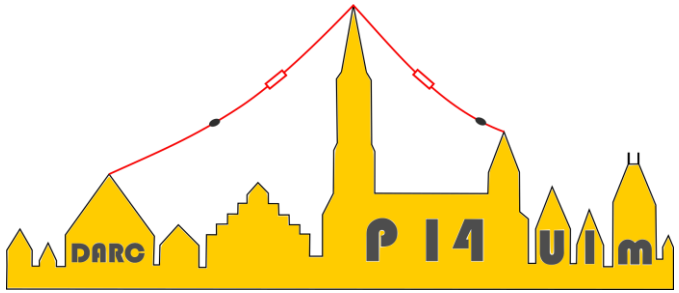


Die Evolution einer Idee, eines Konzepts

Vortrag von Andreas (DM4AB)

P14 OV-Abend Januar 2026

Die Evolution einer Idee, eines Konzepts

Vortrag von Andreas (DM4AB)

P14 OV-Abend Januar 2026

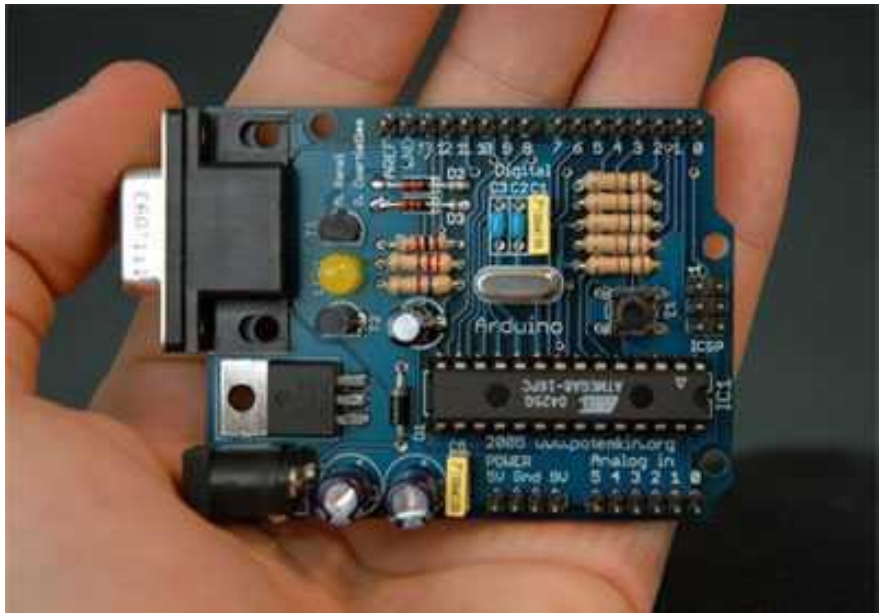
OV-ABEND

Arduino

JANUAR 2026

1. Zielsetzung: „*günstig und zum einfachen Gestalten*“
   - möglichst günstige und integrierte Hardware von der Stange
   - lötfrei verbindbar mit Versuchsaufbauten
   - möglichst barrierefrei programmierbar

2. Umsetzung Platine



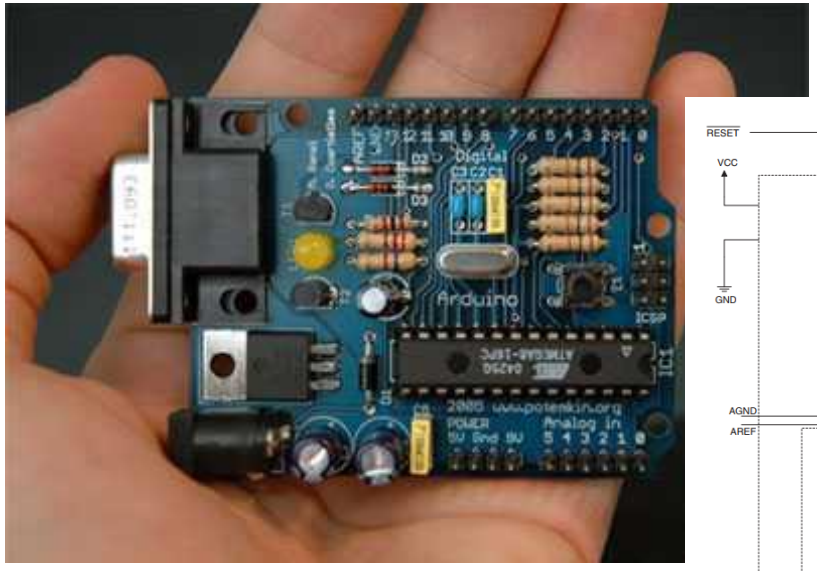
(*) 2006

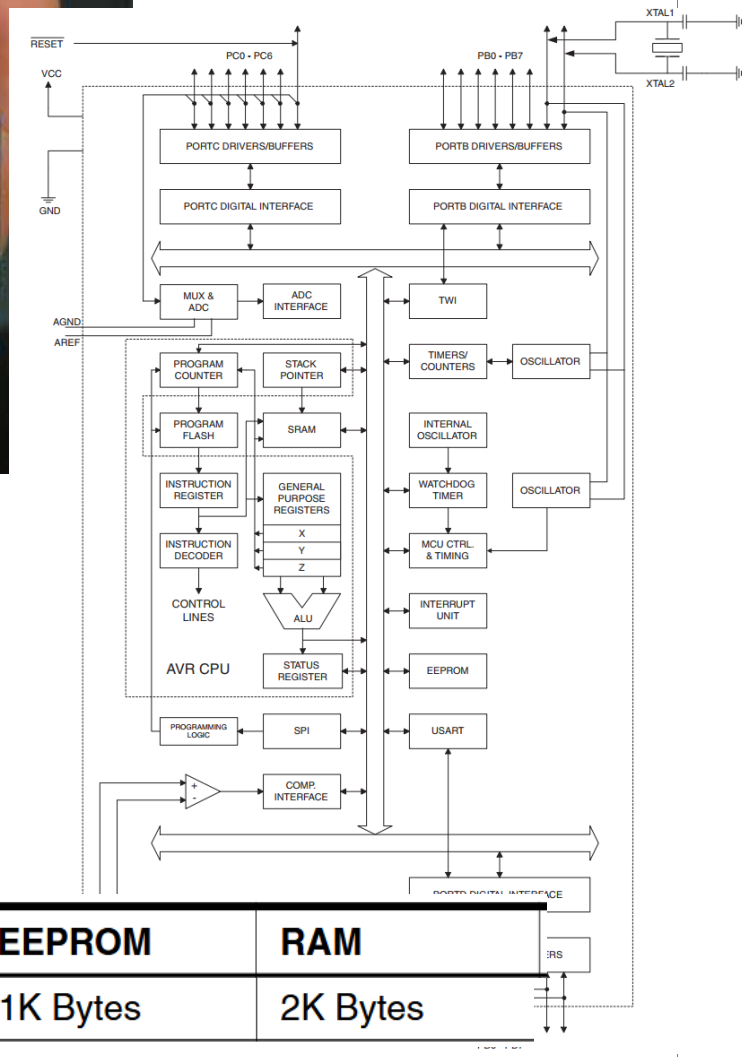
mit Atmel Mikrocontrollern (heute Microchip)

anfangs ATmega128, später **ATmega8**

ARDUINO

Ziel: günstig, einfach, barrierearm





Device	Flash	EEPROM	RAM
ATmega328P	32K Bytes	1K Bytes	2K Bytes

Features

- High-performance, Low-power Atmel®AVR® 8-bit Microcontroller
- Advanced RISC Architecture
  - 130 Powerful Instructions – Most Single-clock Cycle Execution
  - 32 × 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16MIPS Throughput at 16MHz
  - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory segments
  - 8Kbytes of In-System Self-programmable Flash program memory
  - 512Bytes EEPROM
  - 1Kbyte Internal SRAM
  - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
  - Data retention: 20 years at 85°C/100 years at 25°C(1)
  - Optional Boot Code Section with Independent Lock Bits
    In-System Programming by On-chip Boot Program
    True Read-While-Write Operation
  - Programming Lock for Software Security
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescaler, one Compare Mode
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Three PWM Channels
  - 8-channel ADC in TQFP and QFN/MLF package
    Eight Channels 10-bit Accuracy
  - 6-channel ADC in PDIP package
    Six Channels 10-bit Accuracy
  - Byte-oriented Two-wire Serial Interface
  - Programmable Serial USART
  - Master/Slave SPI Serial Interface
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated RC Oscillator
  - External and Internal Interrupt Sources
  - Five Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, and Standby
- I/O and Packages
  - 23 Programmable I/O Lines
  - 28-lead PDIP, 32-lead TQFP, and 32-pad QFN/MLF
- Operating Voltages
  - 2.7V - 5.5V (ATmega8L)
  - 4.5V - 5.5V (ATmega8)
- Speed Grades
  - 0 - 8MHz (ATmega8L)
  - 0 - 16MHz (ATmega8)
- Power Consumption at 4Mhz, 3V, 25°C
  - Active: 3.6mA
  - Idle Mode: 1.0mA
  - Power-down Mode: 0.5µA

Atmel

8-bit Atmel with 8KBytes In-System Programmable Flash

ATmega8
ATmega8L

ARDUINO

Ziel: günstig, einfach, barrierearm

Das sieht aber nicht ganz einfach aus?

Ist es auch nicht wirklich.

Features

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- Advanced RISC Architecture
  - 130 Powerful Instructions – Most Single-clock Cycle Execution
  - 32 × 8 General Purpose Working Registers
  - Fully Static Operation
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Atmel

8-bit Atmel with 8KBytes In-System Programmable Flash

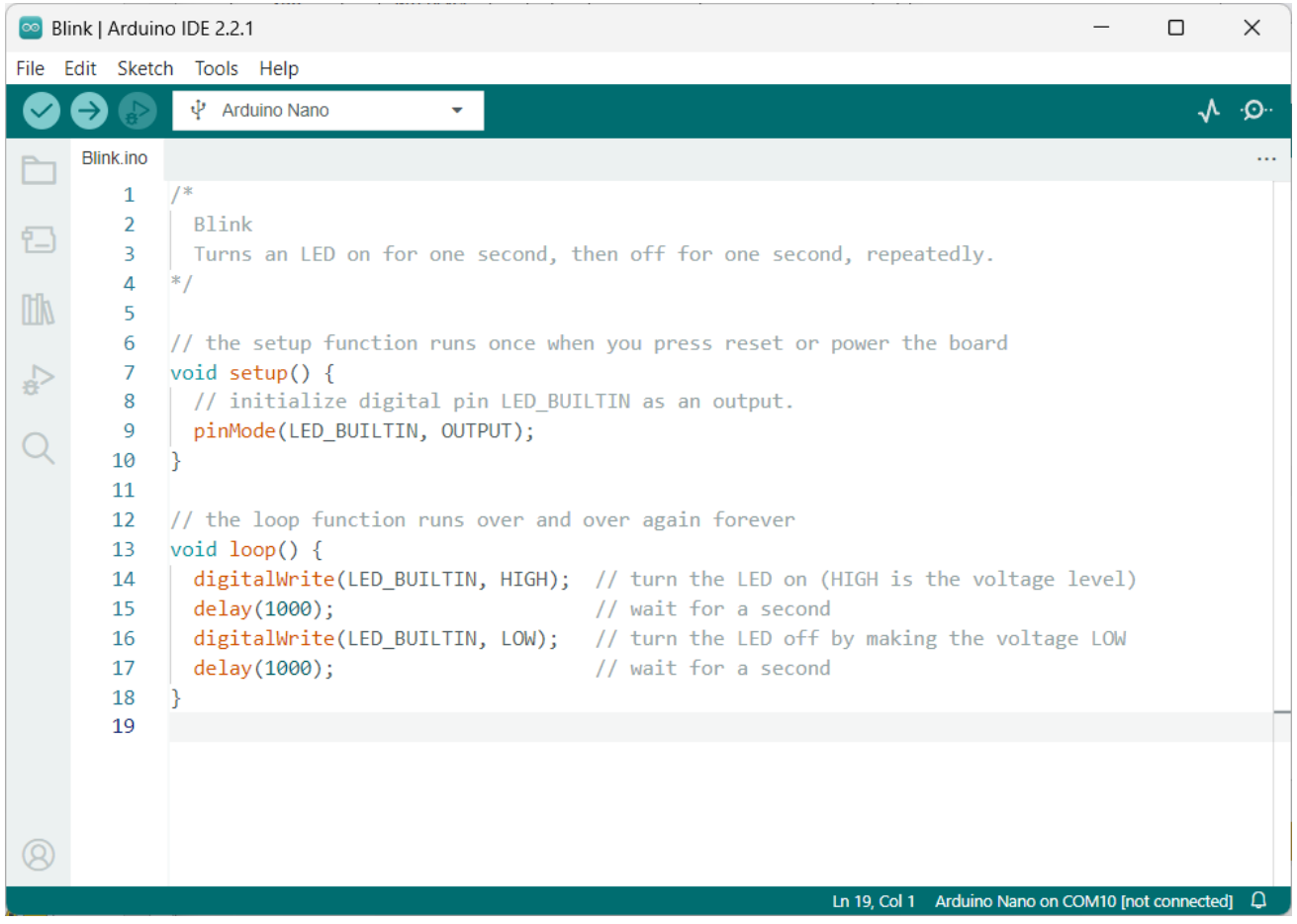
ATmega8
ATmega8L

ARDUINO

JANUAR 2026

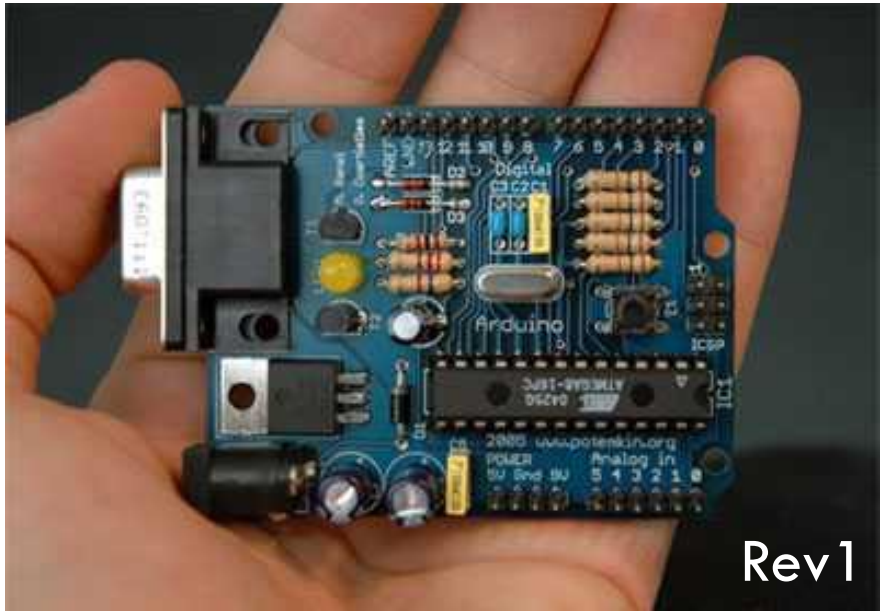
Ziel: günstig, einfach, barrierearm

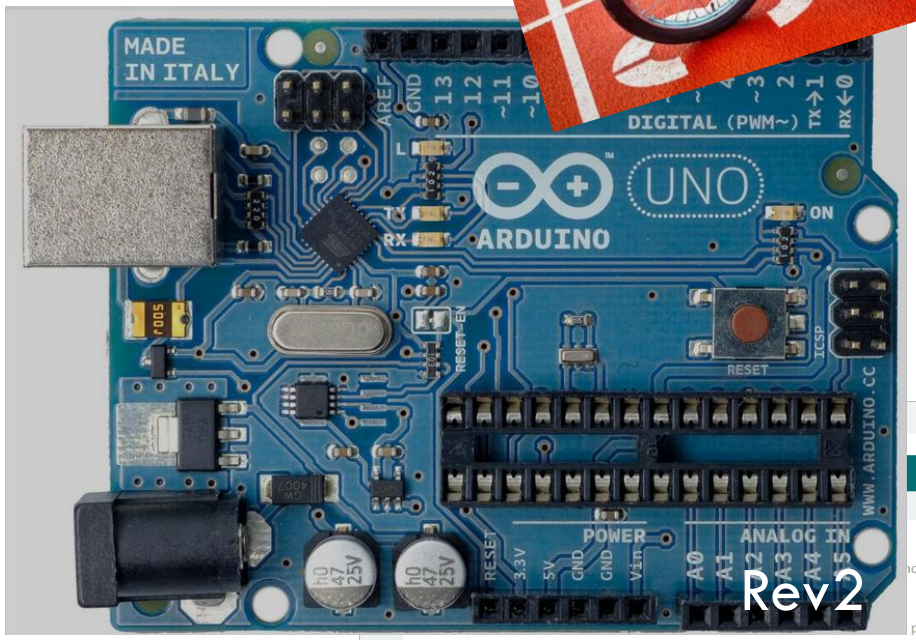
1. Zielsetzung: „*günstig und zum einfachen Gestalten*“
2. Umsetzung Platine
3. eine maximal einfache SW Entwicklungsumgebung, ohne „Bit-Puhlen“ und lange Lernkurve



OV-Abend

Arduino UNO





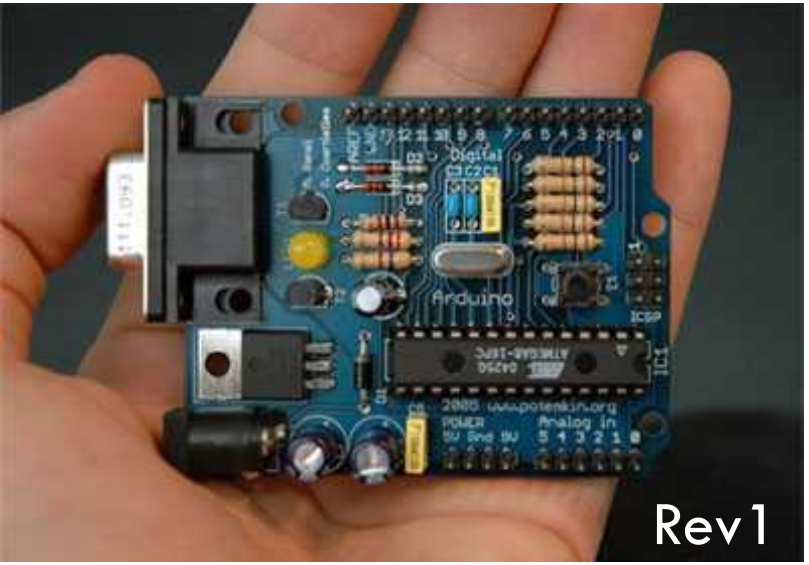

```
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(LED_BUILTIN, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(LED_BUILTIN, HIGH);  // turn the LED on (HIGH is the voltage level)
  delay(1000);                      // wait for a second
  digitalWrite(LED_BUILTIN, LOW);   // turn the LED off by making the voltage LOW
  delay(1000);                      // wait for a second
}
```

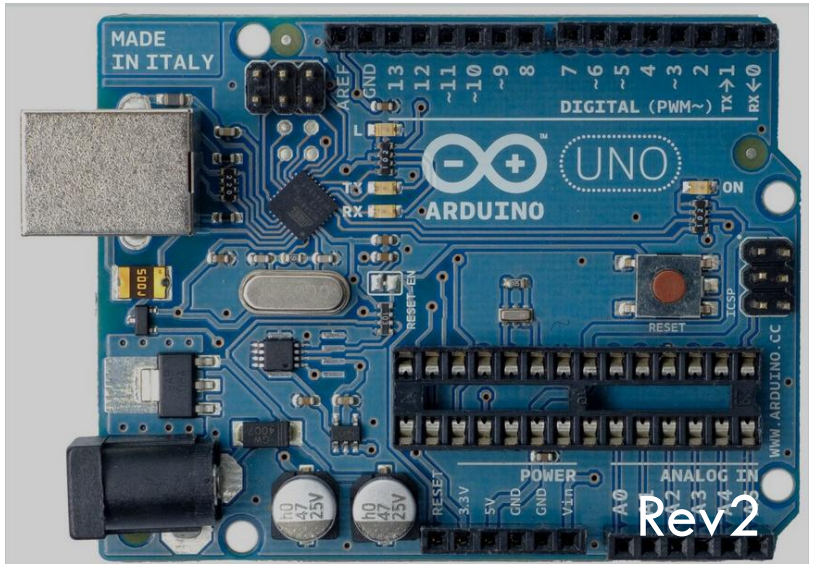
OV-ABEND

Arduino UNO

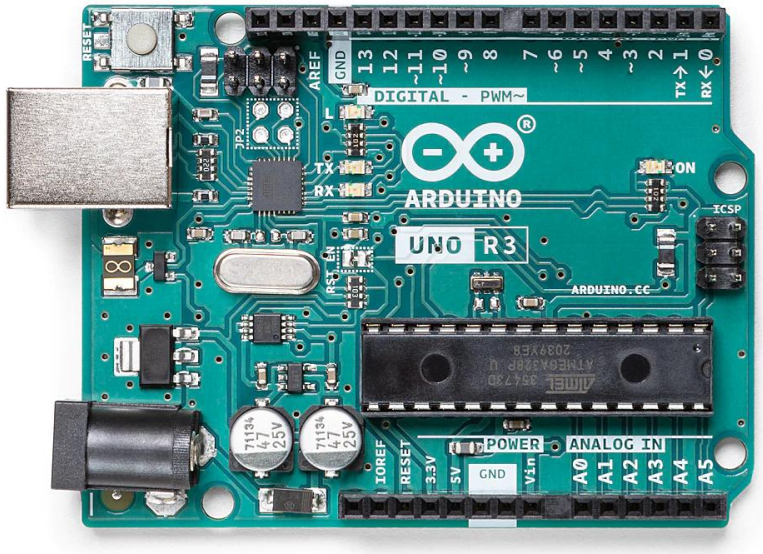
JANUAR 2026



ATmega8



ATmega328 +
ATmega8 für USB-to-serial

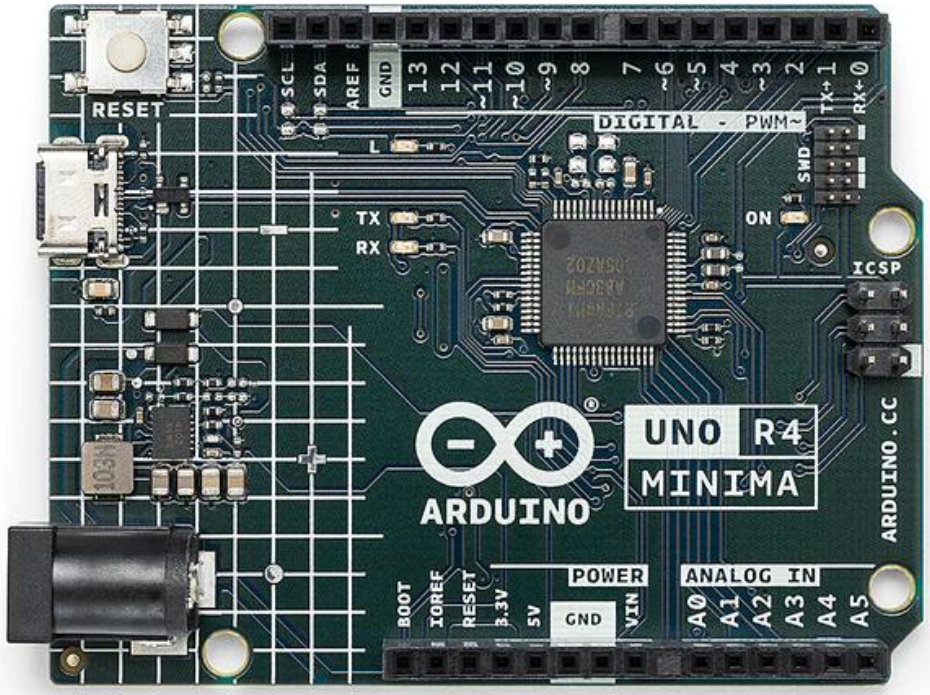


ATmega328 +
ATmega16 für USB-to-serial

OV-Abend

Arduino UNO Rev4

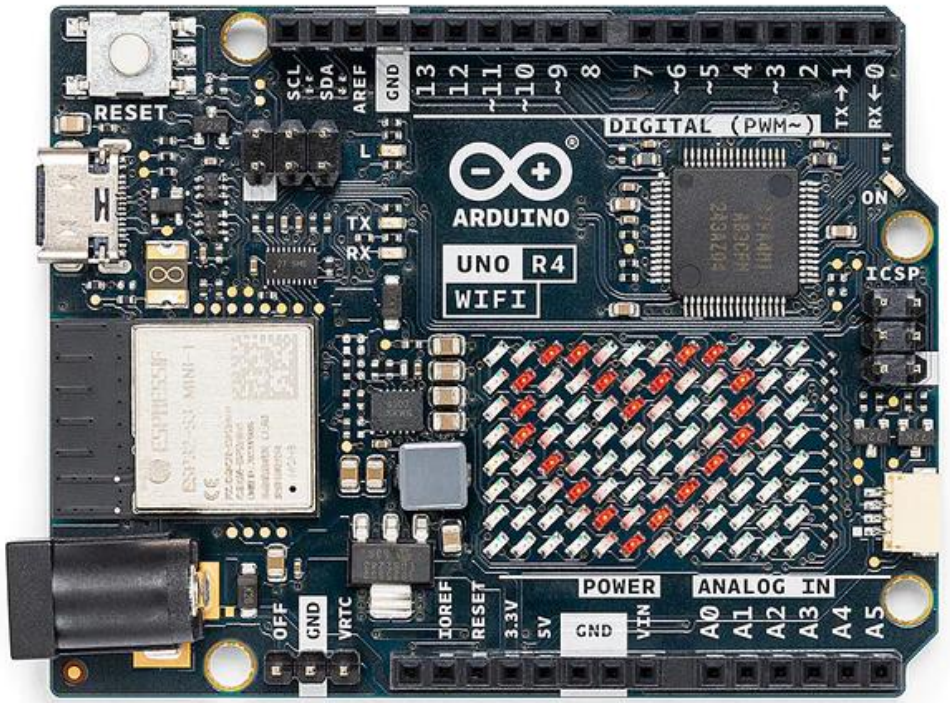
22 €



Renesas R7FA4M1,
Buck-Converter,
USB-C

Januar 2026

31 €



+ LED Matrix
+ ESP32-S3
+ Kleinkram

DARC P14 Ulm

OV-ABEND

Arduino UNO Rev4

Renesas R7FA4M1

Das sieht aber nicht ganz einfach aus?

Ist es tatsächlich gar nicht mehr.

Device	Flash	EEPROM	RAM
ATmega328P	32K Bytes	1K Bytes	2K Bytes

RENESAS

RA4M1 Group

User's Manual

High efficiency 48-MHz Arm® Cortex®-M4 core, 256-KB code flash memory, 32-KB SRAM, Segment LCD Controller, Capacitive Touch Sensing Unit, USB 2.0 Full-Speed Module, 14-bit A/D Converter, 12-bit D/A Converter, security and safety features

Features

■ **Arm Cortex-M4 Core with Floating Point Unit (FPU)**
- Armv7E-M architecture with DSP instruction set
- Maximum operating frequency: 48 MHz
- Support for 4-GB address space
- Arm Memory Protection Unit (Arm MPU) with 8 regions
- Debug and Trace: ITM, DWT, FPB, TPIU, ETB
- CoreSight™ Debug Port: JTAG-DP and SW-DP

■ **Memory**
- 256-KB code flash memory
- 8-KB data flash memory (100,000 program/erase (P/E) cycles)
- 32-KB SRAM
- Flash Cache (FCACHE)
- Memory Protection Unit (MPU)
- 128-bit unique ID

■ **Connectivity**
- USB 2.0 Full-Speed Module (USBFS)
  - On-chip transceiver with voltage regulator
  - Compliant with USB Battery Charging Specification 1.2
- Serial Communications Interface (SCI) × 4
  - UART
  - Simple IIC
  - Simple SPI
- Serial Peripheral Interface (SPI) × 2
- I^2C bus interface (IIC) × 2
- Controller Area Network (CAN) module
- Serial Sound Interface Enhanced (SSIE)

■ **Analog**
- 14-bit A/D Converter (ADC14)
- 12-bit D/A Converter (DAC12)
- 8-bit D/A Converter (DAC8) ×2 (for ACMPLP)
- Low-Power Analog Comparator (ACMPLP) × 2
- Operational Amplifier (OPAMP) × 4
- Temperature Sensor (TSN)

■ **Timers**
- General PWM Timer 32-Bit (GPT32) × 2
- General PWM Timer 16-Bit (GPT16) × 6
- Asynchronous General-Purpose Timer (AGT) × 2
- Watchdog Timer (WDT)

■ **Safety**
- Error Correction Code (ECC) in SRAM
- SRAM parity error check
- Flash area protection
- ADC self-diagnosis function
- Clock Frequency Accuracy Measurement Circuit (CAC)
- Cyclic Redundancy Check (CRC) calculator
- Data Operation Circuit (DOC)
- Port Output Enable for GPT (POEG)
- Independent Watchdog Timer (IWDT)
- GPIO readback level detection
- Register write protection
- Main oscillator stop detection
- Illegal memory access

■ **System and Power Management**
- Low power modes
- Realtime Clock (RTC) with calendar and Battery Backup support
- Event Link Controller (ELC)
- DMA Controller (DMAC) × 4
- Data Transfer Controller (DTC)
- Key Interrupt Function (KINT)
- Power-on reset
- Low Voltage Detection (LVD) with voltage settings

■ **Security and Encryption**
- AES128/256
- GHASH
- True Random Number Generator (TRNG)

■ **Human Machine Interface (HMI)**
- Segment LCD Controller (SLCDC)
  - Up to 38 segments × 4 commons
  - Up to 34 segments × 8 commons
- Capacitive Touch Sensing Unit (CTSU)

■ **Multiple Clock Sources**
- Main clock oscillator (MOSC)
  (1 to 20 MHz when VCC = 2.4 to 5.5 V)
  (1 to 8 MHz when VCC = 1.8 to 2.4 V)
  (1 to 4 MHz when VCC = 1.6 to 1.8 V)
- Sub-clock oscillator (SOSC) (32.768 kHz)
- High-speed on-chip oscillator (HOCO)
  (24, 32, 48, 64 MHz when VCC = 2.4 to 5.5 V)
  (24, 32, 48 MHz when VCC = 1.8 to 5.5 V)
  (24, 32 MHz when VCC = 1.6 to 5.5 V)
- Middle-speed on-chip oscillator (MOCO) (8 MHz)
- Low-speed on-chip oscillator (LOCO) (32.768 kHz)
- IWDT-dedicated on-chip oscillator (15 kHz)
- Clock trim function for HOCO/MOCO/LOCO
- Clock out support

■ **General Purpose I/O Ports**
- Up to 84 input/output pins
  - Up to 3 CMOS input
  - Up to 81 CMOS input/output
    - Up to 9 input/output 5-V tolerant
    - Up to 2 high current (20 mA)

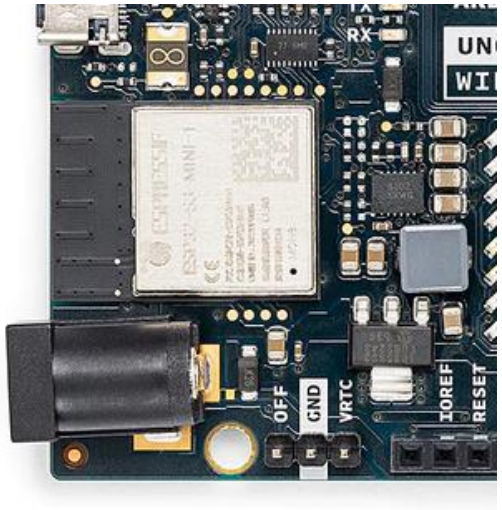
■ **Operating Voltage**
- VCC: 1.6 to 5.5 V

■ **Operating Temperature and Packages**
- Ta = -40°C to +85°C
  - 100-pin LGA (7 mm × 7 mm, 0.65 mm pitch)
- Ta = -40°C to +105°C
  - 100-pin LQFP (14 mm × 14 mm, 0.5 mm pitch)
  - 64-pin LQFP (10 mm × 10 mm, 0.5 mm pitch)
  - 64-pin QFN (8 mm × 8 mm, 0.4 mm pitch)
  - 48-pin LQFP (7 mm × 7 mm, 0.5 mm pitch)
  - 48-pin QFN (7 mm × 7 mm, 0.5 mm pitch)
  - 40-pin QFN (6 mm × 6 mm, 0.5 mm pitch)

OV-ABEND

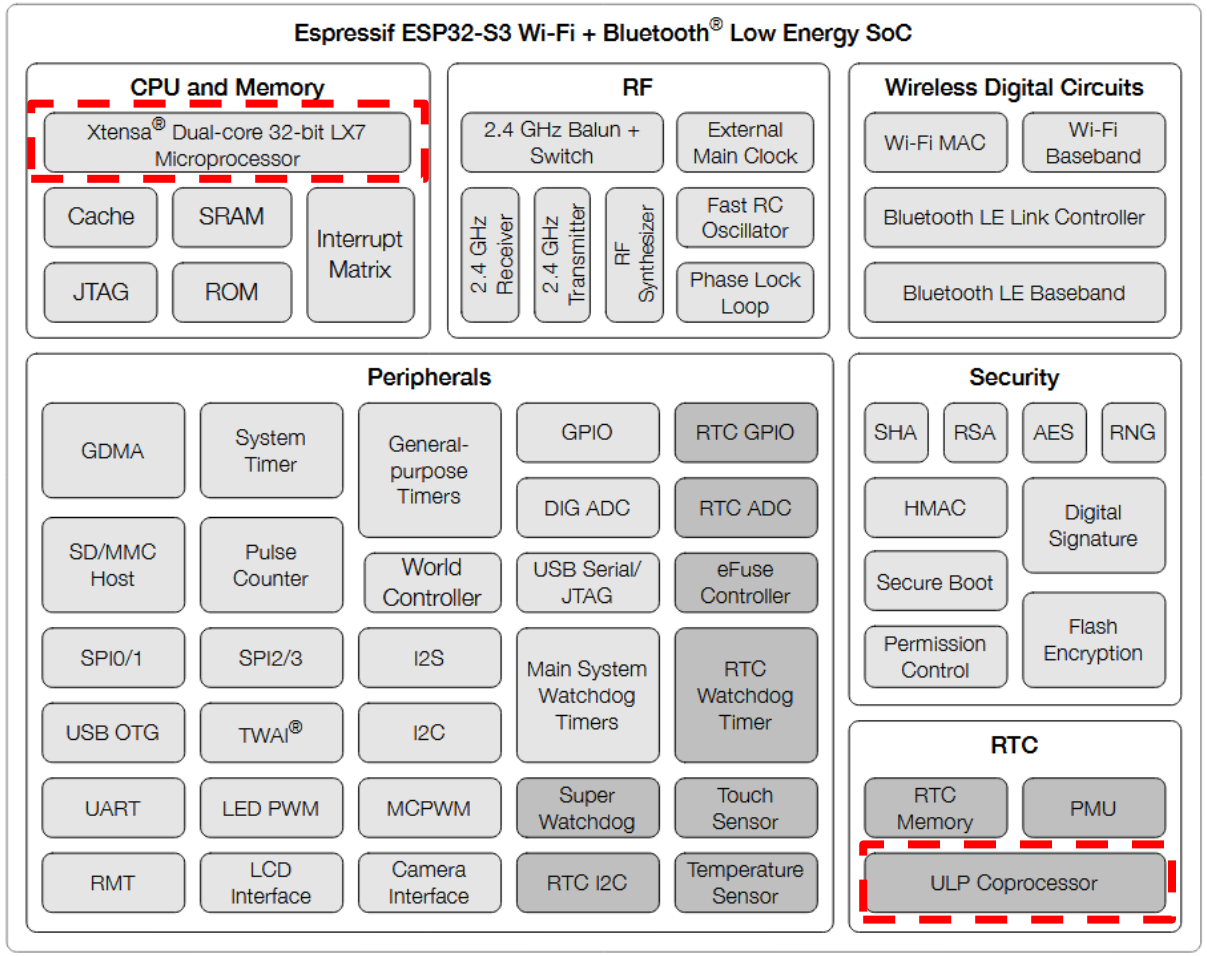
Arduino UNO Rev4

ESP32-S3



ESP32-S3 is a low-power MCU-based system on a chip (SoC) with integrated 2.4 GHz Wi-Fi and Bluetooth® Low Energy (Bluetooth LE). It consists of high-performance dual-core microprocessor (Xtensa® 32-bit LX7), a ULP coprocessor, a Wi-Fi baseband, a Bluetooth LE baseband, RF module, and numerous peripherals.

The functional block diagram of the SoC is shown below.

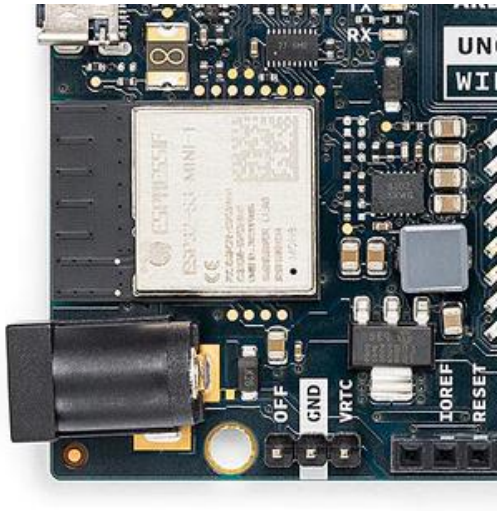


ESP32-S3 Functional Block Diagram

OV-Abend

Arduino UNO Rev4

ESP32-S3



CPU and Memory

- Xtensa® dual-core 32-bit LX7 microprocessor
- Clock speed: up to 240 MHz
- CoreMark® score:
  - Two cores at 240 MHz: 1329.92 CoreMark; 5.54 CoreMark/MHz
- Five-stage pipeline
- 128-bit data bus and dedicated SIMD instructions
- Single precision floating point unit (FPU)
- Ultra-Low-Power (ULP) coprocessors:
  - ULP-RISC-V coprocessor
  - ULP-FSM coprocessor
- General DMA controller, with 5 transmit channels and 5 receive channels
- L1 cache
- ROM: 384 KB
- SRAM: 512 KB
- SRAM in RTC: 16 KB
- 4096-bit eFuse memory, up to 1792 bits for users
- Supported SPI protocols: SPI, Dual SPI, Quad SPI, Octal SPI, QPI and OPI interfaces that allow connection to flash, external RAM, and other SPI devices
- Flash controller with cache is supported
- Flash in-Circuit Programming (ICP) is supported

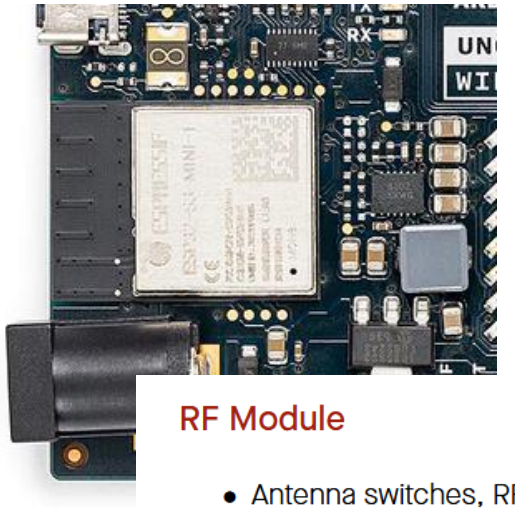
Peripherals

- 45 programmable GPIOs
  - 4 strapping GPIOs
  - GPIOs allocated for in-package memory:
    * 6 GPIOs for either in-package flash or PSRAM
    * 7 GPIOs when both in-package flash and PSRAM are integrated
- Connectivity interfaces:
  - Three UART interfaces
  - Two I2C interfaces
  - Two I2S interfaces
  - LCD interface
  - 8-bit ~ 16-bit DVP camera interface
  - Two SPI ports for communication with flash and RAM
  - Two general-purpose SPI ports
  - TWAI® controller, compatible with ISO 11898-1 (CAN Specification 2.0)
  - Full-speed USB OTG
  - USB Serial/JTAG controller
  - SD/MMC host controller with 2 slots
  - LED PWM controller, up to 8 channels
  - Two Motor Control PWM (MCPWM)

OV-Abend

Arduino UNO Rev4

ESP32-S3 Data rate up to 150Mbps…



RF Module

- Antenna switches, RF balun, power amplifier, low-noise receive amplifier
- Up to +21 dBm of power for an 802.11b transmission
- Up to +19.5 dBm of power for an 802.11n transmission
- Up to -104.5 dBm of sensitivity for Bluetooth LE receiver (125 Kbps)

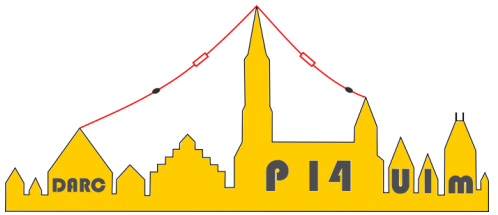
  - RMT (TX/RX)
  - Pulse count controller
- Analog signal processing:
  - Two 12-bit SAR ADCs, up to 20 channels
  - Temperature sensor
  - 14 capacitive touch sensing IOs
- Timers:
  - Four 54-bit general-purpose timers
  - 52-bit system timer
  - Three watchdog timers

Power Management

- Fine-resolution power control, including clock frequency, duty cycle, Wi-Fi operating modes, and individual internal component control
- Four power modes designed for typical scenarios: Active, Modem-sleep, Light-sleep, Deep-sleep
- Power consumption in Deep-sleep mode is 7 μA
- RTC memory remains powered on in Deep-sleep mode

Security

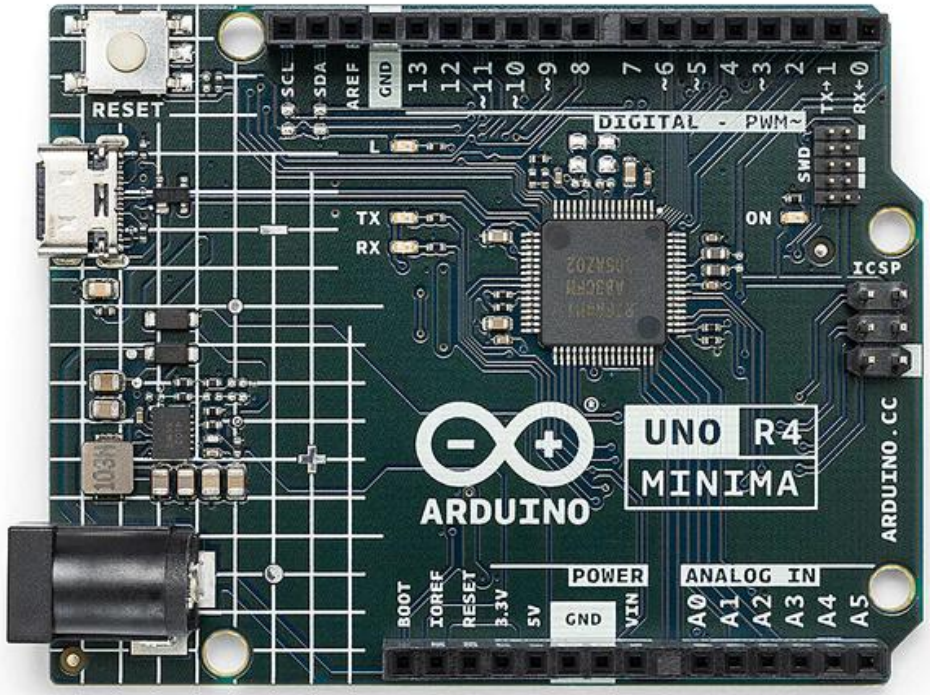
- Secure boot - permission control on accessing internal and external memory
- Flash encryption - memory encryption and decryption
- Cryptographic hardware acceleration:
  - AES-128/256 (FIPS PUB 197)
  - SHA (FIPS PUB 180-4)
  - RSA
  - Random Number Generator (RNG)
  - HMAC
  - Digital signature



OV-Abend

Arduino UNO Rev4

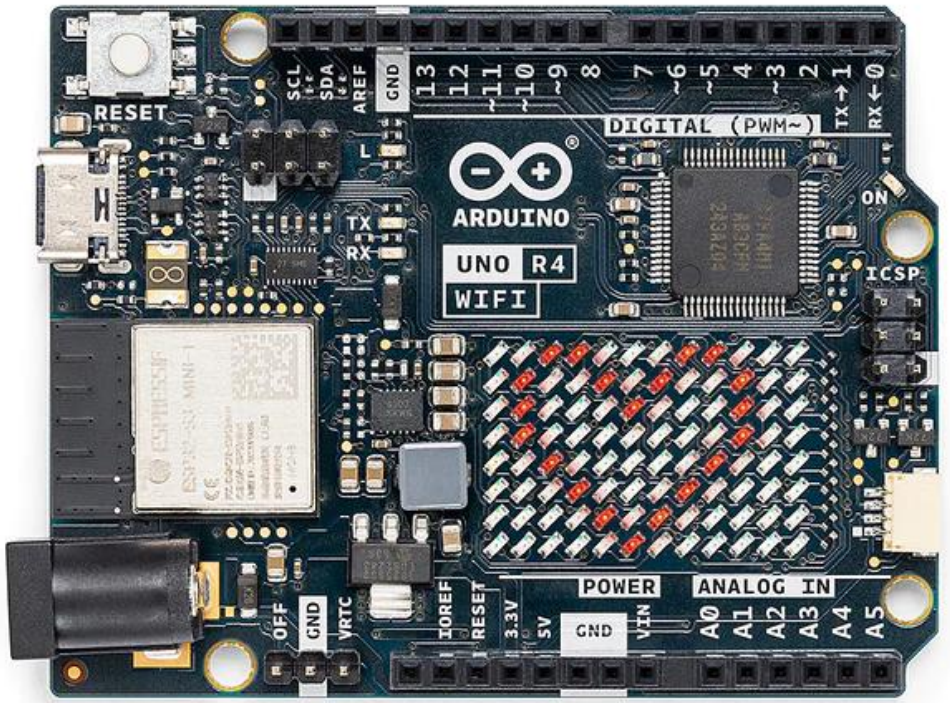
22 €



Renesas R7FA4M1,
Buck-Converter,
USB-C

Januar 2026

31 €



+ LED Matrix
+ ESP32-S3
+ Kleinkram

DARC P14 Ulm

OV-Abend

Januar 2026

Das war‘s doch noch nicht ganz.

Ab 39 Euro: Qualcomm kauft Arduino und stellt Raspi-Konkurrenten vor

Der Einplatinencomputer Arduino Uno Q bekommt einen Qualcomm-Prozessor. Er ermöglicht ähnliche Projekte wie ein Raspberry Pi.

131

(Bild: Arduino)

07.10.2025, 15:00 Uhr

Von Mark Mantel

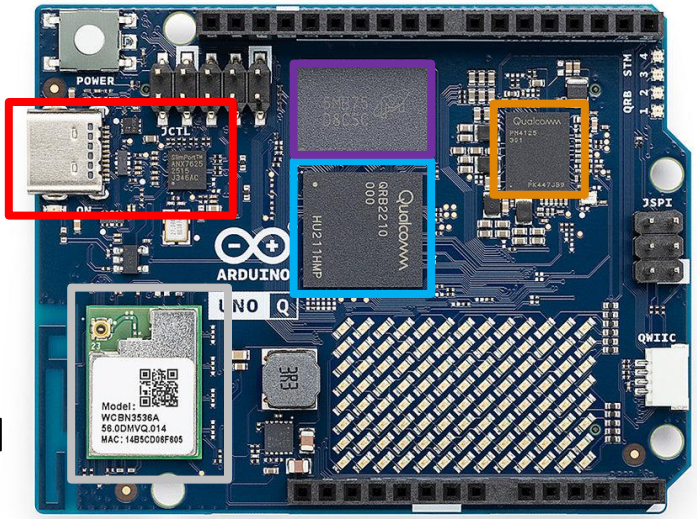
OV-Abend

Arduino UNO Q

48 €

Januar 2026

front



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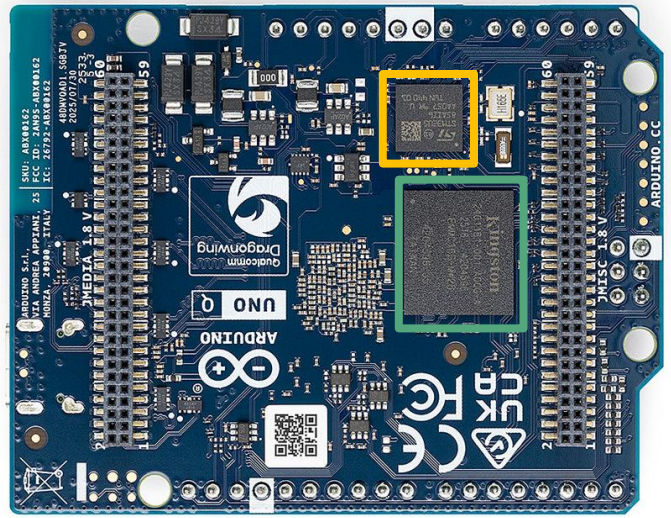


- **STM32U585 ARM Cortex-M33 32-bit MCU**, up to 160 MHz, 2 MB flash, 786 kB SRAM, FPU, DSP, MPU, 20µA/Mhz, @160MHZ: 3.1mA
  Arduino Code on ZephyrOS (!!)

- **Qualcomm Dragonwing QRB2210,**
  Quad-core Arm Cortex-A53 64bit 2.0 GHz,
  dual DSP core, USB3.1,
  processing cap. for WiFi, BT, GNSS,
  Camera Interface@>2.5Gbps, H.264, H.265,
  Adreno 702 GPU 3D 845MHz, 1080p 8bit @30fps,
  z.B. mit Debian Trixie (d.h. aktueller Linux Kernel)

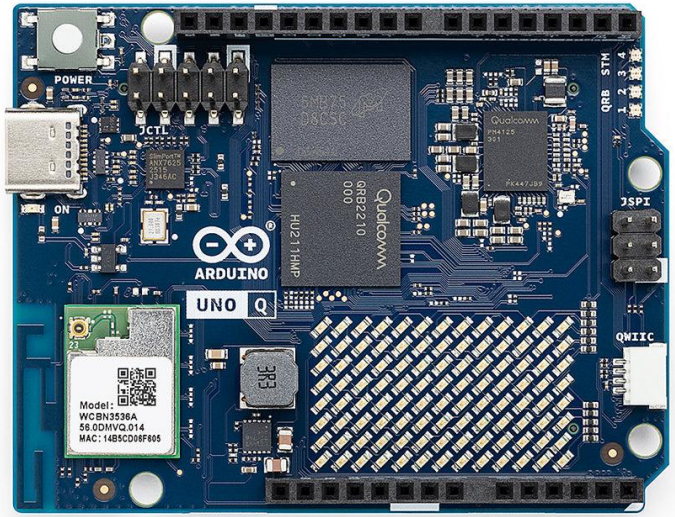
- 16GB/32GB **eMMC**
- 2GB/4GB **LPDDR4**
- **Power** Management 1.8V
- **USB3.1** mit **DisplayPort**
- **Wi-Fi 5** (dual-band, max. 867Mbps), **Bluetooth 5.1**

DARC P14 Ulm

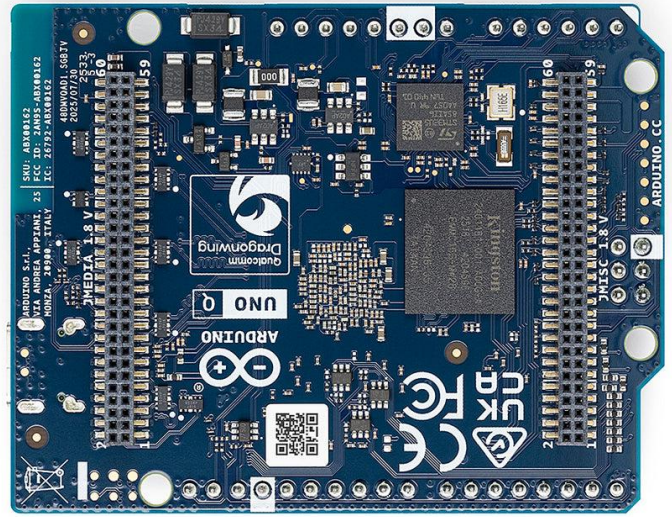
OV-ABEND

Arduino UNO Q

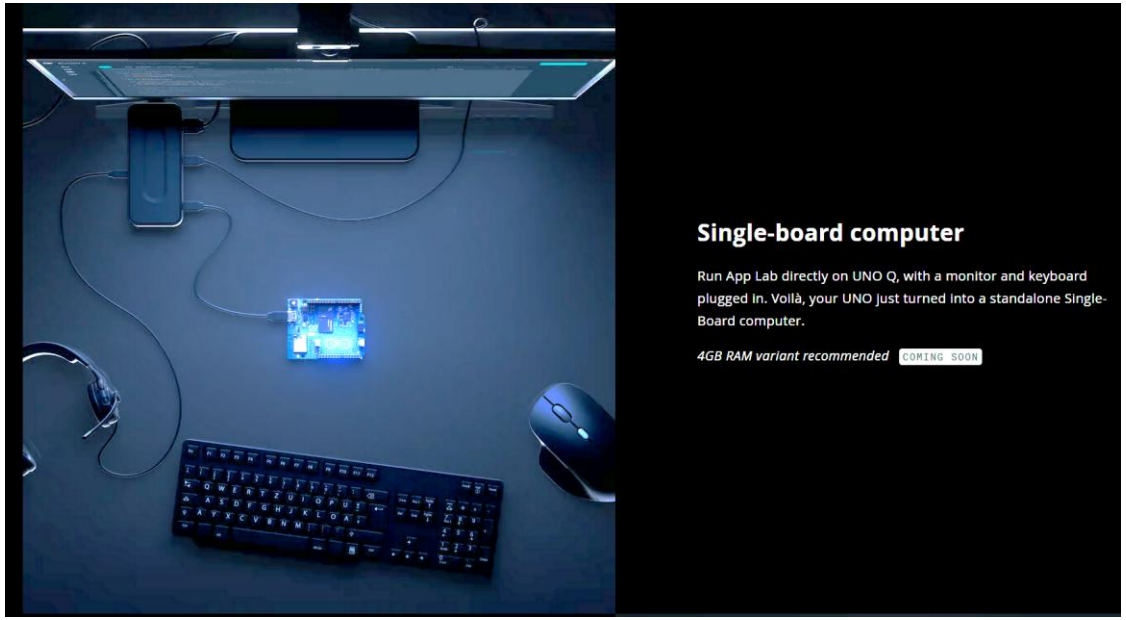
front

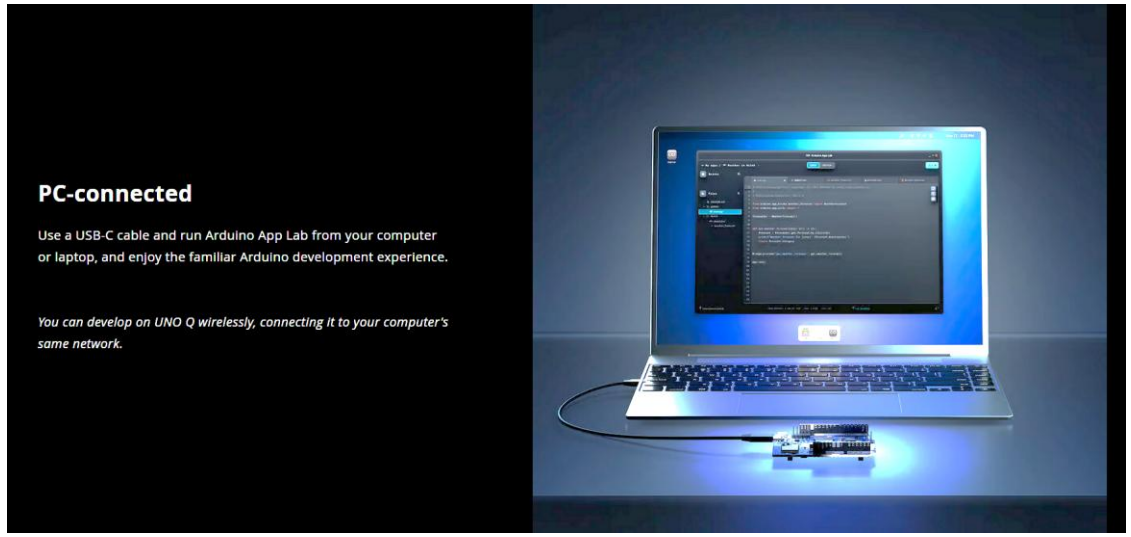


back



JANUAR 2026

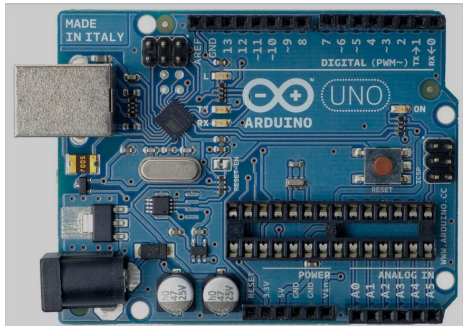


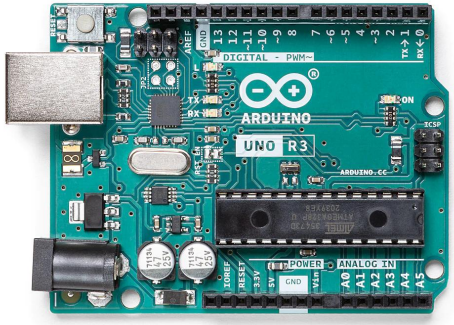


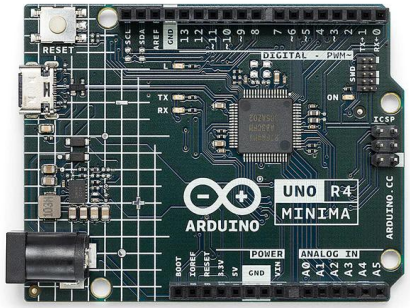
OV-Abend

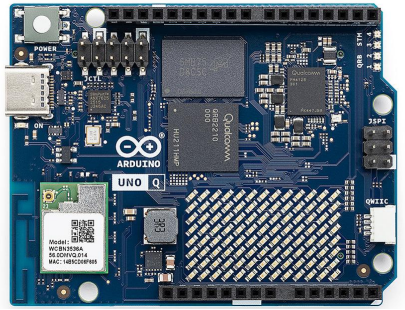
Januar 2026

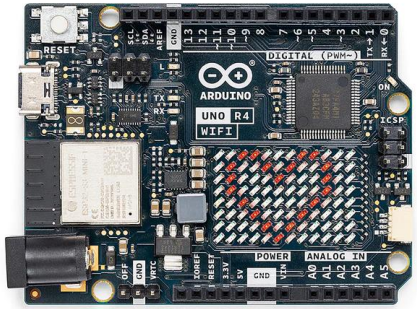
Das war‘s final.











2006 → 2025

DARC P14 Ulm