



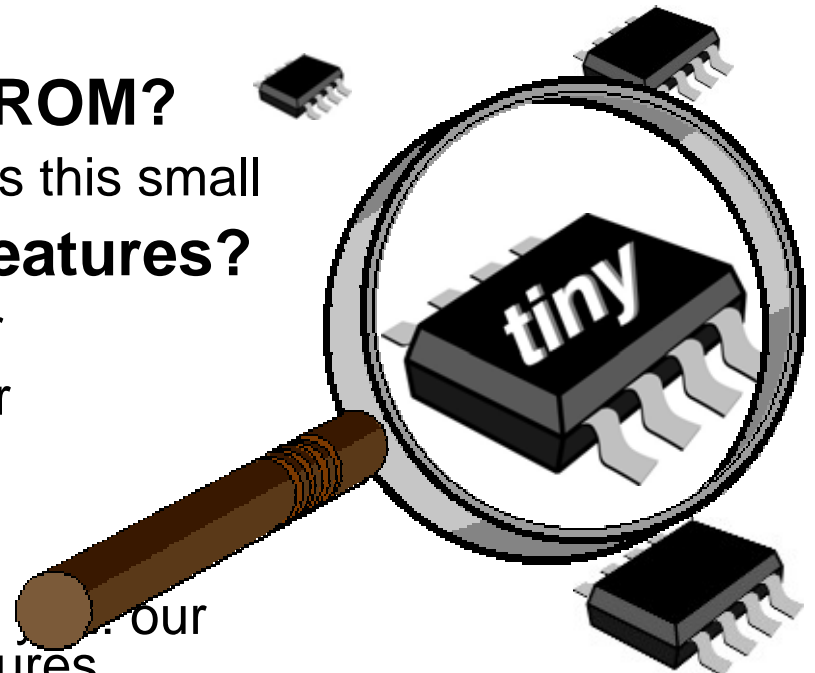
# AVR<sup>®</sup>

## tinyAVR Overview

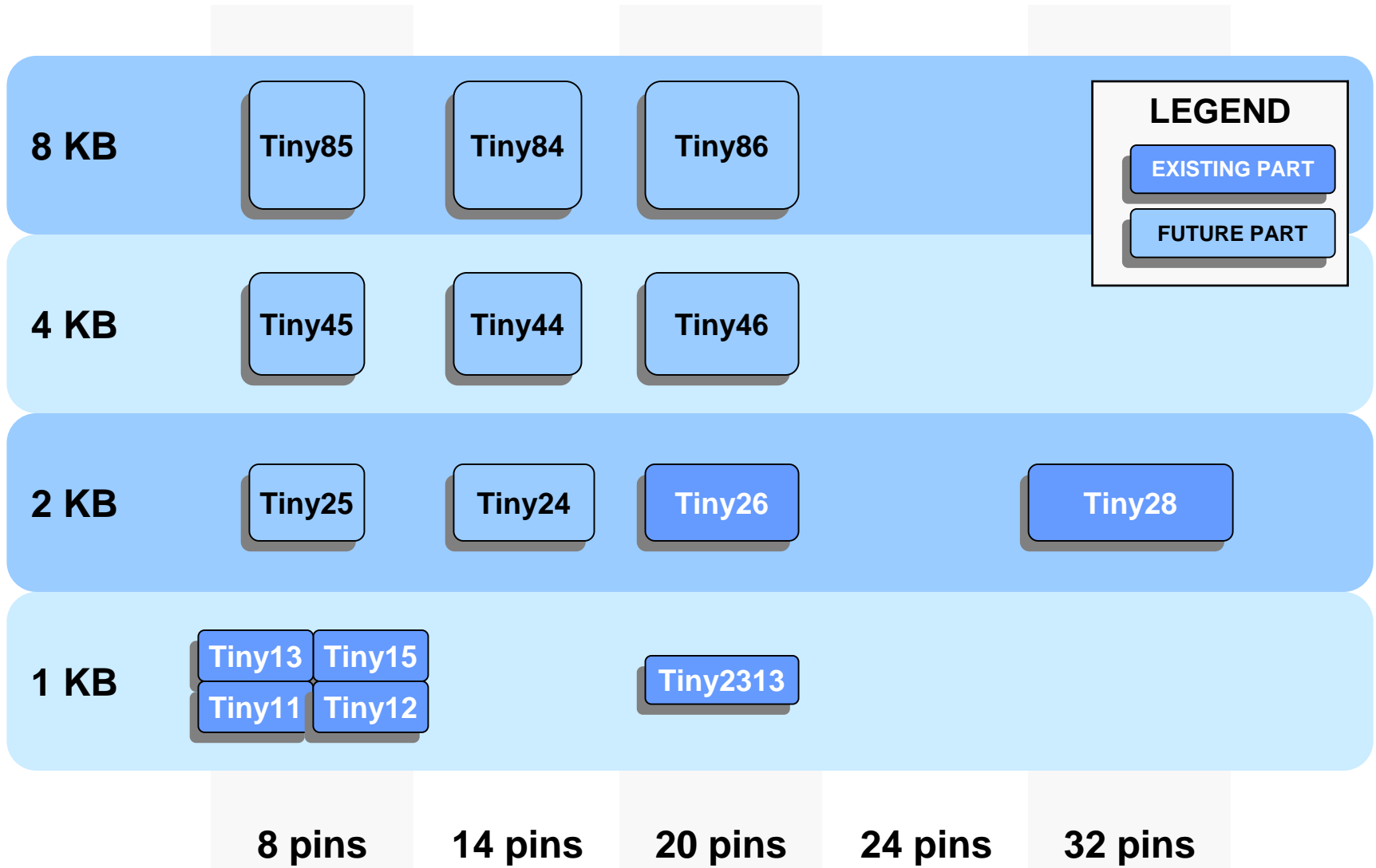


- **What is a tinyAVR?**
- **Past, present and future**
- **Standard peripherals**
- **New features**
- **ATtiny13**
- **ATtiny2313**
- **ATtiny25/45/85**
- **ATtiny24/44/84**
- **ATtiny26/46/86**

- **Does it have a low pin count?**
  - 8, 14, and 20 pins, typically (but 32-pin devices have been spotted)
- **Does it have a small memory size?**
  - 1, 2, 4, or 8 KB FLASH
- **Does it come with an EEPROM?**
  - Not usually included in devices this small
- **Does it have any special features?**
  - Single-wire, on-chip debugger
  - Integrated temperature sensor
  - PLL-driven, high-speed PWM
- **Does it kick butt?**
  - Don't let the size or name fool you...our tinyAVRs are loaded with features



- **1999: First tinyAVR sees daylight**
  - ATtiny11
    - No SRAM
    - No EEPROM
- **2000: Three more tinyAVRs**
  - ATtiny28
  - ATtiny12 & ATtiny15
    - With EEPROM
- **2002: One more**
  - ATtiny26
    - With EEPROM & SRAM
- **2004: Now going into production**
  - ATtiny13 and ATtiny2313



# Tiny Features

- **Common Features**

- 8-bit or 16-bit
- Each timer/counter has a separate prescaler
- May be clocked from internal or external source
- Double-buffered compare units with interrupt & auto reload
- Waveform generators with two PWM outputs, each

- **In Selected Devices**

- High-speed 8-bit
- Clocked from internal PLL
- User-adjustable dead-time generation



- **Common Features**

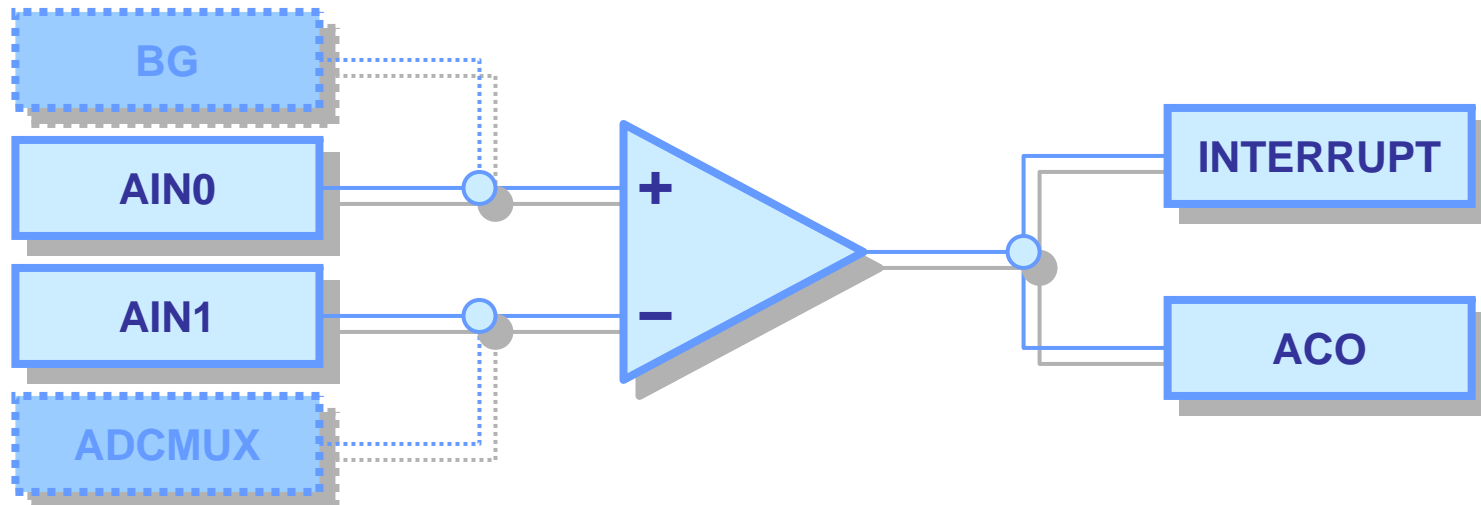
- 15 kSPS @ 10 bit
- INL: 0.5 LSB. Absolute (OS+G+D+NL+Q):  $\pm 2$  LSB
- Free-running / interrupt (AC, TCCMA, TCCMB, TCOPCI, Ext)
- X-channel MUX (Y single-ended or Z differential channels)
- Unipolar operating mode (1...1023)
- Reference voltage  $V_{cc}$

- **In Selected Devices**

- Programmable gain (1x or 20x)
- Bipolar (-512...+511) operating mode
- Input polarity reversal mode
- Internal reference voltages of 1.1 V and/or 2.56 V
- Temperature measurement from built-in sensor
- Digital input disable



- **Common Features**
  - Fast processing of analogue signals
  - Two external inputs
  - Synchronised output
  - Interrupt on rise, fall or toggle
- **In Selected Devices**
  - Digital input disable
  - Alternative inputs from BG and/or ADCMUX

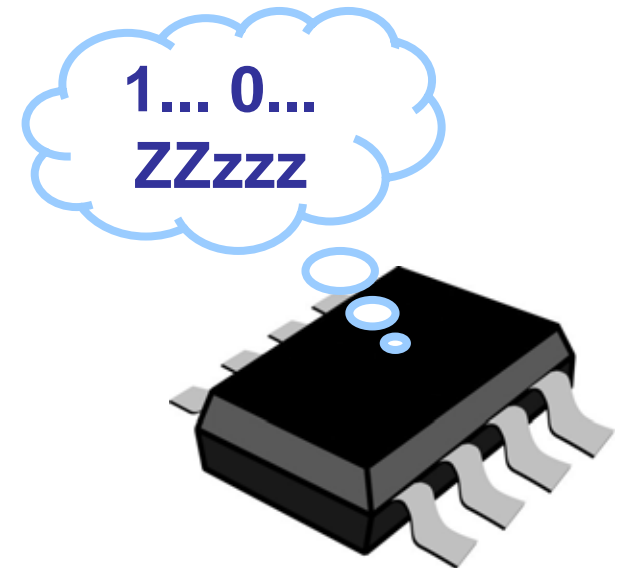


- **Common Features**

- Conserve power by shutting down unused modules
- Idle mode
  - CPU stopped
  - Wakeup: INT0, PCI, SPM/EEPROM, Other I/O, WD
- Power-down mode
  - All generated clocks stopped
  - Wakeup: INT0, PCI, WD

- **In Selected Devices**

- ADC Noise Reduction mode
  - CPU stopped but ADC running
  - Wakeup: INT0, PCI, SPM/EEPROM, WD
- Standby mode
  - As Power-down, but with oscillator running
  - Fast wake-up (six clock cycles)

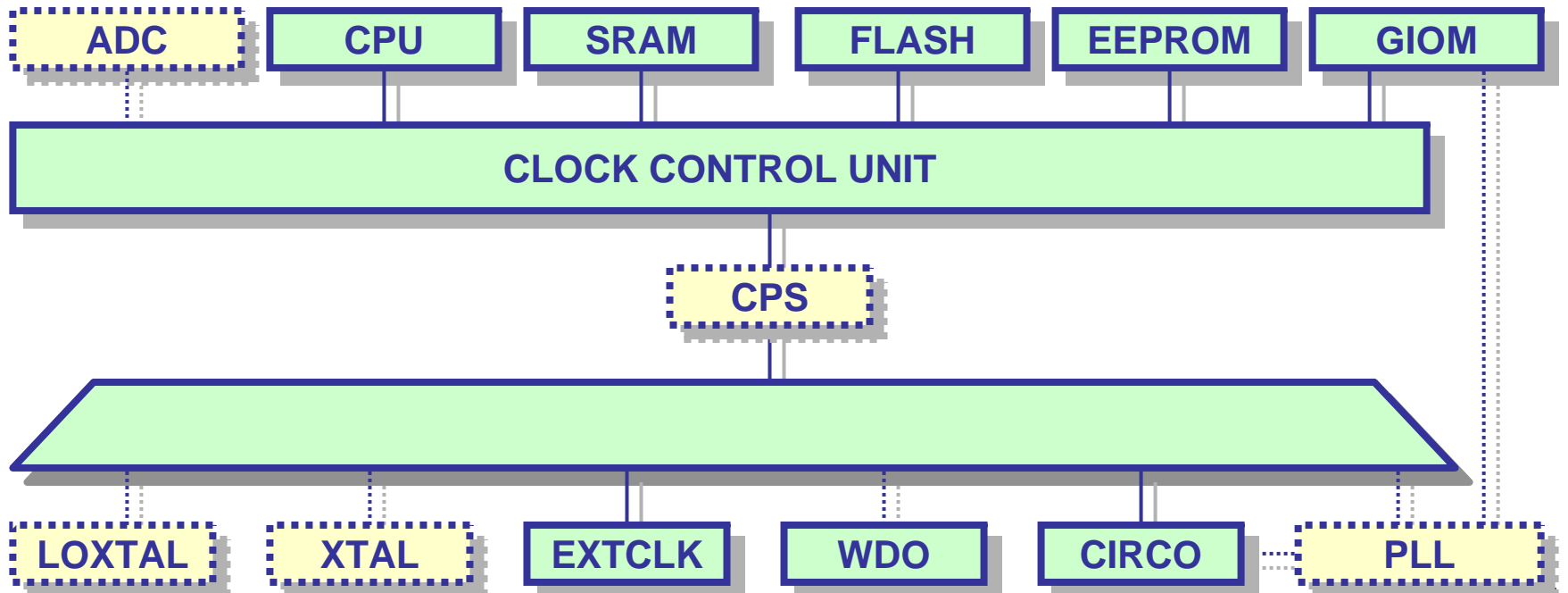


- **Common Features**

- Internal osc.
- External source

- **In Selected Devices**

- CKDIV8 fuse
- Prescaler
- 128 kHz WD oscillator
- External crystal
- Internal PLL



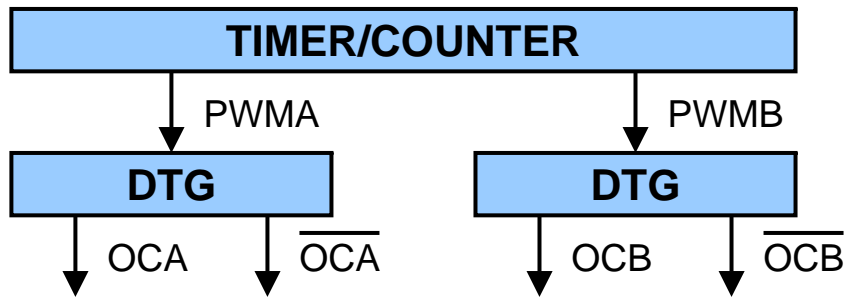
- **In Selected Devices: USI**
  - Three-wire mode: SPI (master or slave)
  - Two-wire mode: TWI (i.e. Inter IC)
  - UART (half-duplex)
  - Can also be used as additional, 4-bit counter
  - Or, as an external interrupt
- **In Selected Devices: USART**
  - Full duplex operation
  - Synchronous or asynchronous
  - Master or slave
  - Programmable data bits, stop bits and parity settings
  - Data overrun and framing error detectors
  - Multi-processor communication mode



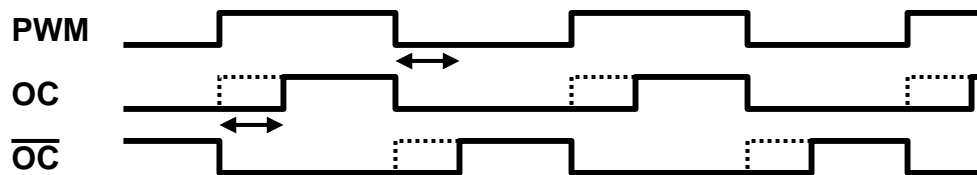
- **High-frequency clock signal from source**
  - PLL clock locked to reference frequency
  - Reference may drift
  - PLL saturates at high limit
- **Peripheral clock frequency other than system clock**
  - For example:  $8 \times 8 \text{ MHz} = 64 \text{ MHz}$
  - Peripherals can run faster than system core
  - 64 MHz peripheral clock allows 8-bit PWM at 250 kHz
- **PLL clock can also be used as system clock**
  - Typically scaled down by a factor of four
  - Careless use may result in overclocking the device
- **In selected devices, only**
  - ATtiny25/45/85
  - ATtiny26/46/86



- Inserts non-overlapping times for PWM output
- Two DTGs, physically separate from timer/counter



- Programmable counters delay PWM transitions



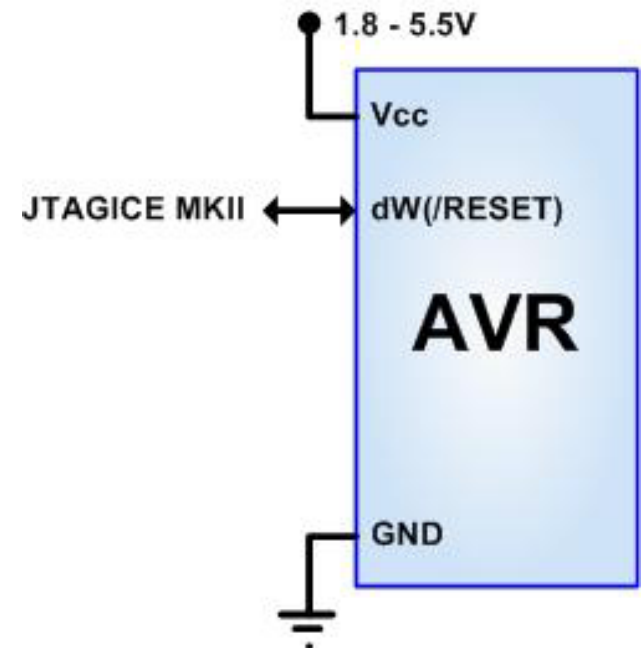
- Available in ATtiny25/45/85 family



- **Runs from separate, 128 kHz internal RC oscillator**
- **Reset interval controlled by programmable prescaler**
- **Programmable action on time-out**
  - Device reset
  - Watchdog interrupt
- **Watchdog interrupt gives new functionality**
  - Wake up from power down without reset
  - General system timer
- **Typical time-out periods range from 16 ms to 8 s**
- **In selected devices, only**
  - All new tiny devices, except ATtiny26/46/86



- **Single-Wire, On-Chip Debugging**
  - Reset pin used as one-wire, bi-directional interface
  - All other pins available during debugging
- **All AVR resources available while debugging**
  - Except reset pin, of course
- **Fast communication**
  - 4 KB @ 1 MHz in about one second
- **Available in all new tinyAVRs:**
  - Tiny13, Tiny2313
  - Tiny25/45/85
  - Tiny24/44/84
  - Tiny26/46/86



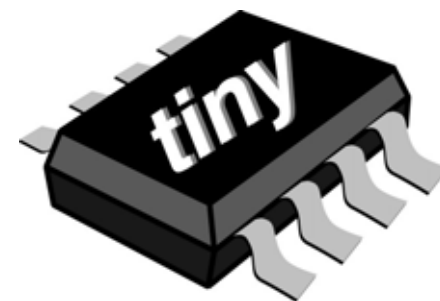


- **Low end temperature measurement**
- **One ADC channel routed to internal sensor**
  - 10-bit reading, effective signal range 250...350
- **Accuracy (PRELIMINARY):**
  - Not calibrated: 10 degrees C
  - One-point calibration: 5 degrees C
  - Two-point calibration: 2 degrees C
  - Linearity within one degree
- **Applications:**
  - Dynamic calibration of internal oscillator vs. temperature
  - Temperature-controlled applications, like fan control
- **Temperature range of sensor exceeds that of the MCU**
- **Available in all new tinyAVRs (starting from T25/T45/T85)**



# Tiny Devices

- **Going into production NOW**
- **Small, 8-pin package - packed with features**
  - Enhanced watchdog timer
    - Interrupt and/or reset
  - debugWIRE
    - On-chip debug system
  - Six programmable i/o lines
    - Pin change interrupt on all i/o pins
  - 8-bit Timer/Counter
    - Prescaler and compare
    - Two PWM outputs
  - 10-bit ADC
    - Four single-ended channels
  - Internal oscillators
    - Programmable prescaler
- **High Performance**
  - 4 MHz @ 1.8 V
  - 20 MHz @ 4.5 V



## AVAILABLE NOW

Device	Flash	RAM	E <sup>2</sup>	Prod.
Tiny13	1 K	64	64	NOW

1 KB FLASH	64 B SRAM	64 B EEPROM	ISP	debug WIRE	
4.8/9.6 MHz OSC	128 kHz OSC	<b>AVR<sup>®</sup></b> <b>CORE</b>	8-bit T/C	2 PWM Channels	
4-channel ADC	Clock Prescaler		6-Input PCI	6 I/O Lines	
Analogue Comparator	Enhanced Watchdog		Progr. BOD	Enhanced POR	
Power Manag.	10 MHz @ 1.8...5.5 V		20 MHz @ 4.5...5.5 V	-40...+85°C	240 µA @ 1.8 V, 1 MHz

**And all this in a tiny 8-pin package!**

- **Printer cartridge**
  - Handshake and ink control
- **Secure EEPROM**
  - Replace stand-alone EEPROM with secure AVR
- **Simple battery charger**
  - Winning Features:
    - ADC: provides required accuracy
    - EEPROM: Calibration data and battery history
    - Enhanced watchdog: Inexpensive wake-up timer
- **Toilet seat**
  - Water and seat heater control
  - Winning features:
    - T/C: turns off heater
    - ADC: temperature control
    - Internal RC: high resolution + prescaler
    - Tools: low cost development



- **debugWIRE**
  - Unparalleled feature
- **EEPROM**
  - Usually not provided in this device range
- **Size**
  - Competition low, but ramping up
- **ADC**
- **Price**

Competitors (closest match)

Corp	Device	Flash	RAM	E <sup>2</sup>	ADC	Pins
Atmel	ATtiny13	1024	64	64	4 x 10-bit	8
Freescale	68HC908QT2	1536	128	-	4 x 8-bit	8
Microchip	PIC12F675	1792	64	128	4 x 10-bit	8
Renesas	R5F21102	8192	512	-	8 x 10-bit	32
TI	MSP430F1122	1024	128	-	5 x 10-bit	20

- **Now sampling**
- **20-pin package - packed with features**
  - Enhanced watchdog timer
    - Interrupt or reset
  - debugWIRE
    - On-chip debug system
  - 18 programmable i/o lines
    - Pin change interrupt on 8 pins
  - 8-bit & 16-bit timer/counters
    - Separate prescalers
    - Four PWM channels
  - USI & USART
  - Internal RC oscillators
    - 128 kHz and 4/8 Mhz
- **High Performance**
  - 4 MHz @ 1.8 V
  - 20 MHz @ 4.5 V



## NOW SAMPLING

Device	Flash	RAM	E <sup>2</sup>	Prod.
Tiny2313	2 K	128	128	Q4/2004

4/8 MHz OSC	ISP	debug WIRE	USI	USART
128 kHz OSC	2 KB FLASH	128 B SRAM	128 B EEPROM	4 PWM Channels
CKDIV8	Analogue Comparator	<b>AVR<sup>®</sup></b> CORE	8-bit T/C	16-bit T/C
Enhanced Watchdog	18 I/O Lines	8-Input PCI	Progr. BOD	Enhanced POR
Power Manag.	10 MHz @ 1.8...5.5 V	20 MHz @ 4.5...5.5 V	-40...+85°C	230 µA @ 1.8 V, 1 MHz

**All fitted in a 20-pin package!**



- **Cost saving upgrade for AT90S1200 & AT90S2313**
- **Improved features:**
  - Lower operating voltage (2.7 V >> 1.8 V)
  - Lower power consumption (230  $\mu$ A @ 1 MHz & 1.8 V)
  - Three more i/o lines (now a total of 18)
  - Watchdog now has interrupt (wake-up without reset)
  - Flash memory now self-programmable
  - 8-bit timer/counter now has PWM output
- **New features not present in old device:**
  - Integrated BOD
  - Integrated RC oscillator, dynamically prescaled by software
  - Pin change interrupt with wake-up on 8 pins
  - USI for TWI/SPI
  - debugWIRE
  - Additional 16-bit timer/counter with PWM output



- **Universal TV remote control**
- **One PCB for 500 models**
- **Personalisation over ISP**
  - Needs to manufacture and store only one product
  - Final adjustments to Flash, EEPROM and KB sticker, only
  - Customisation is quick and done using 5 pins, only
- **Winning features:**
  - Low Power
    - Only two AA batteries required (was: four)
  - ISP
    - Programming of Flash and EEPROM
  - Two T/C
    - Simplifies firmware
    - For carrier and protocol generation

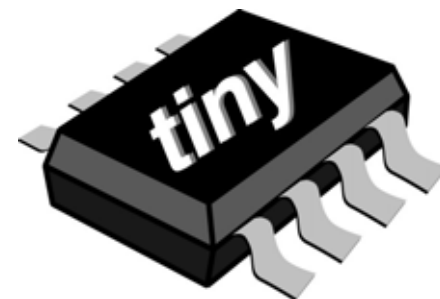


- **debugWIRE**
  - Unparalleled feature
- **EEPROM**
  - Usually not provided in this device range
- **USI**
  - Flexible interface module fits many applications

Competitors (closest match)


Corp	Device	Flash	RAM	E <sup>2</sup>	I/O	Pins
Atmel	ATtiny2313	2048	128	128	18	20
Freescale	MC68HRC98JK3	4096	128	-	15	20
Microchip	PIC16F818	1792	128	128	16	18
Renesas	R5F21102	8192	512	-	22	32
TI	MSP430F1111	2048	128	-	14	20

- **Subfamily of pin and functionally compatible devices**
- **Small, 8-pin package - packed with features**
  - Enhanced watchdog timer
    - Interrupt or reset
  - debugWIRE
    - On-chip debug system
  - Six programmable i/o lines
    - Pin change interrupt on all pins
  - Two 8-bit Timer/Counters
    - Normal + high-speed
  - 10-bit ADC
    - Integrated temperature sensor
    - Programmable gain
  - Universal Serial Interface
  - Internal RC oscillator
    - Programmable prescaler
- **High Performance**
  - 4MHz @ 1.8 V
  - 20 MHz @ 4.5 V



## COMING SOON

Device	Flash	RAM	E <sup>2</sup>	Prod.
Tiny25	2 K	128	128	Q2/2005
Tiny45	4 K	256	256	Q2/2005
Tiny85	8 K	512	512	Q2/2005

6.4/8 MHz OSC	ISP	debug WIRE	USI	ATtiny15 Mode
128 kHz OSC	2...8 KB FLASH	128...512 B SRAM	128...512 B EEPROM	DTG
Clock Prescaler	Temperature Sensor		PLL	4 PWM Channels
4-channel Bipolar ADC	Analogue Comparator		High-Speed 8-bit T/C	8-bit T/C
Enhanced Watchdog	6 I/O Lines	6-Input PCI	Progr. BOD	Enhanced POR
Power Manag.	TBD MHz @ 1.8...5.5 V	16 MHz @ 4.5...5.5 V	-40...+85°C	230 µA @ 1.8 V, 1 MHz

**Would you believe all this in an 8-pin package?!**

## Battery chargers and monitors

- **Winning features:**

- Flash
  - Enough to implement most functions
- ADC
  - 10-bit ADC + PGA provide required accuracy
  - Bipolar mode suited for polarity checking
- EEPROM
  - Storage for calibration data and battery history
- Fast PWM
  - Allows charge control at frequencies up to 250 kHz
  - Can use smaller and less expensive external inductors
- Enhanced watchdog
  - Allows inexpensive wake-up timer



## Fluorescent lamp ballast & dimmers

- **Winning features:**
  - 10-bit ADC + PGA
    - Accurate monitoring of voltages & current
  - Analogue comparator
    - Fast-action monitoring of safe operating limits
  - Fast PWM output
    - Controlling warm-up, striking and normal operation



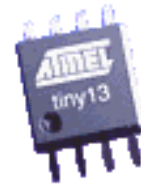
## Replacement for Tiny15

- Pin and functionally compatible replacement
- Enhanced functionality over Tiny15



## Migration path for Tiny13

- Pin compatible devices



## Motor control

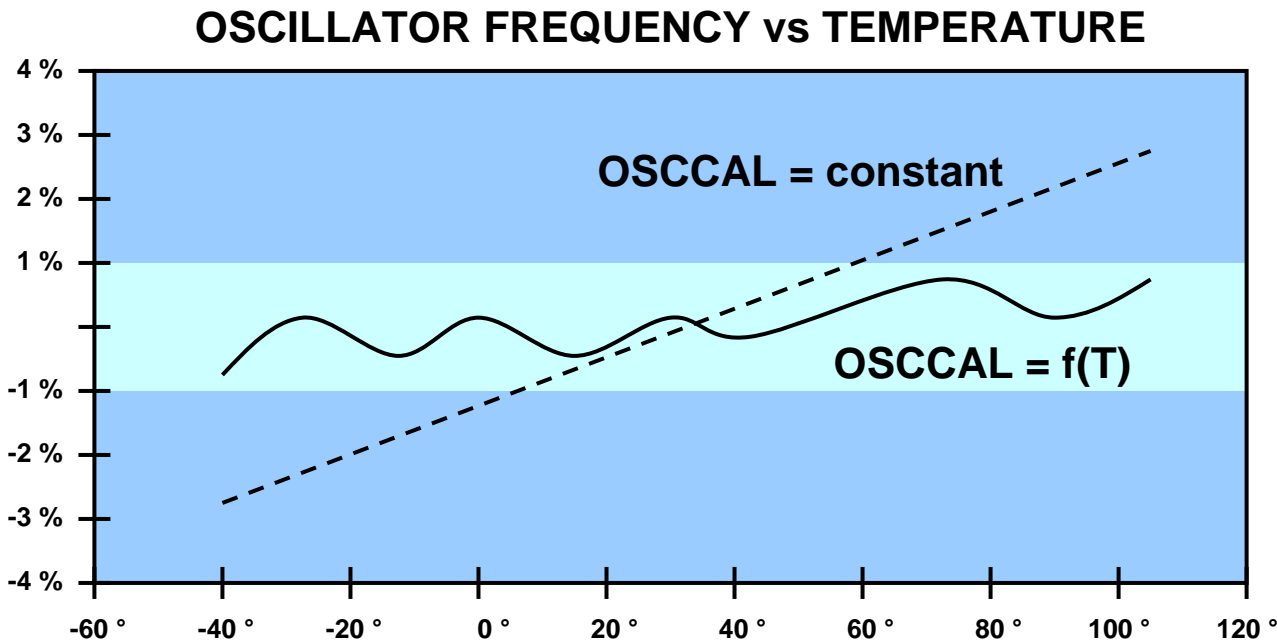
- Fan controller: rotational speed vs. temperature
- **Winning features:**
  - Integrated temperature sensor
  - Small size
  - Low cost
- **AVR441: Brushless DC motor control for fans**





## Dynamic Calibration of Internal RC Oscillator

- Oscillator frequency depends on temperature
- Adjust OSCCAL according to temperature
- Reduces temperature dependency of internal oscillator to below 1%





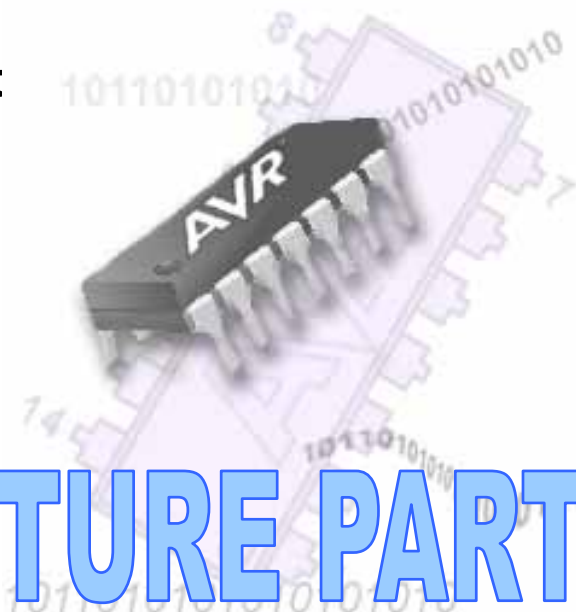
# ATtiny25/45/85 Competitive Advantages

- Low pin count, yet feature rich
- Integrated temperature sensor
- High-speed PWM
- debugWIRE
- Low power consumption
- EEPROM

Competitors (closest match)


Corp	Device	Flash	RAM	E <sup>2</sup>	T	8-bit PWM	Pins
Atmel	tiny25	2048	128	128	Yes	250 kHz	8
Freescale	68HC908QT4	4096	128	-	-	31 kHz	8
Microchip	PIC12F683	3584	128	256	-	78 kHz	8
Renesas	R5F21102	8192	512	-	-	-	32
TI	MSP430F1122	4096	256	-	Yes	39 kHz	20

- **Pin and functionally compatible devices**
- **Small, 14-pin package - packed with feat**
  - Enhanced watchdog timer
    - Interrupt or reset
  - debugWIRE
    - On-chip debug system
  - 12 programmable i/o lines
    - Pin change interrupt on all pins
  - 8-bit & 16-bit timer/counters
    - Four PWMs
  - 10-bit ADC
    - Programmable gain
  - Universal Serial Interface
  - Internal RC oscillator
    - Programmable prescaler
- **High performance**
  - 1MHz @ 1.8 V
  - 16 MHz @ 4.5 V



## FUTURE PART

Device	Flash	RAM	E <sup>2</sup>	Prod.
Tiny24	2 K	128	128	Q3/2005
Tiny44	4 K	256	256	Q3/2005
Tiny84	8 K	512	512	Q3/2005

8 MHz OSC	ISP	debug WIRE	2...8 KB FLASH	12 I/O Lines	
128 kHz OSC	USI		128...512 B SRAM	12-Input PCI	
Clock Prescaler	Enhanced Watchdog		128...512 B EEPROM	4 PWM Channels	
PGA 1x / 20x	8-channel Bipolar ADC		8-bit T/C	16-bit T/C	
Analogue Comparator	Temperature Sensor		Progr. BOD	Enhanced POR	
Power Manag.	10 MHz @ 1.8...5.5 V		20 MHz @ 4.5...5.5 V	-40...+85°C	TBD $\mu$ A @ 1.8 V, 1 MHz

**All this in a 14-pin package!**

## Battery chargers and monitors

- **Winning features:**
  - Flash
    - Enough to implement most functions
  - ADC
    - 10-bit ADC + PGA provide required accuracy
    - Bipolar mode suited for polarity checking
  - EEPROM
    - Storage for calibration data and battery history
  - I/O Pins
    - Larger package - more i/o pins





# ATtiny24/44/84 Competitive Advantages

- Low pin count but high I/O count
- Two timer/counters with four PWM outputs
- Low power consumption
- Differential ADC with gain
- Integrated temperature sensor
- debugWIRE
- EEPROM

Competitors (closest match)

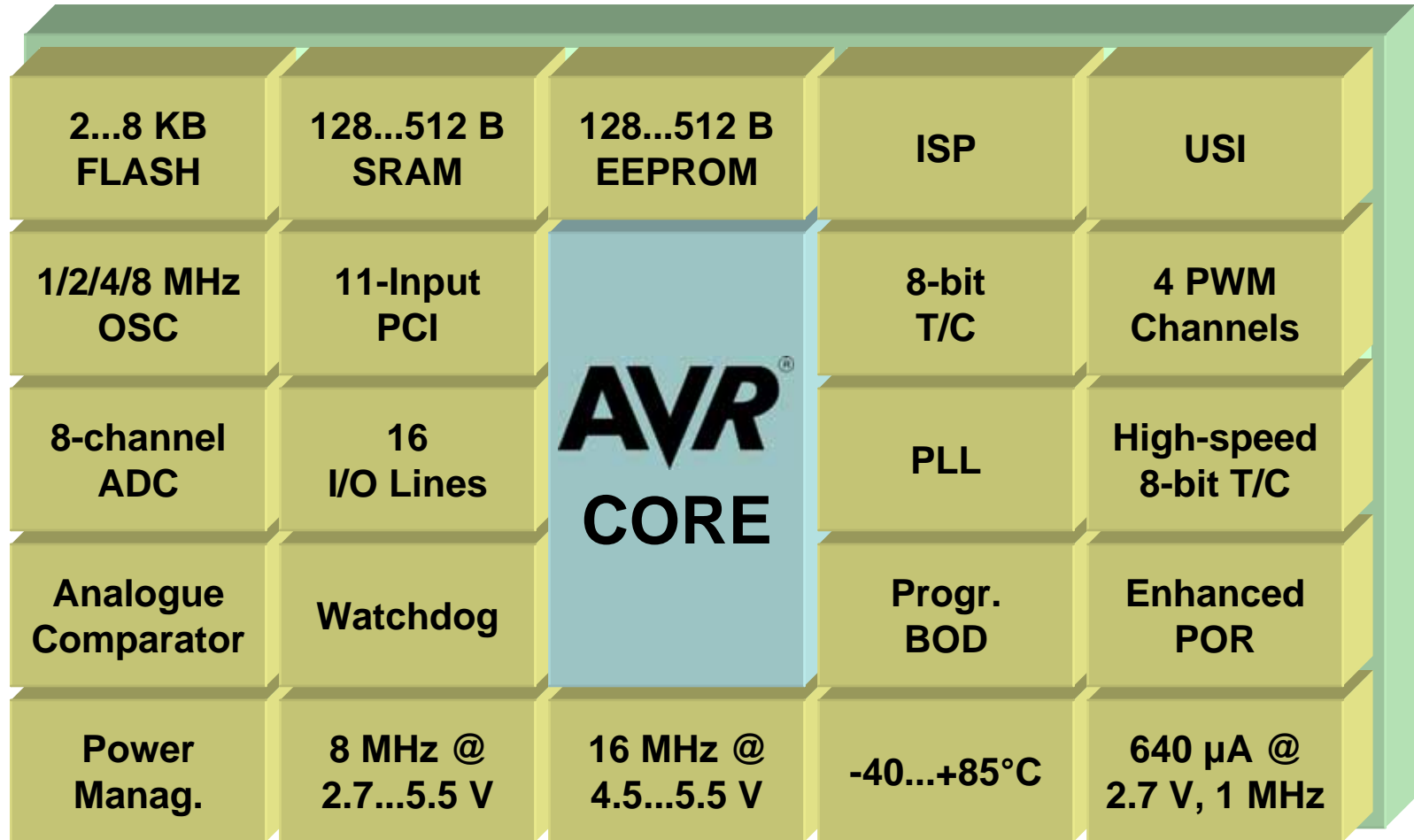
Corp	Device	Flash	RAM	E <sup>2</sup>	T	Pin s
Atmel	tiny24	2048	128	128	Yes	14
Freescale	M68HC908KX2	2048	192	-	-	16
	M68HC908QY4	4096	128	-	-	16
Microchip	PIC16F676	1792	64	128	-	14
Renesas	R5F21102	8192	512	-	-	32
TI	MSP430F1122	4096	256	-	Yes	20

- **Pin and functionally compatible devices**
- **20-pin package - packed with features**
  - 16 programmable i/o lines
    - Pin change interrupt on 11 pins
  - Two 8-bit timer/counters
    - One normal, one high-speed
    - Two + two PWM channels
  - 10-bit ADC
    - 8/11 channels
    - Programmable gain
  - Programmable BOD
  - Universal Serial Interface
  - Internal RC oscillator
    - 1/2/4/8 MHz
- **High Performance**
  - 8 MHz @ 2.7 V
  - 16 MHz @ 4.5 V



PARTLY AVAILABLE

Device	Flash	RAM	E <sup>2</sup>	Prod.
Tiny26	2 K	128	128	NOW
Tiny46	4 K	256	256	Q4/2005
Tiny86	8 K	512	512	Q4/2005



**In a small, 20-pin package!**



## Kitchen cooker

- **Cooking process and user interface**
- **Winning features:**
  - ADC: Kettle temperature control
  - BOD & internal RC: Gives minimum component count
  - Flash: Same microcontroller used for other kitchen products



## Docking station for digital camera

- **Camera charging and user interface**
- **Winning features:**
  - Flash: flexibility
  - ADC: charge monitor
  - BOD & internal RC: Minimum component count



## Smart Battery

- **Winning features:**

- Low power consumption
- ADC: Provides charging information
- Flash: Smart battery functionality
- EEPROM: Manufacturer ID and compatibility information



## Battery Charger

- **Control battery charging of power tool**

- **Winning features:**

- Flash & EEPROM
- ADC: Provides charging information
- Low power consumption



## White Goods Module

- **Add-on card for high-end white goods**
- **Main board communication over TWI**
- **Tasks:**
  - LED driver (BCD to 7-segment decoder)
  - I/O expander
- **Winning features**
  - AVR: Architecture, migration
  - Low pin count (20), but high I/O count (16)
  - Application Notes: TWI, BCD to 7-segment decoding
  - Price: Best price/performance AND absolute price on market
  - EEPROM: Storage of state and factory defaults
  - USI: TWI
  - ISP: Fast programming of device
  - Tools: IAR C
  - EMC: Outstanding (main processor by Freescale failed at 2kV)





# ATtiny26/46/86 Competitive Advantages

- **Two timer/counters with four PWM outputs**
  - One T/C with high-speed PWM
- **Low power consumption**
- **Differential ADC with gain**
- **ADC with 8/11 channels**
- **EEPROM**

Competitors (closest match)

Corp	Device	Flash	RAM	E <sup>2</sup>	Pins	ADC	8-bit PWM
Atmel	tiny26	2048	128	128	20	8 x 10-bit	250 kHz
Freescale	M68HC908KX2	2048	192	-	16	4 x 8-bit	31 kHz
Microchip	PIC16F819	3584	256	256	18	5 x 10-bit	78 kHz
Renesas	R5F21102	8192	512	-	32	10 x 8-bit	-
TI	MSP430F1122	4096	256	-	20	5 x 10-bit	39 kHz

