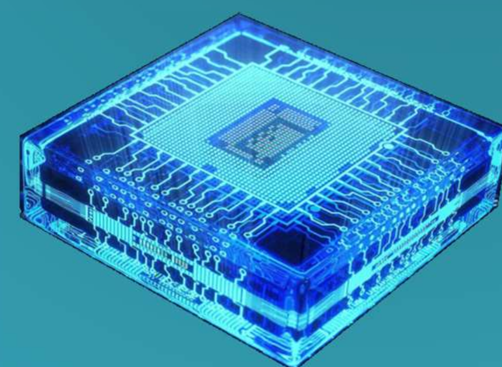
Microprocessors and Assembly language

Isfahan University of Technology (IUT)



The AVR Microcontroller

Dr. Hamidreza Hakim
hamid.hakim.u@gmail.com

بسم الله الرحمن الرحیم

Topics

- Computer History
- Microcontroller vs. Microprocessor
- AVR History and features

INTRODUCTION TO THE MICROPROCESSOR AND COMPUTER

Vacuum tube computers

www.williamson-labs.com/480_cpu.htm

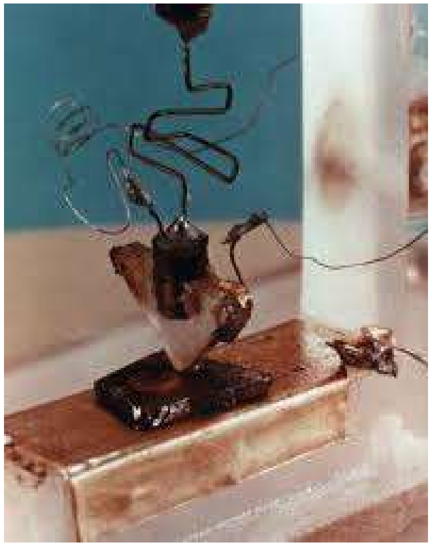
1nd Generation 1940
military
SAGE Blockhouse/Computer:
10,170m^2, 250 tons, houses More than 200,000 vacuum tubes @ 3,000,000 Watts

Collaboration learning

- Reseach How Relay Computer works?
- History, Gates,…

Transistor Computers

- 2^{nd} Generation
- From 1956
- Half a room



The Harwell Dekatron Computer under restoration at the British National Museum of Computing

Invention of ICs

- 3^{rd} generation
- Integrated Circuits
- 1960
- IBM 360

IBM 360 made by ICs (1964)

www.araxai.ir

VLSI technology

- 1970
- Fourth Generation
- the VLSI technology or the Very Large Scale Integrated (VLSI) circuits technology
- millions or billions of MOS transistors

ULSI

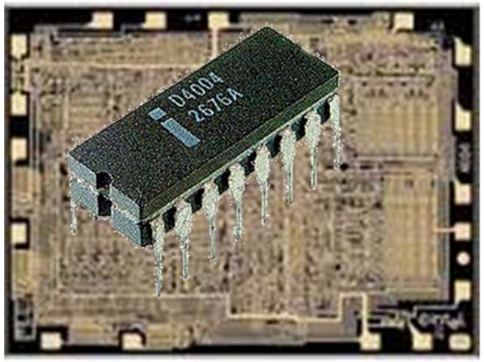
- 1980-till date
- the fifth generation, VLSI technology became ULSI (Ultra Large Scale Integration)
- microprocessor chips having ten million electronic components.
- parallel processing hardware

First microprocessors/Microcontrollers

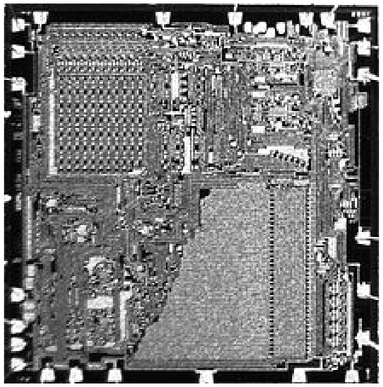
- 4004 (from Intel)
- TI TMS1000
- 6800 (Motorola)

- Microwave oven

TI TMS1000
(1971-1974)
http://www.antiquetech.com/



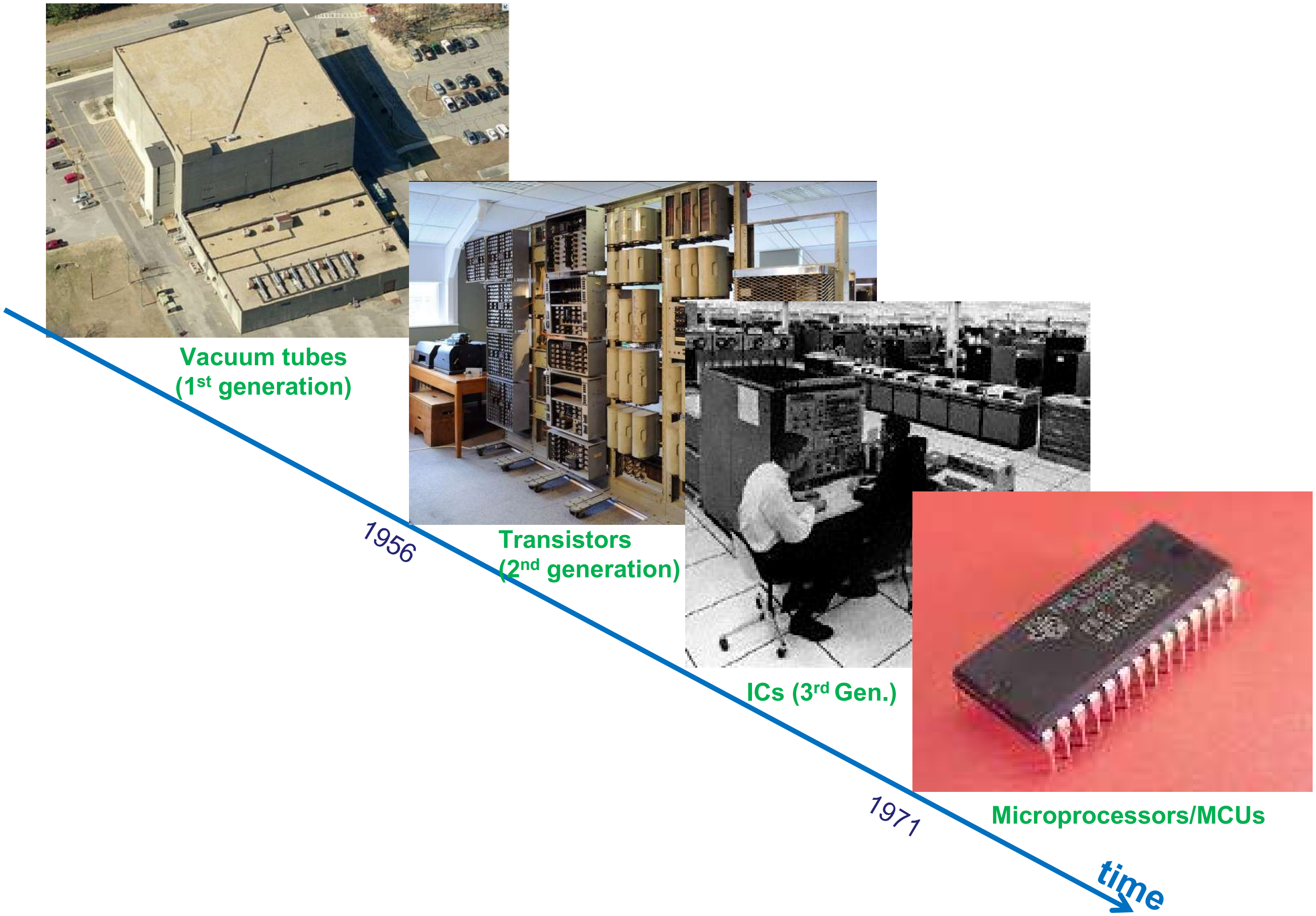
Intel 4004 (1971)
www.computerhistory.org
4BIT DATA
2300 transistors



PICO1 (1971)
http://en.wikipedia.org/wiki/Microprocessor

Motorola MC6800
(1974)
http://en.wikipedia.org/wiki/Motorola_6800

Now!

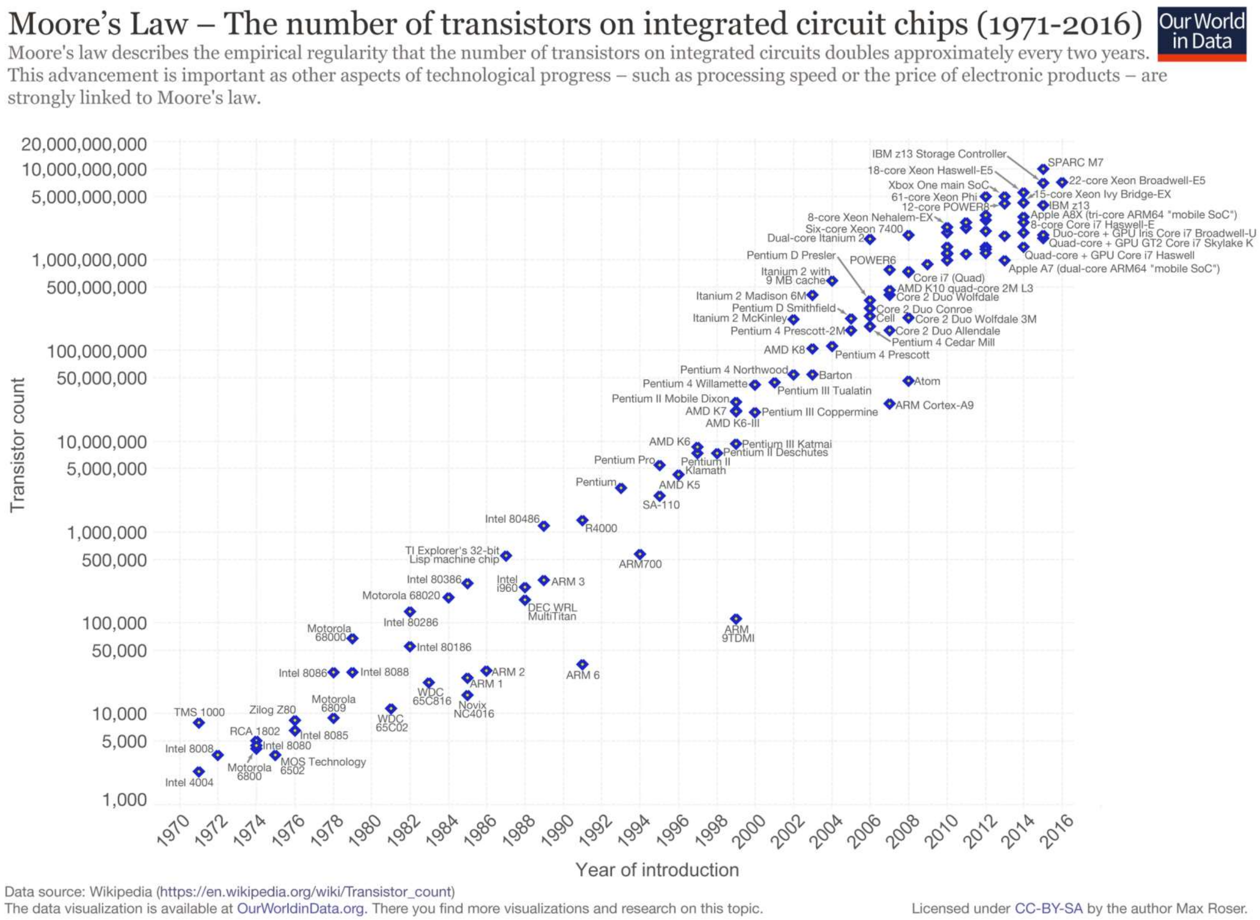

Vacuum tubes
(1st generation)
1956
Transistors
(2nd generation)
ICs (3rd Gen.)
1971
Microprocessors/MCUs
time

Chip packaging

Arax
www.araxai.ir

Moore's law

- number of transistors in an IC) doubles about every two years



In 2020, Samsung Electronics planned to produce the 5 nm node, using FinFET and EUV technology.[36][needs update]

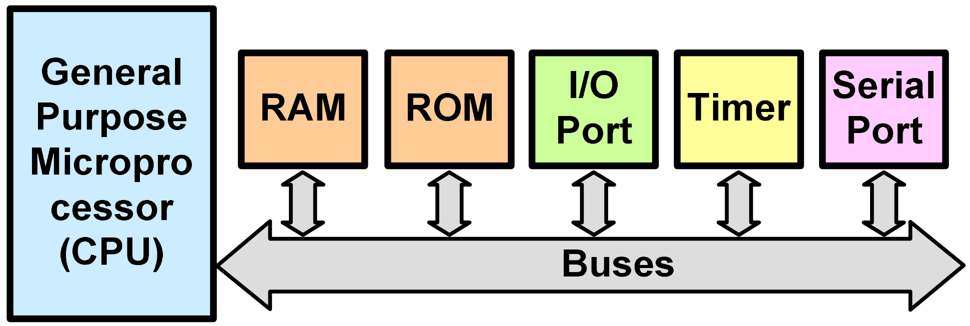
In May 2021, IBM announced the creation of the first 2 nm computer chip, with parts supposedly being smaller than human DNA.[101]

- https://www.computerhistory.org/timeline/computers/

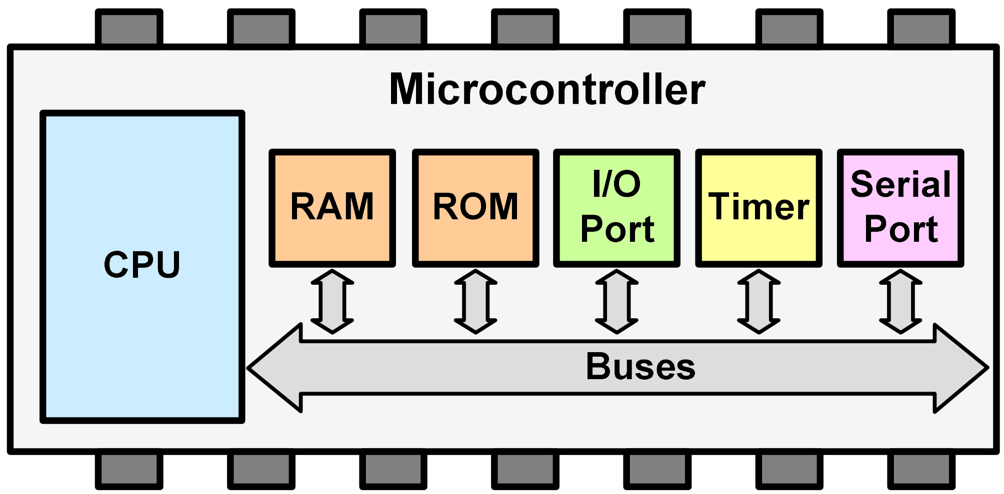
MICROCONTROLLER VS. MICROPROCESSOR

General Purpose Microprocessors vs. Microcontrollers

- General Purpose Microprocessors



- Microcontrollers
  - Fix Wiring
  - Fix RAM



Most common microcontrollers

- 4 bit->32 bit
- 8-bit microcontrollers
  - AVR
  - PIC
  - HCS12
  - 8051
- 32-bit microcontrollers
  - ARM
  - AVR32
  - PIC32
  - CodeFire
  - PowerPC

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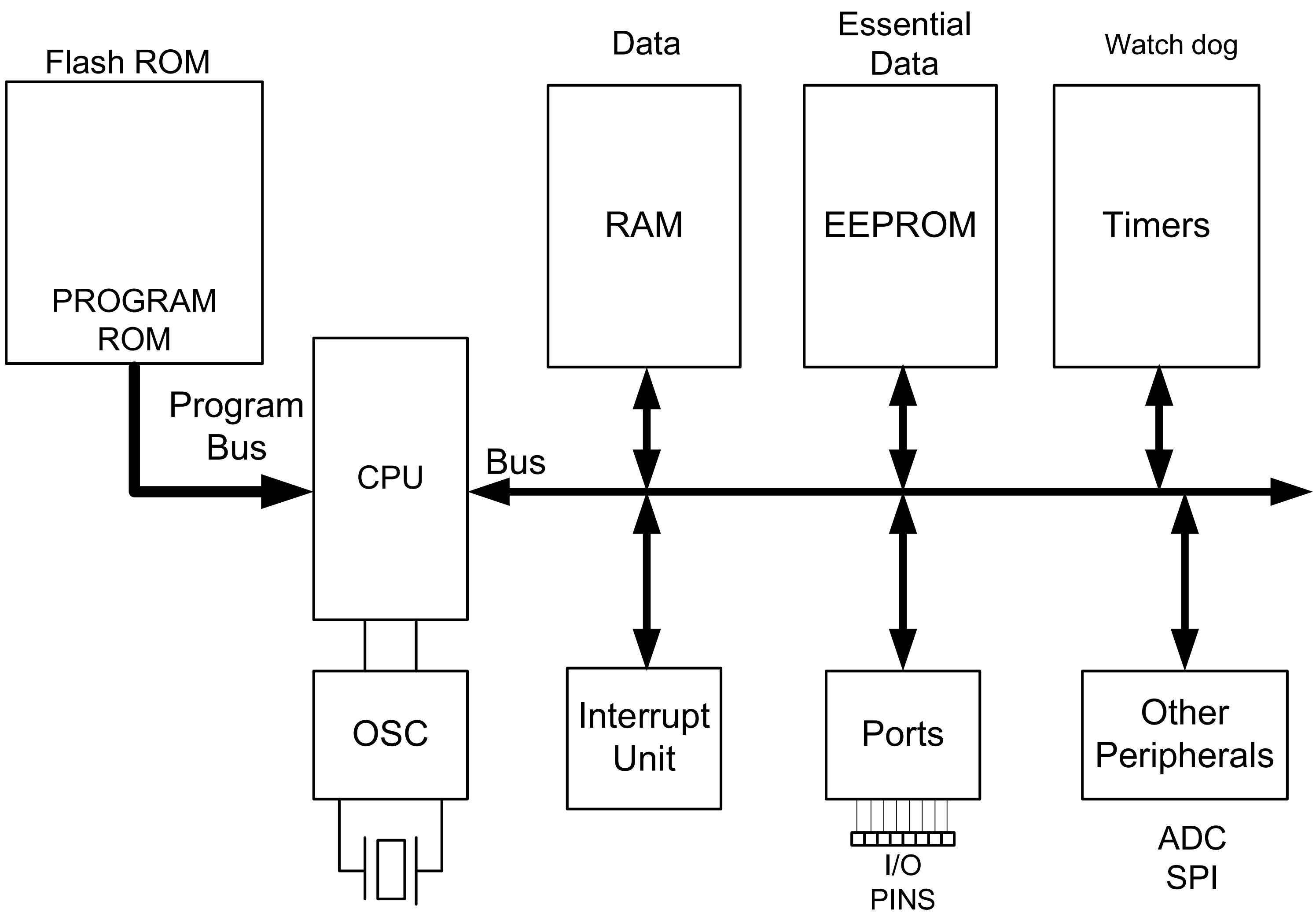
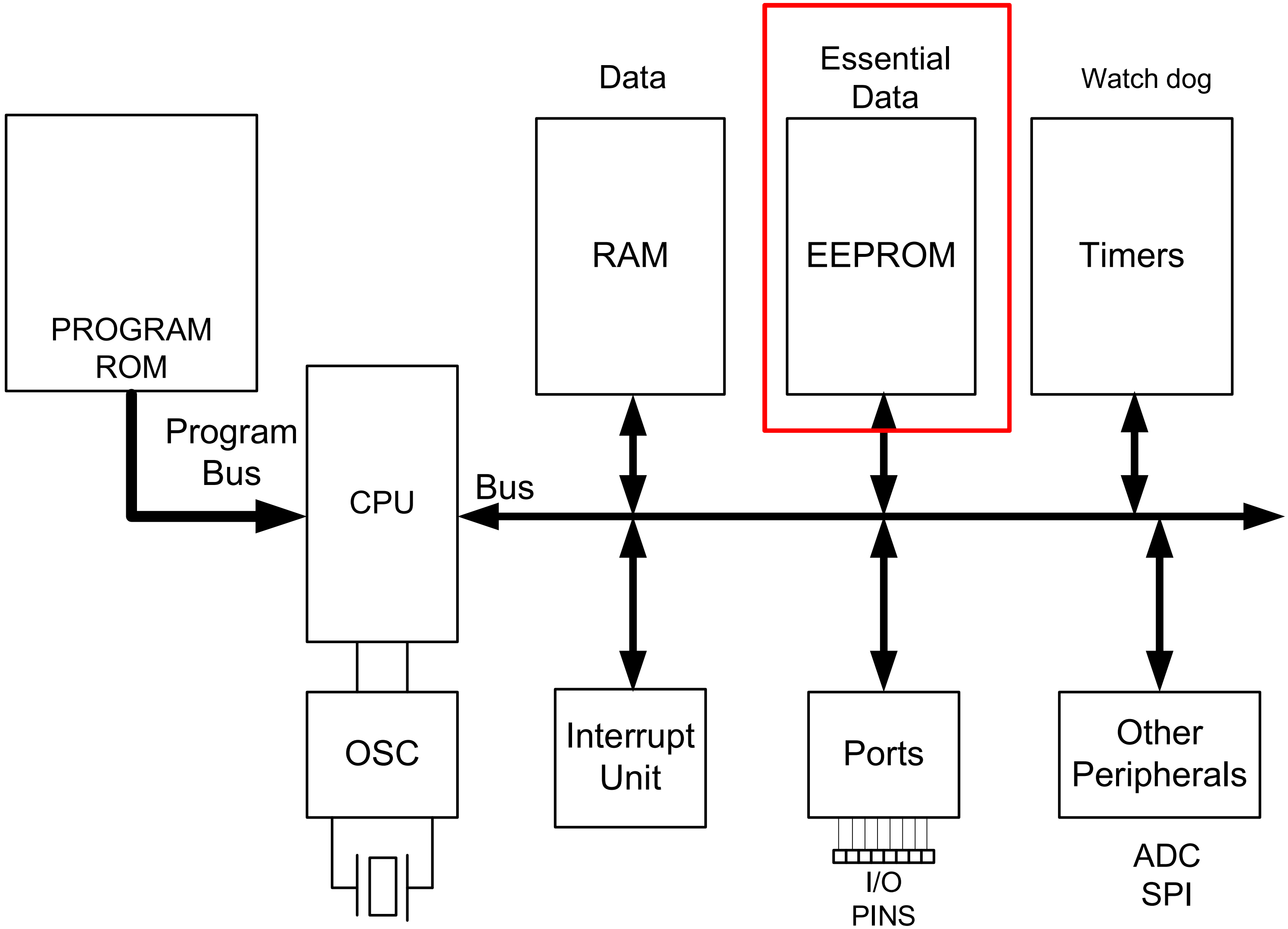
AVR HISTORY AND FEATURES

AVR internal architecture



AVR internal architecture



AVR different groups

- Classic AVR
  - e.g. AT90S2313, AT90S4433
- Mega(120 inst)
  - e.g. ATmega8, ATmega32, ATmega128
- Tiny(low power)
  - e.g. ATtiny13, ATtiny25
- Special Purpose AVR (Application Oriented AVR)
  - e.g. AT90PWM216,AT90USB1287
- XMega
  - New features like DMA, DAC, crypto engine, etc.

AVR different groups

- Classic AVR
  - e.g. AT90S2313, AT90S4433
- Mega
  - e.g
- Tiny(
  - e.g
- Spec AVR)
  - e.g.
- XMega
  - New features like DMA, DAC, crypto engine, etc.

Table 1-3: Some Members of the Classic Family

Part Num	Code ROM	Data RAM	Data EEPROM	I/O pins pins	ADC	Timers	Pin numbers & Package
AT90S2313	2K	128	128	15	0	2	SOIC20,PDIP20
AT90S2323	2K	128	128	3	0	1	SOIC8,PDIP8
AT90S4433	4K	128	256	20	6	2	TQFP32,PDIP28

Notes:
1. All ROM, RAM, and EEPROM memories are in bytes.
2. Data RAM (General-Purpose RAM) is the amount of RAM available for data manipulation (scratch pad) in addition to the Registers space.

AVR different groups

- Classic AVR
  - e.g. AT90S2313, AT90S4433
- Mega(120 inst)
  - e.g. ATmega8, ATmega32, ATmega128
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- Mega(120 inst)
  – e.g. ATmega8, ATmega32, ATmega128
- Tiny(
  – e.g
- Spec AVR)
  – e.g
- XMe
  – Ne etc.

Table 1-4: Some Members of the Mega Family

Part Num	Code ROM	Data RAM	Data EEPROM	I/O pins pins	ADC	Timers	Pin numbers & Package
ATmega8	8K	1K	0.5K	23	8	3	TQFP32,PDIP28
ATmega16	16K	1K	0.5K	32	8	3	TQFP44,PDIP40
ATmega32	32K	2K	1K	32	8	3	TQFP44,PDIP40
ATmega64	64K	4K	2K	54	8	4	TQFP64,MLF64
ATmega1280	128K	8K	4K	86	16	6	TQFP100,CBGA

Notes:
1. All ROM, RAM, and EEPROM memories are in bytes.
2. Data RAM (General-Purpose RAM) is the amount of RAM available for data manipulation (scratch pad) in addition to the Registers space.
3. All the above chips have USART for serial data transfer.

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  - e.g. ATmega8, ATmega32, ATmega128
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- XMega
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AVR different groups

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  - e.g. ATmega8, ATmega32, ATmega128
- Tiny(low power)
  - e.g. ATtiny13, ATtiny25
- Spec … AVR)
  - e.g …
- XMe …
  - Ne … etc.

Table 1-5: Some Members of the Tiny Family

Part Num	Code ROM	Data RAM	Data EEPROM	I/O pins pins	ADC	Timers	Pin numbers & Package
ATtiny13	1K	64	64	6	4	1	SOIC8,PDIP8
ATtiny25	2K	128	128	6	4	2	SOIC8,PDIP8
ATtiny44	4K	256	256	12	8	2	SOIC14,PDIP14
ATtiny84	8K	512	512	12	8	2	SOIC14,PDIP14

AVR different groups

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  - e.g. ATmega8, ATmega32, ATmega128
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- Special Purpose AVR (Application Oriented AVR)
  - e.g. AT90PWM216,AT90USB1287
- XMega
  - New features like DMA, DAC, crypto engine, etc.

AVR different groups

- Classic AVR
  - e.g. AT90S2313, AT90S4433
- Mega(120 inst)
  - e.g
- Tiny(
  - e.g

Table 1-6: Some Members of the Special purpose Family

Part Num	Code ROM	Data RAM	Data EEPROM	Max I/O pins	Special Capabilities	Timers	Pin numbers & Package
AT90CAN128	128K	4K	4K	53	CAN	4	LQFP64
AT90USB1287	128K	8K	4K	48	USB Host	4	TQFP64
AT90PWM216	16K	1K	0.5K	19	Advanced PWM	2	SOIC24
ATmega169	16K	1K	0.5K	54	LCD	3	TQFP64,MLF64

- Special Purpose AVR (Application Oriented AVR)
  - e.g. AT90PWM216,AT90USB1287
- XMega
  - New features like DMA, DAC, crypto engine, etc.

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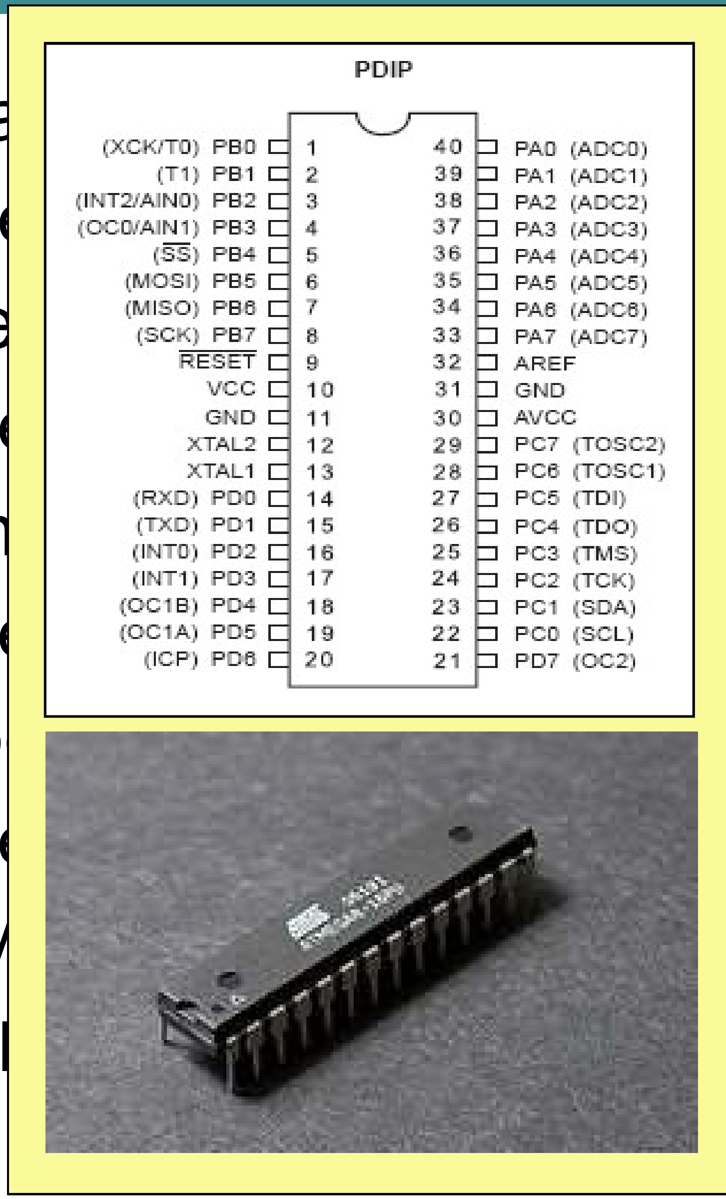
  - e.g. AT90PWM216,AT90USB1287
- XMega
  - New features like DMA, DAC, crypto engine, etc.

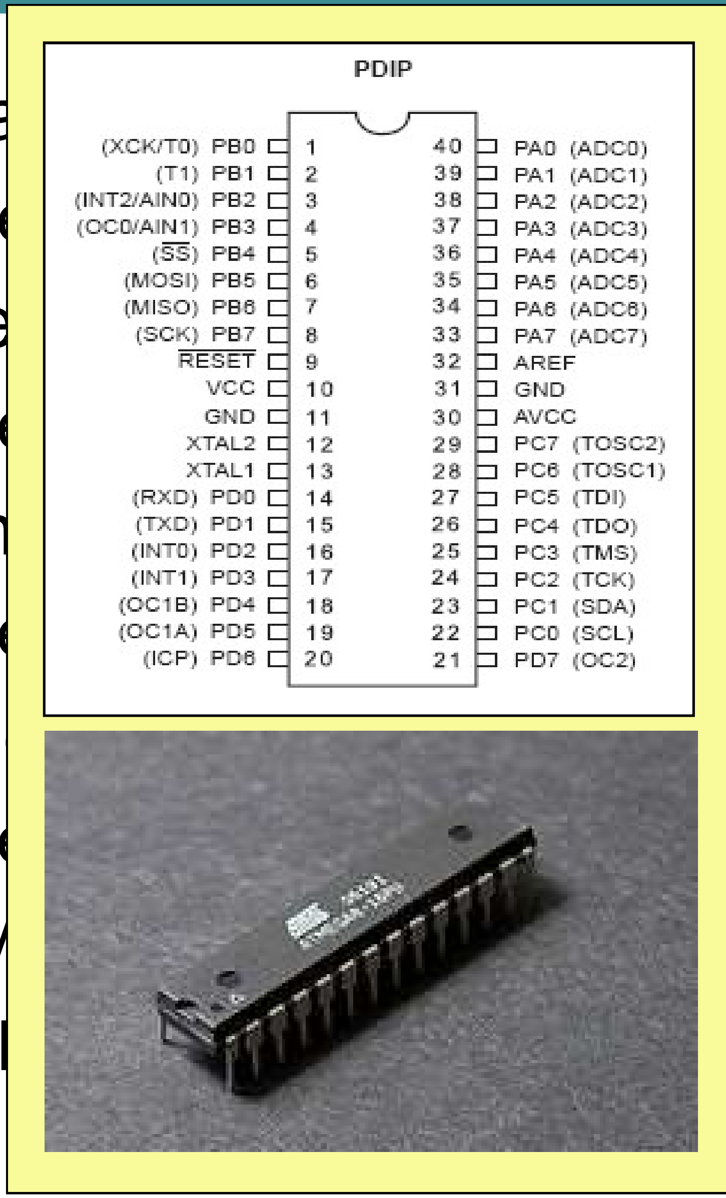
AVR different groups

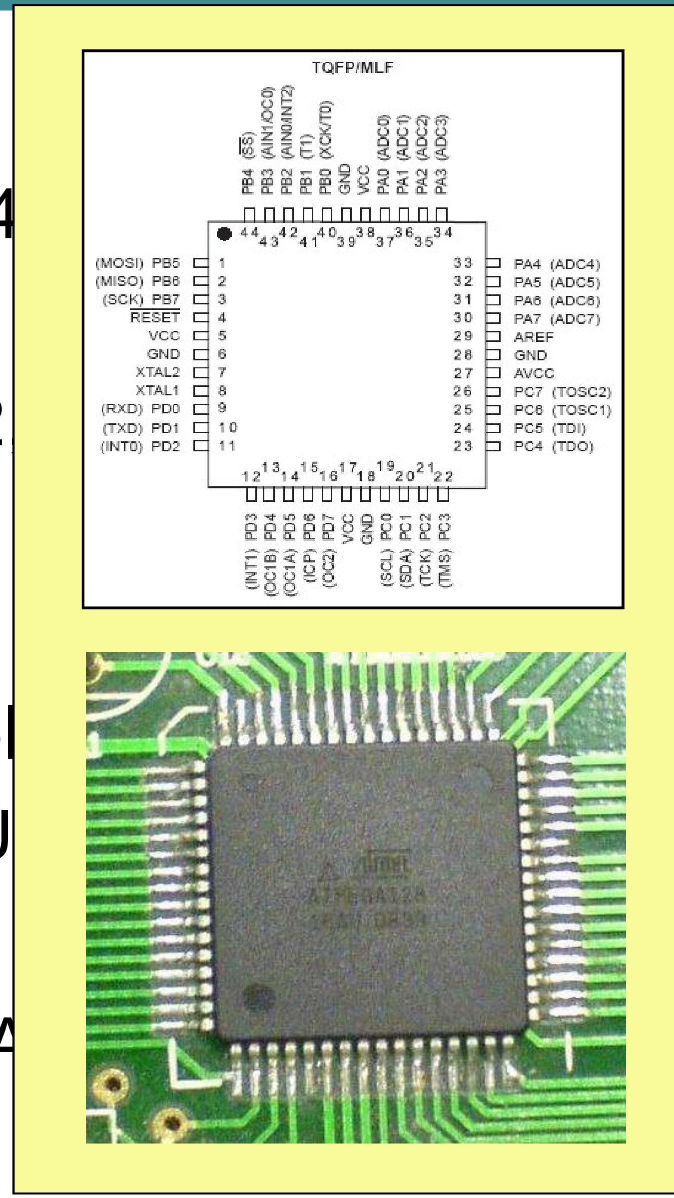
- Cla
  - e ... 4433
- Me
  - e ... 32, ATmega128
- Tin
  - e
- Sp ... pplication Oriented AVR)
  - e ... 0USB1287
- XM
  - I ... DAC, crypto engine, etc.



AVR different groups

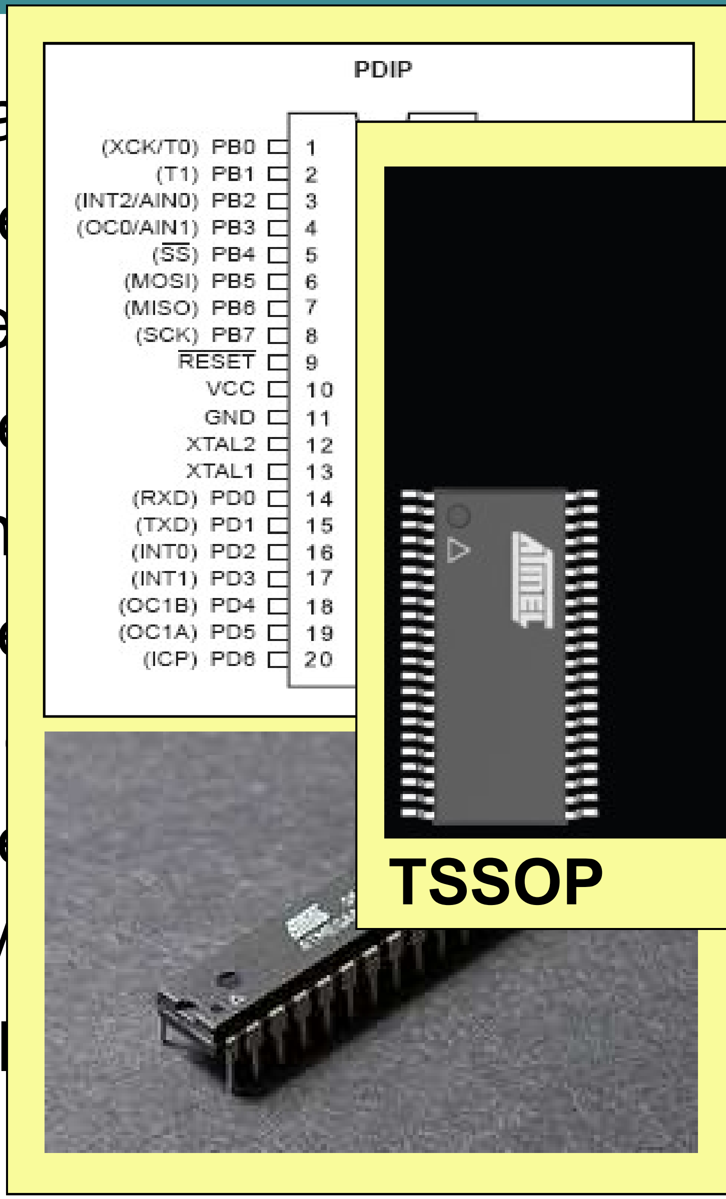
- Cla
  - S44
- Me
  - 32
- Tin
  -
- Sp ppl R)
  - 0U
- XM
  - I DA

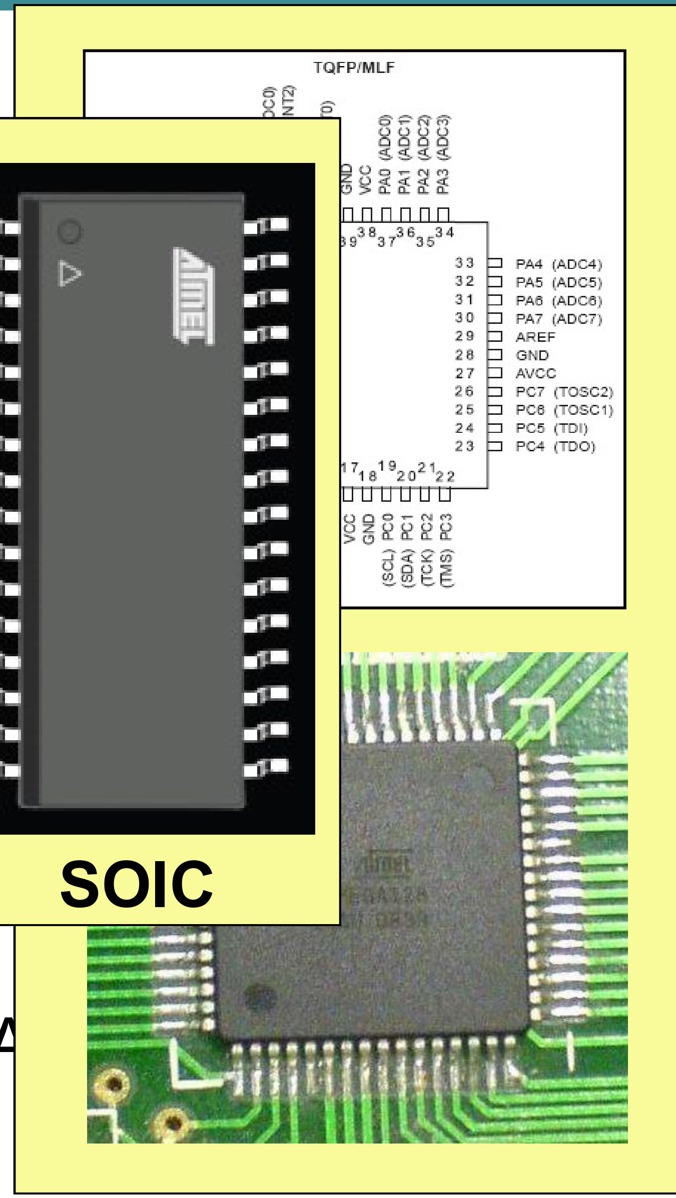


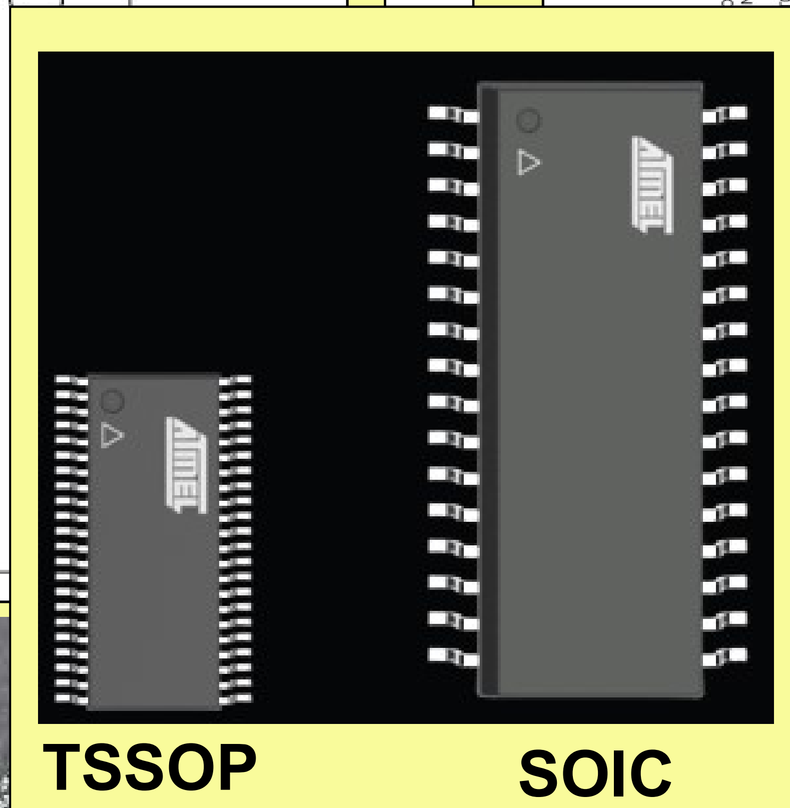


AVR different groups

- Cla
  - c
- Me
  - c
- Tin
  - c
- Sp R)
  - c
- XM
  - I DA

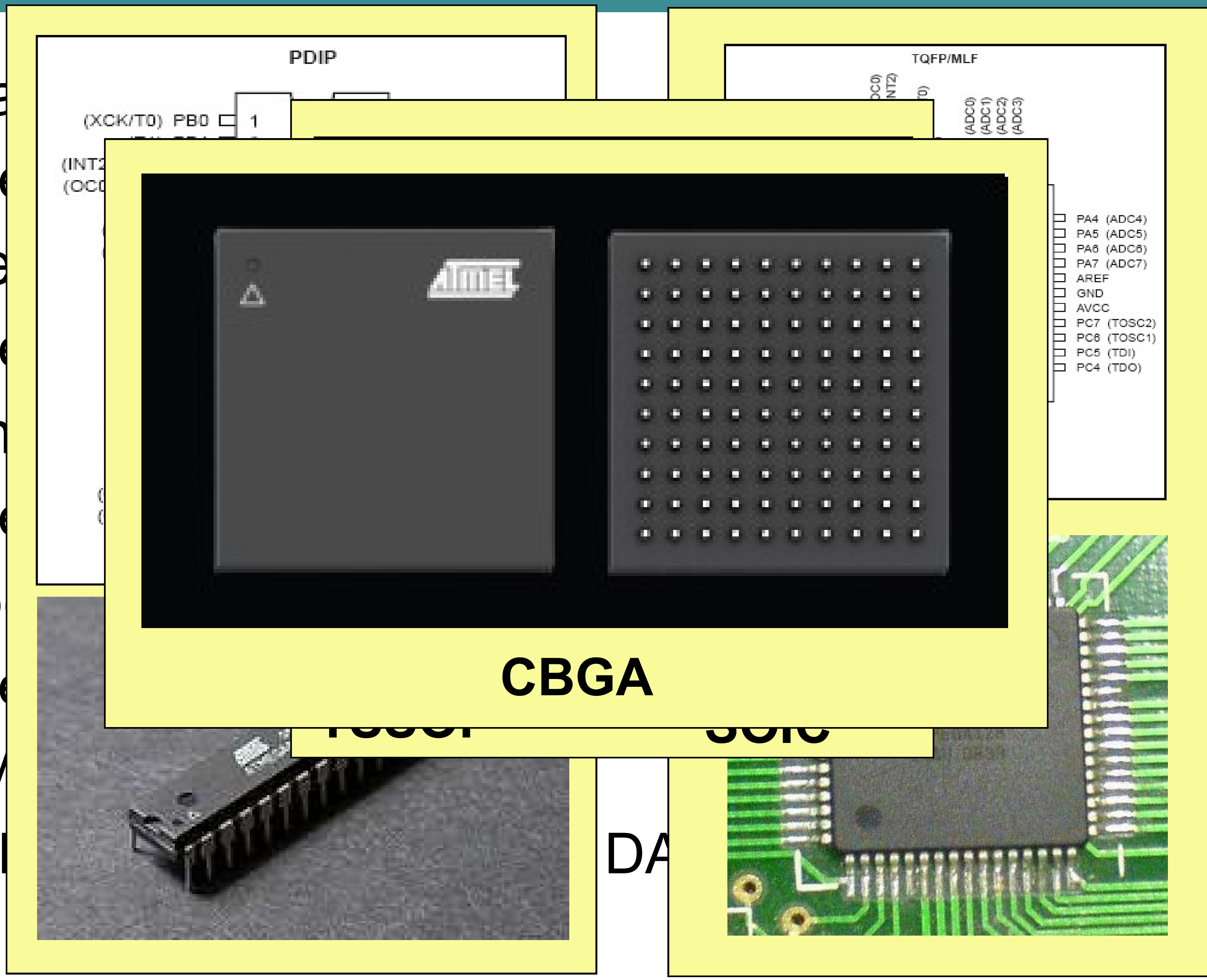






AVR different groups

- Cla
  - ...
- Me
  - ...
- Tin
  - ...
- Sp   R)
  - ...
- XM
  - ...   DA



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AVR different groups

- Classic AVR
  - e.g. AT90S2313, AT90S4433
- Mega
  - e.g. ATmega8, ATmega32, ATmega128
- Tiny

VR)

tc.

Product	Flash	SRAM	I/O	16-bit Timers	SPI/TWI/USART	12-bit ADC	Analog Comparator
ATxmega64A1	64	4	78	8	4/4/8	2x8	4
ATxmega128A1	128	8	78	8	4/4/8	2x8	4
ATxmega192A1	192	8	78	8	4/4/8	2x8	4
ATxmega256A1	256	16	78	8	4/4/8	2x8	4
ATxmega64A3	64	4	50	7	4/4/7	2x8	4
ATxmega256A3	256	16	50	7	4/2/7	2x8	4
ATxmega16A4	16	2	36	5	2/2/5	1x12	2
ATxmega32A4	32	4	36	5	2/2/5	1x12	2
ATxmega64A4	64	4	36	5	2/2/5	1x12	2
ATxmega128A4	128	8	36	5	2/2/5	1x12	2

AVR different groups

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- Mega
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- Special Purpose AVR (Application Oriented AVR)
  - e.g. AT90PWM216,AT90USB1287
- XMega
  - New features like DMA, DAC, crypto engine, etc.

Let’s get familiar with the AVR part numbers

ATmega128

- AT → Atmel
- mega → group
- 128 → Flash =128K

ATtiny44

- AT → Atmel
- tiny → Tiny group
- 44 → Flash =4K

AT90S4433

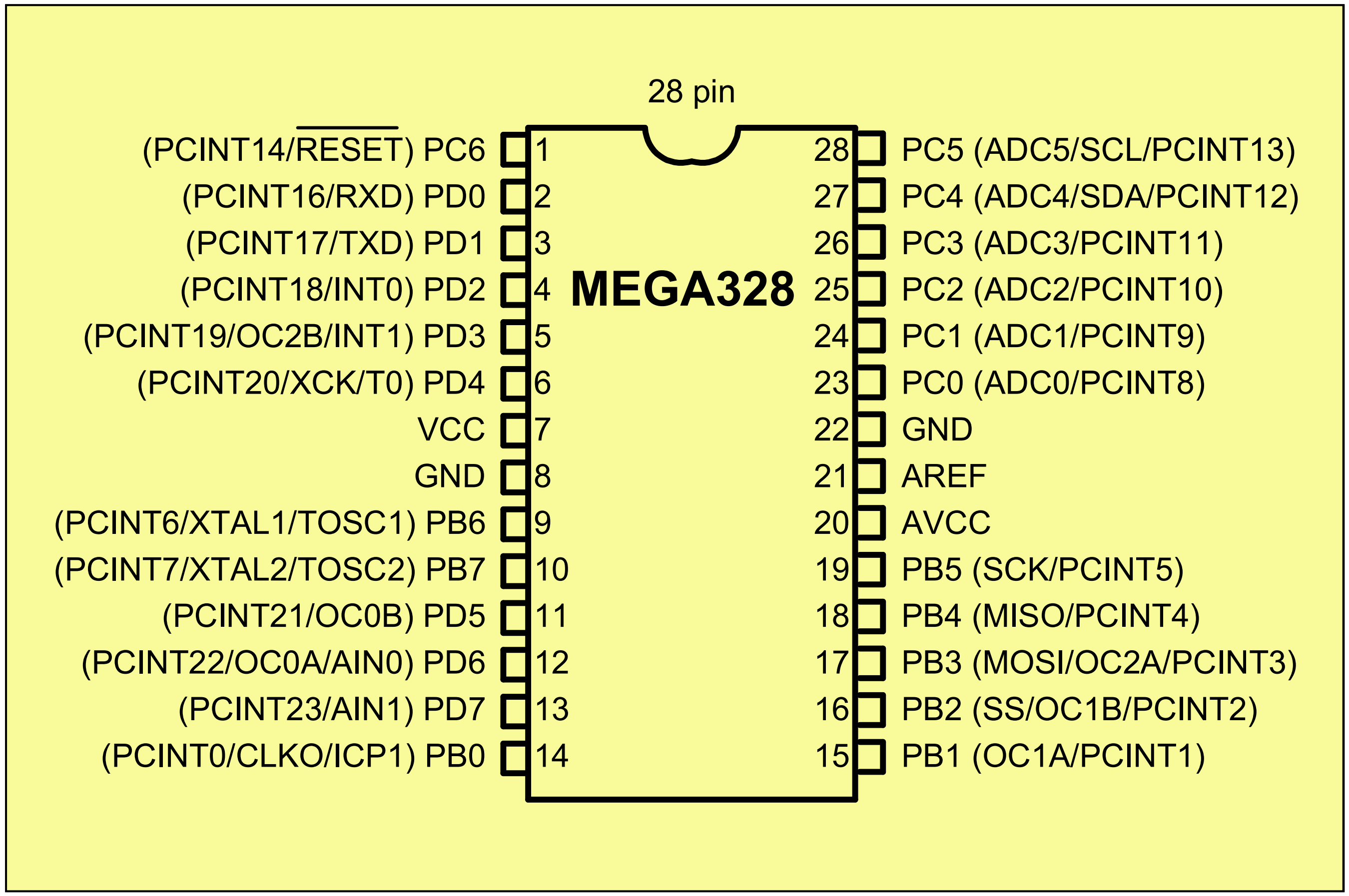
- AT → Atmel
- 90S → Classic group
- 4 → Flash =4K

AVR Pin/out

Xtal=OSI
AREFF= ADC

AVR Pin/out

Xtal=OSI
AREFF= ADC



AVR Pin/out

Xtal=OSI
AREFF= ADC

ATmega32 Block Diagram

THE AVR MICROCONTROLLER

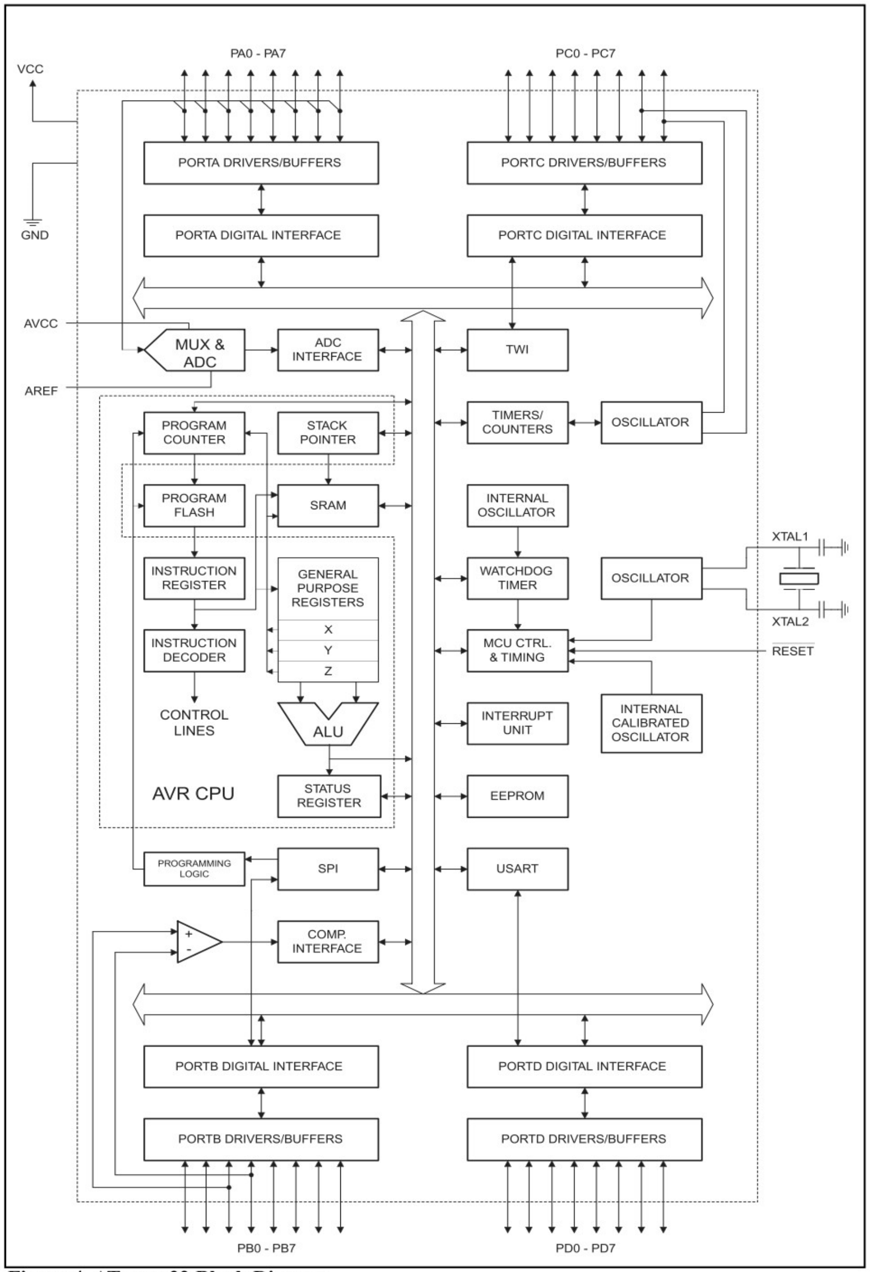


Figure 4. ATmega32 Block Diagram

References

- https://www.msu.edu/course/lbs/126/lectures/history.html
- www.williamson-labs.com/480_cpu.htm
- www.computerhistory.org
- The AVR Microcontroller and Embedded systems, Mazidi & Naimi
- http://www.antiquetech.com/
- http://en.wikipedia.org/