt Definition
1	\$0000 ⁽¹⁾	RESET	External Pin, Power-on Reset, Brown-out Reset, Watchdog Reset, and JTAG AVR Reset
2	\$0002	INT0	External Interrupt Request 0
3	\$0004	INT1	External Interrupt Request 1
4	\$0006	INT2	External Interrupt Request 2
5	\$0008	INT3	External Interrupt Request 3
6	\$000A	INT4	External Interrupt Request 4
7	\$000C	INT5	External Interrupt Request 5
8	\$000E	INT6	External Interrupt Request 6
9	\$0010	INT7	External Interrupt Request 7
10	\$0012	TIMER2 COMP	Timer/Counter2 Compare Match
11	\$0014	TIMER2 OVF	Timer/Counter2 Overflow
12	\$0016	TIMER1 CAPT	Timer/Counter1 Capture Event
13	\$0018	TIMER1 COMPA	Timer/Counter1 Compare Match A
14	\$001A	TIMER1 COMPB	Timer/Counter1 Compare Match B
15	\$001C	TIMER1 OVF	Timer/Counter1 Overflow

```

Address  LabelsCode      Comments
$0000    jmp    RESET      ; Reset Handler
$0002    jmp    EXT_INT0   ; IRQ0 Handler
$0004    jmp    EXT_INT1   ; IRQ1 Handler
$0006    jmp    EXT_INT2   ; IRQ2 Handler
$0008    jmp    EXT_INT3   ; IRQ3 Handler
$000A    jmp    EXT_INT4   ; IRQ4 Handler
$000C    jmp    EXT_INT5   ; IRQ5 Handler
$000E    jmp    EXT_INT6   ; IRQ6 Handler
$0010    jmp    EXT_INT7   ; IRQ7 Handler
$0012    jmp    TIM2_COMP ; Timer2 Compare Handler
$0014    jmp    TIM2_OVF  ; Timer2 Overflow Handler
$0016    jmp    TIM1_CAPT ; Timer1 Capture Handler
$0018    jmp    TIM1_COMPA; Timer1 CompareA Handler
$001A    jmp    TIM1_COMPB; Timer1 CompareB Handler
$001C    jmp    TIM1_OVF  ; Timer1 Overflow Handler
$001E    jmp    TIM0_COMP ; Timer0 Compare Handler
$0020    jmp    TIM0_OVF  ; Timer0 Overflow Handler
    
```

Microcontrollori - Interrupt Overheads

Interrupt arrives

Complete current instruction

Save essential register information

Vector to ISR

Save additional register information



Interrupt
Latency

Execute body of ISR

Restore other register information

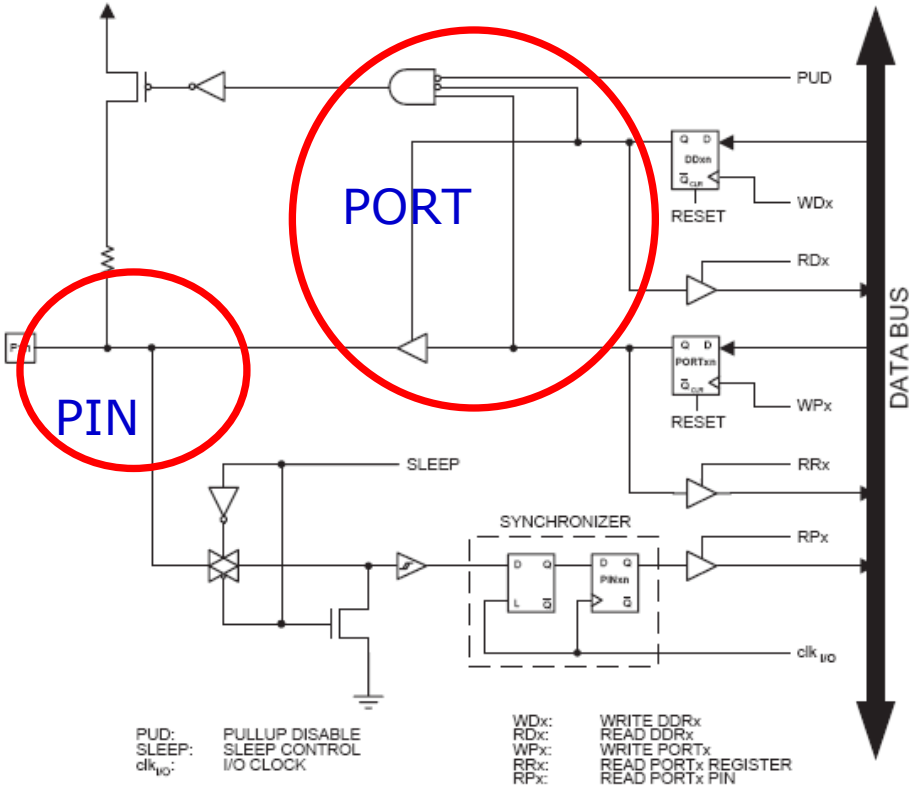
Return from interrupt and restore essential
registers

Resume task



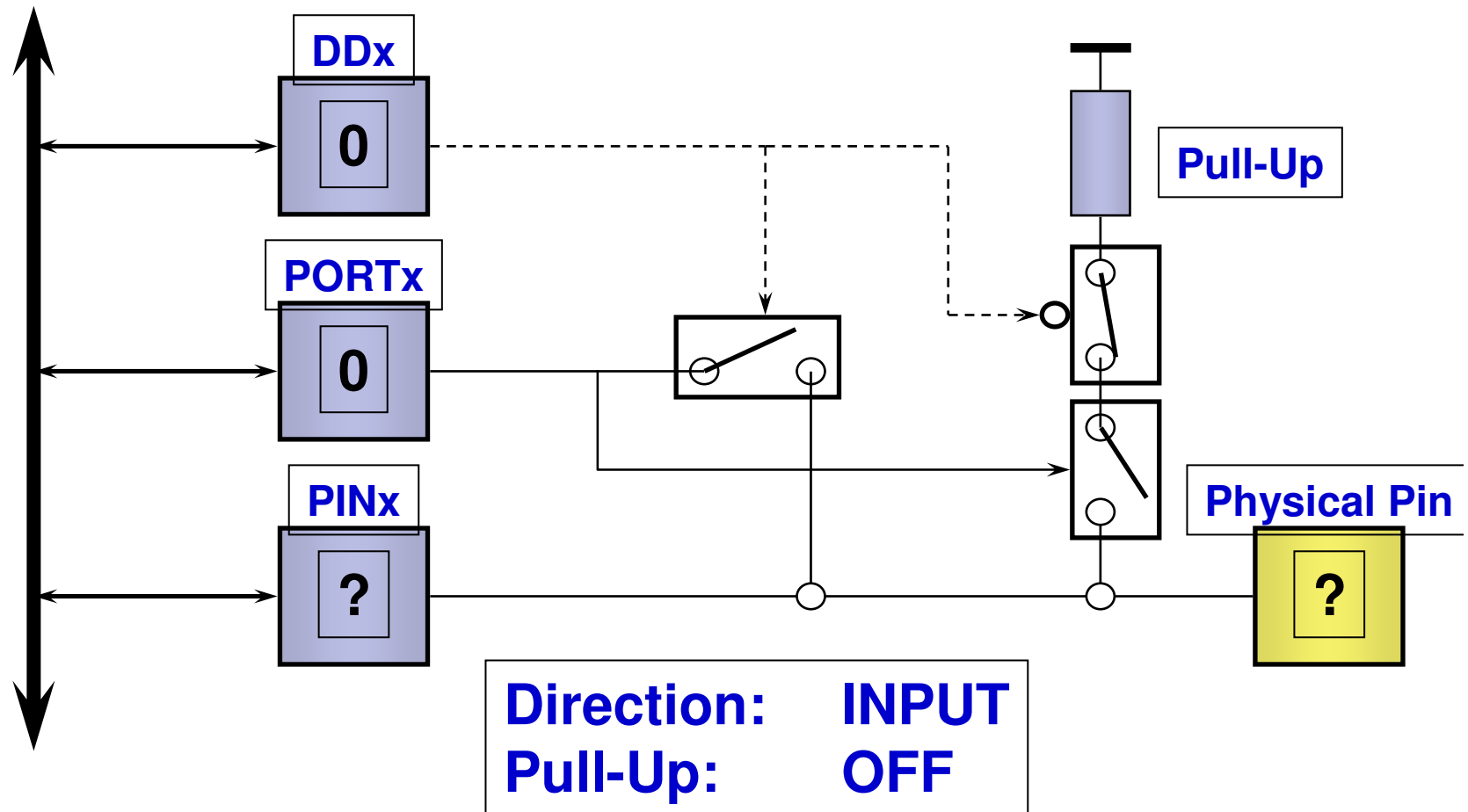
Interrupt
Termination

Microcontrollori - GPIO

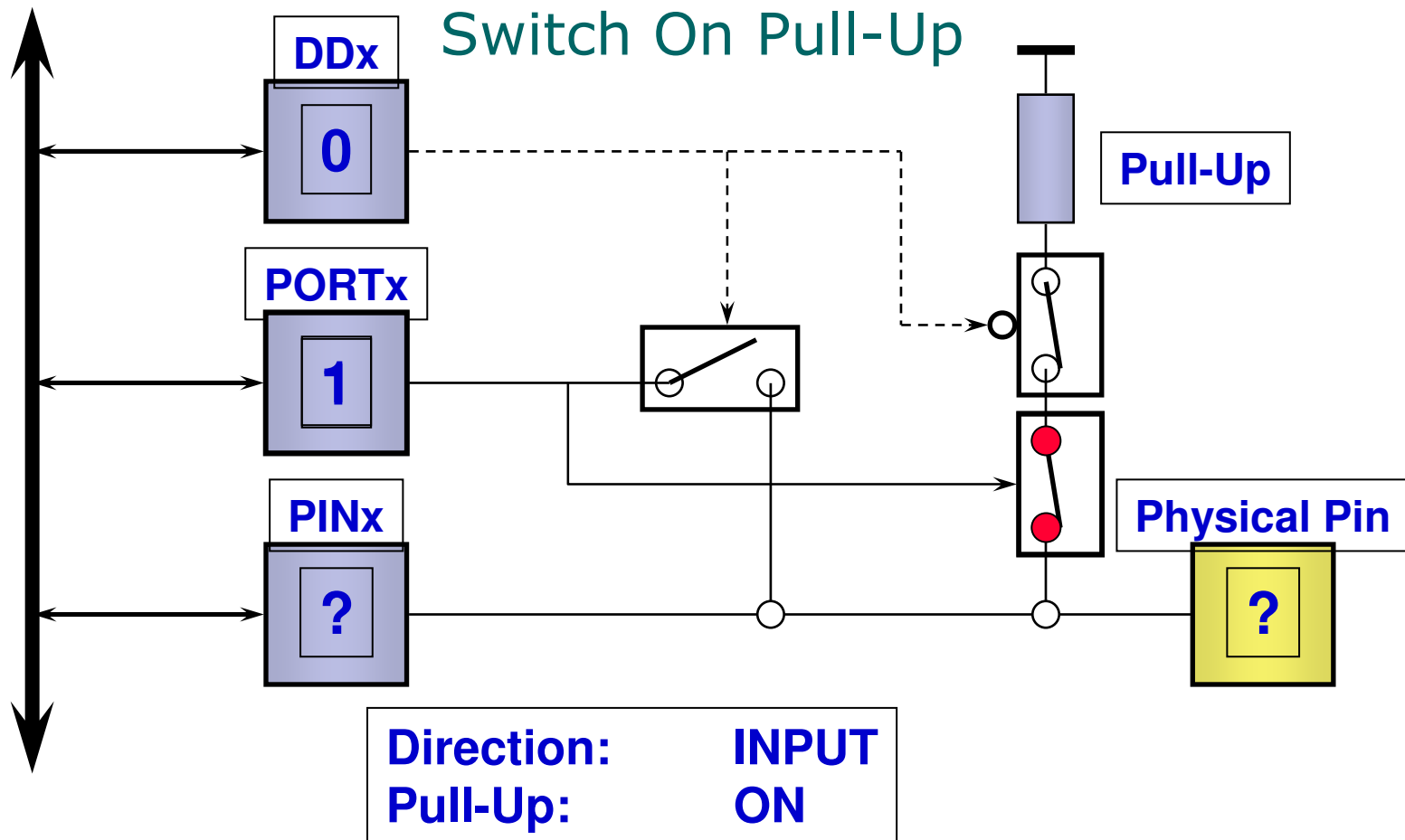


PORT NOT EQUAL TO PIN !!!

Microcontrollori - GPIO



Microcontrollori - GPIO



Microcontrollori - GPIO

