Ingar Fredriksen
AVR Applications Manager

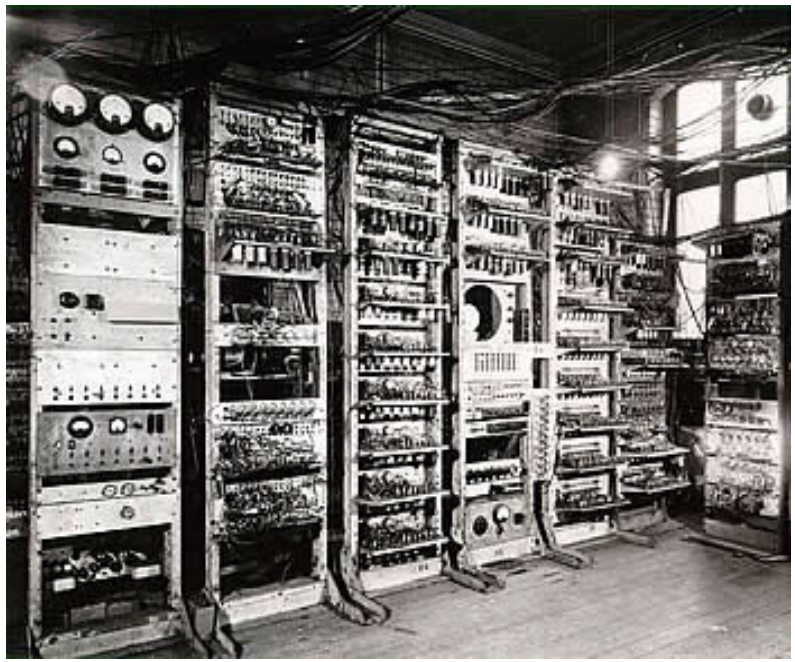
Tromsø August 12, 2005

# The history of computers

- An automatic computing machine must have:
  - A store for the numbers (memory)
  - A device for performing arithmetic operations (ALU)
  - A device for causing the operations of the machine (CU)
  - An input and output device (Mouse, keyboard, screen)

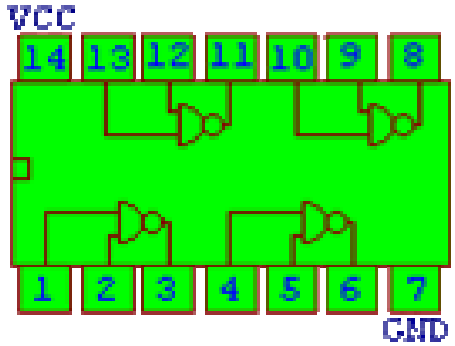
# First Generation: The Manchester Computer

- The world's first stored-program electronic digital computer
- Executed its first program on June 21st in 1948.
- Designed and constructed by Machester University
- Ferranti Ltd. was given rights to produce and sell a commercial version of the machine (Manchester mark I)



# The Most Important Step: Integrated Circuits

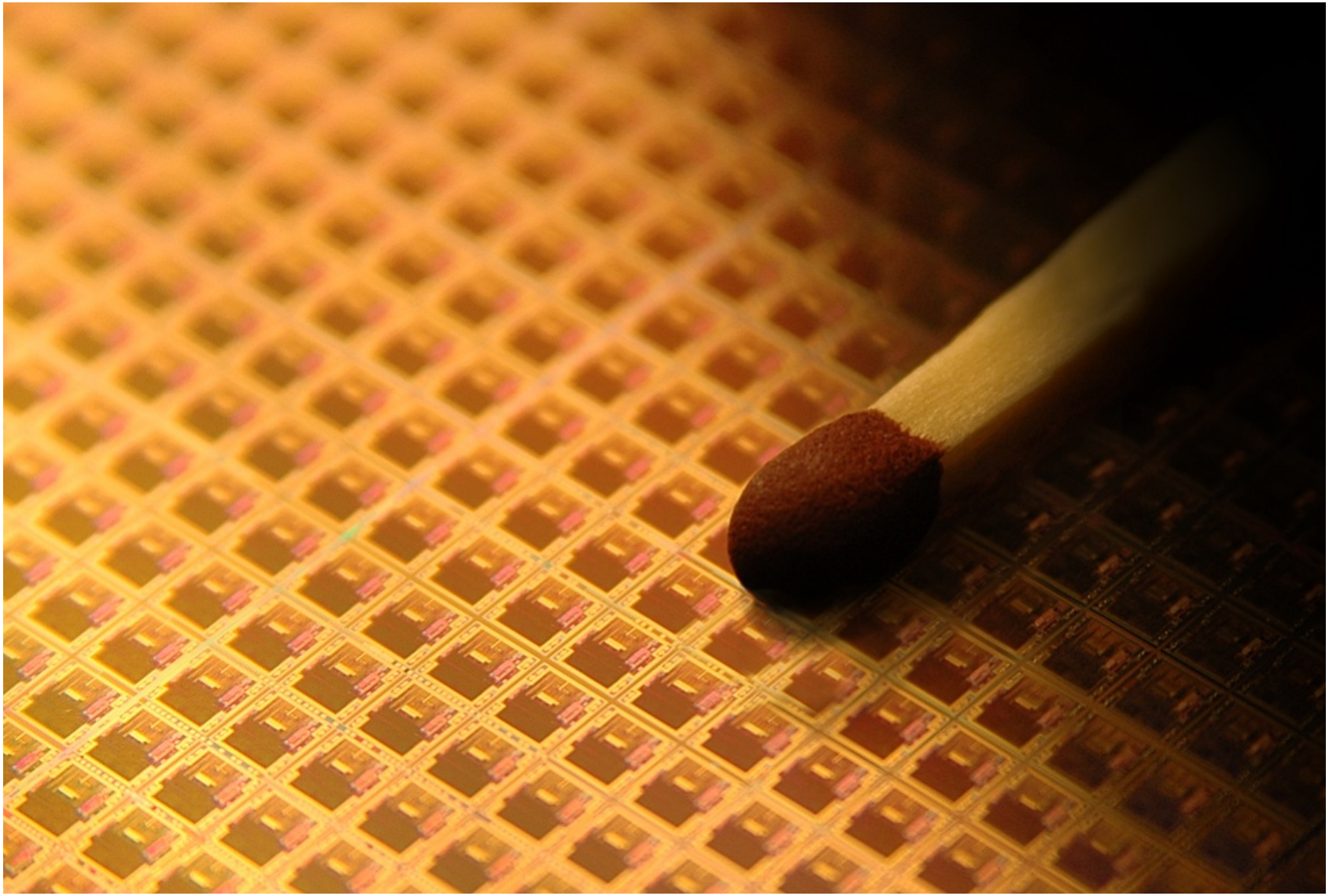
- The introduction of integrated circuits led to the third generation of computers




- Mini-machines made out of logic gates


- Small scale integrated circuits

# tiny13 AVR chip



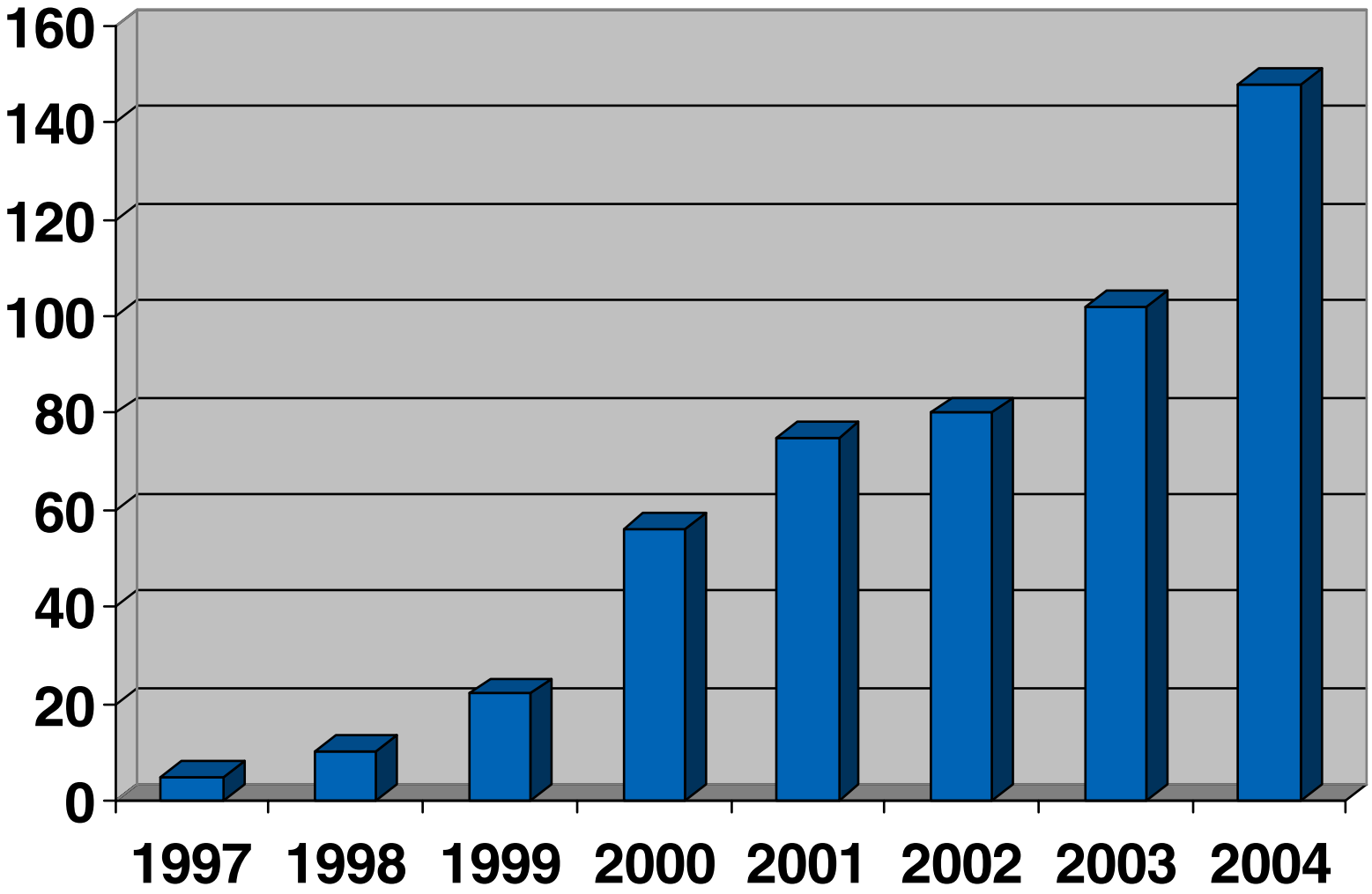
# tiny13 AVR chip

# The AVR fairy tale

how the west was won and how we got there


ATMEL
NORTH AMERICA
EUROPE
ASIA
AFRICA
SOUTH AMERICA
AUSTRALIA
NORTH ATLANTIC OCEAN
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
PACIFIC OCEAN
GREENLAND
ARCTIC OCEAN
SAHARA
ANDES
MID-ATLANTIC RIDGE
SOUTHWEST INDIAN RIDGE
SOUTHEAST INDIAN RIDGE
MEDITERRANEAN SEA
CARIBBEAN SEA
ARABIAN SEA
SOUTH CHINA SEA
INDONESIA

# AVR Standard Product Revenues



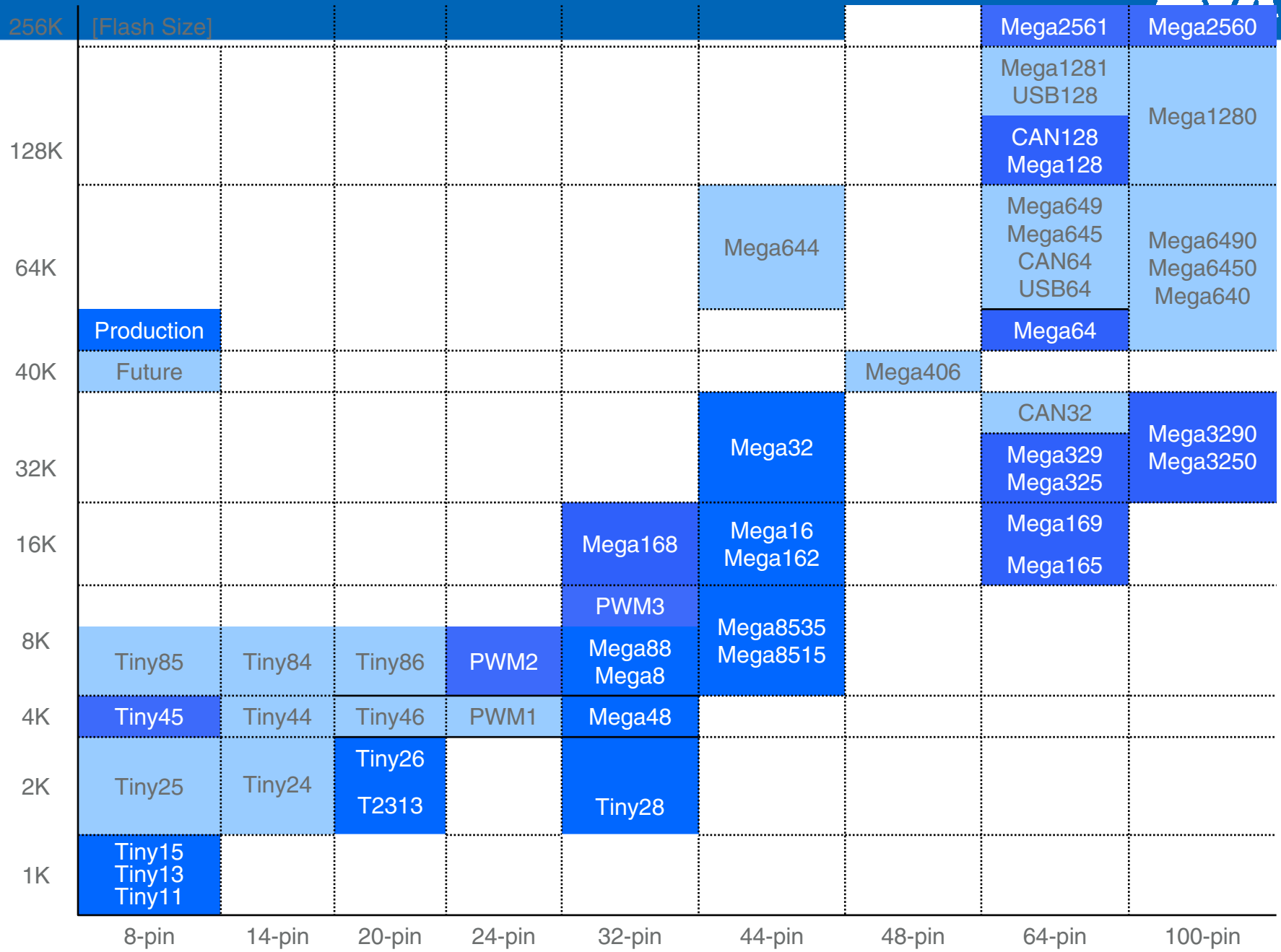
# Atmel Norway AS - today

- 120 employees in Trondheim
- 50  employees abroad
- 35 products in production
- 12.000.000 chips/month
- 4.5 chips pr. second
- Own 100% by Atmel Corp
  - Nasdaq: ATML

# Key AVR Features – the sales pitch

- Flash and EEPROM, both in-system programmable
- Highest performance, low power 8-bit MCU
- Excellent code density in C and assembly
- A broad family of MCUs - 1K to 256K Bytes flash
- High integration

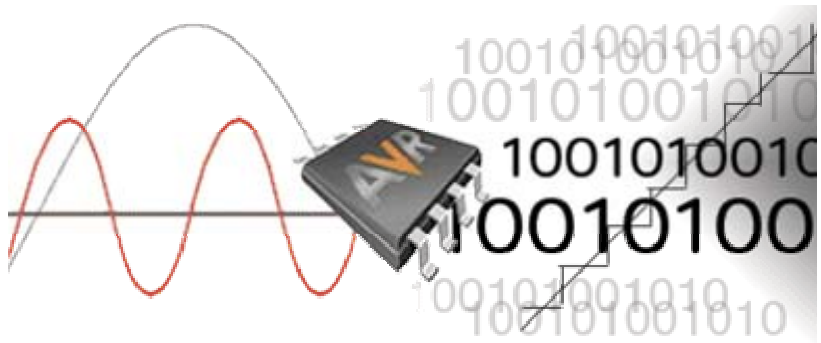



256K
[Flash Size]
128K
64K
40K
32K
16K
8K
4K
2K
1K
Mega2561
Mega2560
Mega1281
USB128
CAN128
Mega128
Mega1280
Mega644
Mega649
Mega645
CAN64
USB64
Mega64
Mega6490
Mega6450
Mega640
Production
Future
Mega406
CAN32
Mega32
Mega329
Mega325
Mega3290
Mega3250
Mega168
Mega16
Mega162
Mega169
Mega165
PWM3
Mega8535
Mega8515
Tiny85
Tiny84
Tiny86
PWM2
Mega88
Mega8
Tiny45
Tiny44
Tiny46
PWM1
Mega48
Tiny26
Tiny25
Tiny24
T2313
Tiny28
Tiny15
Tiny13
Tiny11
8-pin
14-pin
20-pin
24-pin
32-pin
44-pin
48-pin
64-pin
100-pin

# 8-Pin Family Details

- Tiny25/45/85
  - Three Pin and fuctionally compatible devices
  - 4-channel 10-bit ADC
    - Differential channels with 10/20X Gain
  - High frequency (200 KHz) 8-bit PWM
  - Pin-change interrupt on all I/O-pins
  - Low power consumption
    - 100 nA power down mode
  - debugWIRE On-chip Debug
- Tiny13
  - Pin compatible with Tiny25/45/85
  - 4-channel 10-bit A/D
  - Pin-change interrupt on all I/O pins
  - Low power consumption
  - 100 nA power down mode
  - debugWIRE On-chip Debug

| Device | Flash | RAM | EEprom |
|---|---|---|---|
| Tiny13 | 1K | 64 | 64 |
| *Tiny25* | *2K* | *128* | *128* |
| Tiny45 | 4K | 256 | 256 |
| *Tiny85* | *8K* | *512* | *512* |



# 14-pin family highlights

- Pin/Functionally compatible devices
- 8-channel 10-bit ADC
  - 7 Differential channels with 1/8/20X Gain
- Pin-change interrupt on all I/O-pins
- Low power consumption
  - 100 nA power down mode
  - 1.8 to 5.5 volt operation
- Internal 8 MHz RC oscillator
- debugWIRE On-chip Debug

| Device | Flash | RAM | EEprom |
|---|---|---|---|
| *Tiny24* | *2K* | *128* | *128* |
| *Tiny44* | *4K* | *256* | *256* |
| *Tiny84* | *8K* | *512* | *512* |

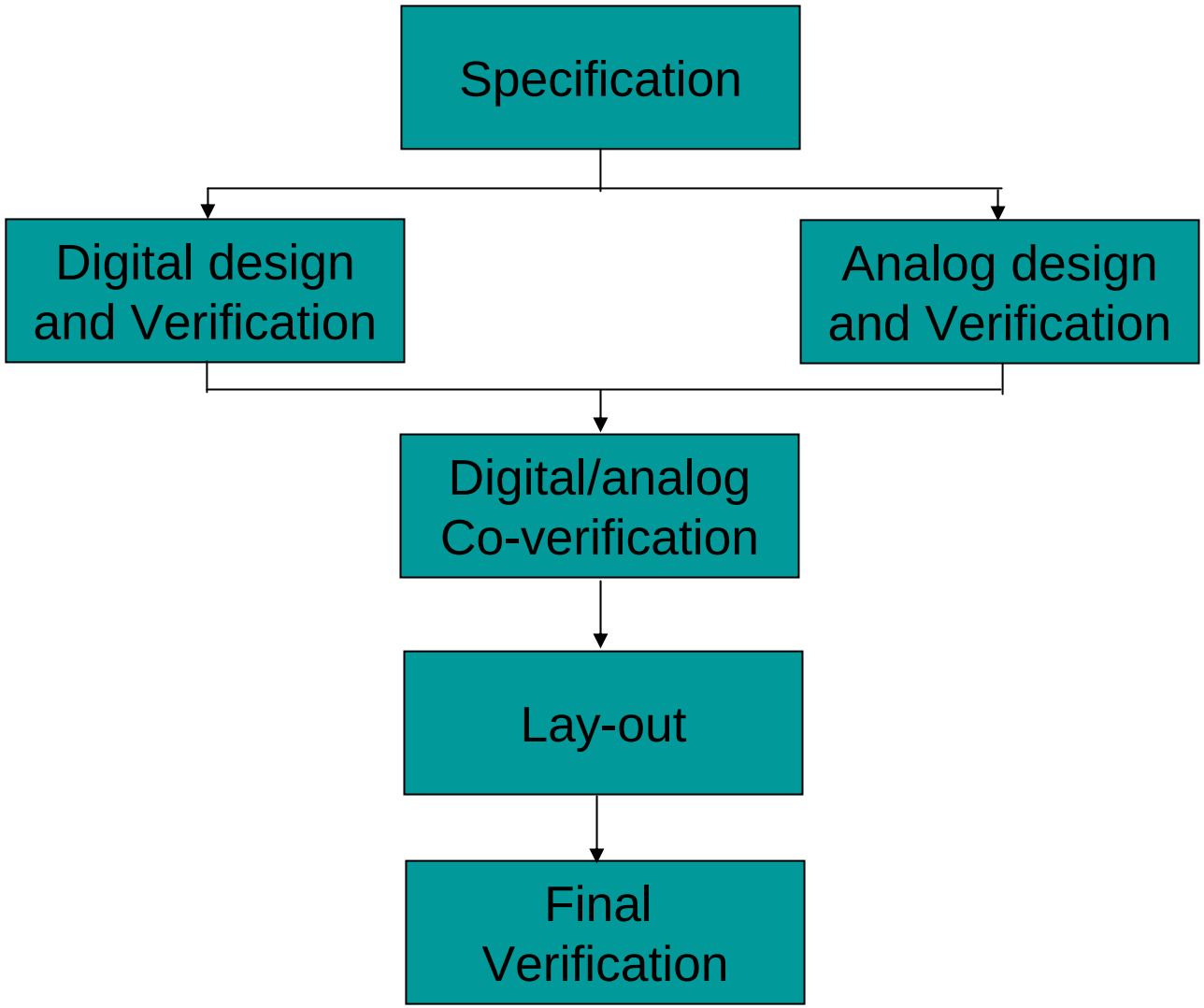
# 20-pin family

- Tiny26/46/86
  - 11-channel 10-bit A/D
    - Differential Channels with 10/20X gain
  - High frequency (200 KHz) PWM
  - Debugwire On-Chip Debug (Tiny45/85)
  - 8 MHz Internal RC
- Tiny2313
  - Hardware USART
  - Interrupt on pin-change on all I/O
  - USI gives hardware support for SPI/TWI
  - Low power consumption
    - 100 nA Power down mode
  - DebugWIRE On-Chip Debug

| Device | Flash | RAM | EE | VCC |
|---|---|---|---|---|
| Tiny26 | 2K | 128 | 128 | 2.7 – 5.5V |
| *Tiny46* | *4K* | *256* | *256* | *1.8 – 5.5V* |
| *Tiny86* | *8K* | *512* | *512* | *1.8 – 5.5V* |
| Tiny2313 | 2K | 128 | 128 | 1.8 – 5.5V |

# The Development of an AVR Microcontroller

# Developing a Microcontroller



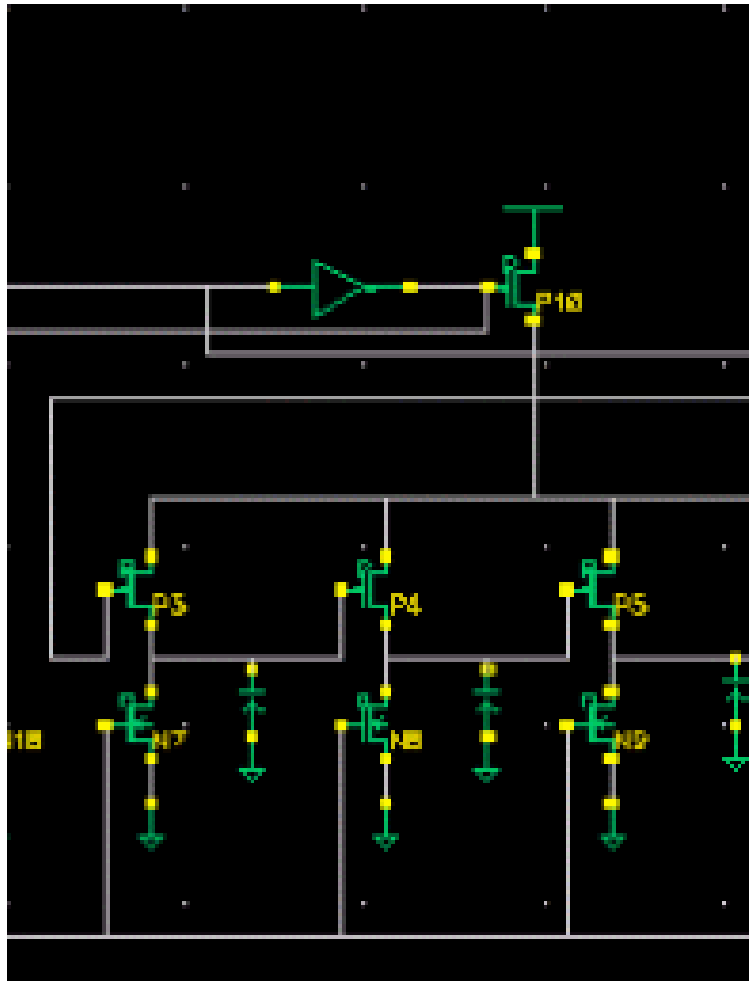
- CPU, Interrupt Controller, DMA, Peripheral Functions etc.
- Developed in HDL (Verilog)
- Verification on HDL model
- Module Reuse and Improvement
- IP Modules
- HDL synthesis

- Verilog Example:

```
always @ ( posedge clk )
  begin  // Register write
    if((adr==UCSRB_adr)&iowe)
        begin
          rxcie <= `DD dbus[7];
          txcie <= `DD dbus[6];
          udrie <= `DD dbus[5];
          rxen  <= `DD dbus[4];
          txen  <= `DD dbus[3];
          chr9  <= `DD dbus[2];
        end
  end
```

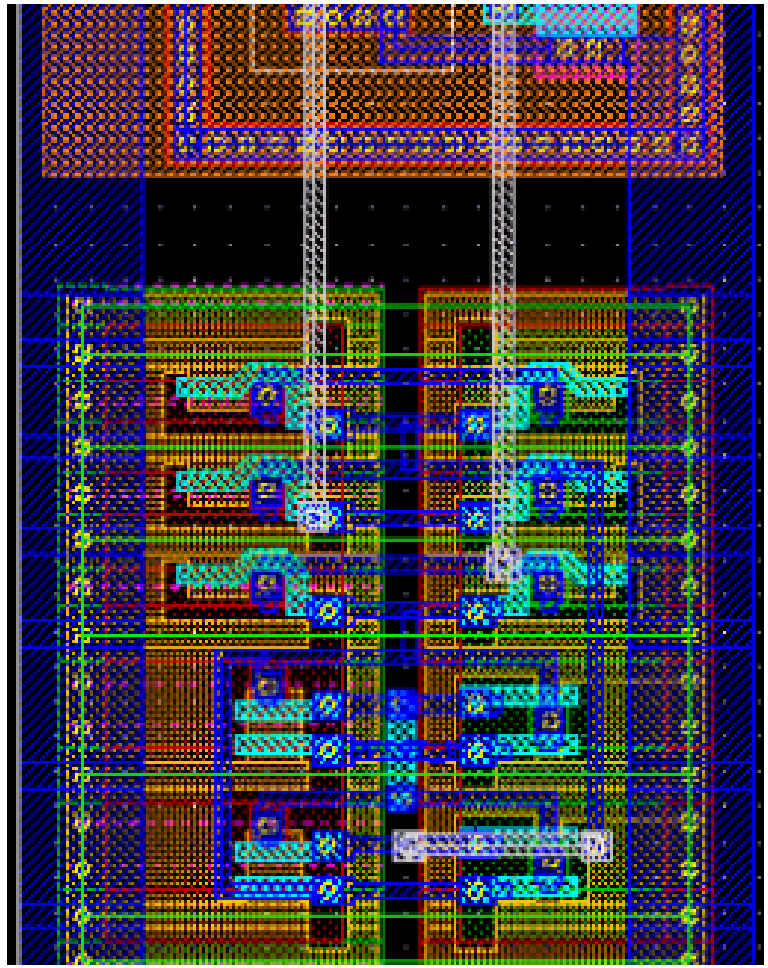
# Analog Design

- Memories, ADCs, DACs, Regulators, Oscillators, PADs, etc.
- Analog modules implemented as schematic drawings
- Digital Interfaces
- IP Modules
- Process shrink (libraries) 0.35µ, 0.25µ, 0.18µ, 0.13µ

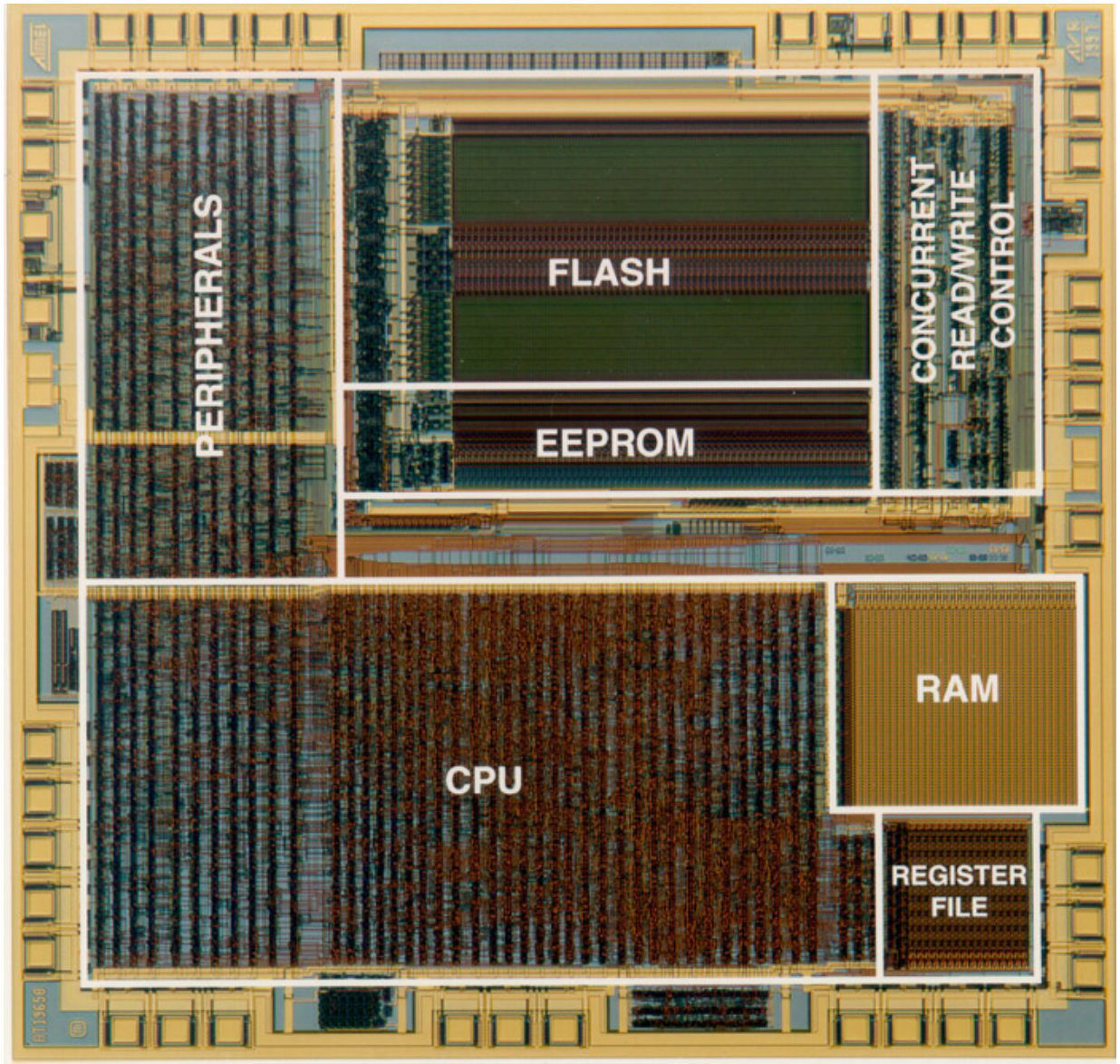


# Lay Out

- The Digital Design has been synthesized to a low level representation
- The Digital Design has to be merged with the Analog Design
- The Lay Out must meet performance and size constraints

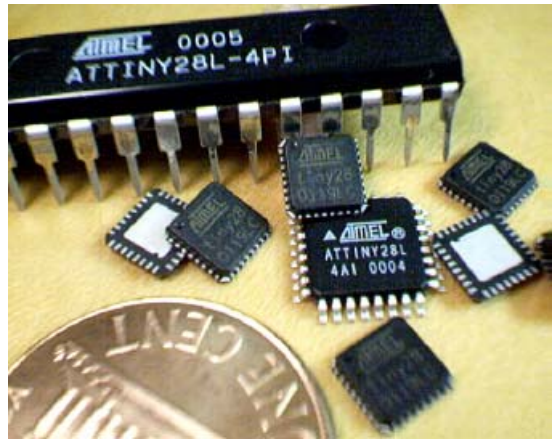


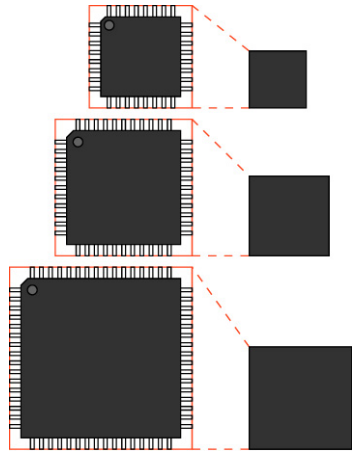
# Silicon Die


PERIPHERALS
FLASH
CONCURRENT READ/WRITE CONTROL
EEPROM
CPU
RAM
REGISTER FILE

# Packaging

- Die
  - All devices available in Die Form
- Micro Lead Frame Packaging
  - Low cost package technology
  - Very good noise immunity substrate connected to ground
  - Smallest standard package available
  - Near chip-scale package size; Save up to 69% of board space



| TQFP size | MLF size | TQFP area | MLF area | |
|---|---|---|---|---|
| 9 x 9 | 5 x 5 | 81 | 25 | 31 % |
| 12 x 12 | 7 x 7 | 144 | 49 | 34 % |
| 16 x 16 | 9 x 9 | 256 | 81 | 32 % |

Size in millimeters  Area in $mm^2$

The future

# Trends into the future

- Shrink
  - Size decrease will continue
  - Lower production cost and end user price
- Lower power
  - Today 1.8V operation
    - 1 Li cell or 2 AA/AAA batteries to run
  - 0.9V technology will be introduced
    - 1 AA/AAA battery to run
- On-chip debug
  - The end of expensive in-circuit emulators
- Open source
  - Linux OS
  - User interaction. www.avrfreaks.net