

DIGITAL WE DAYS 2025



DEMYSTIFYING BLUETOOTH® WITH WÜRTH ELEKTRONIK SOLUTIONS BASED ON NRF54

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

TODAY'S SPEAKERS



PRESENTATION

Balazs Markus
Embedded Software Engineer
Wireless Connectivity & Sensors



MODERATION

Markus Eberle
Marketing Department

INFORMATION ABOUT THE WEBINAR

You are muted during the webinar.

However, you can ask us questions using the chat function.

Duration of the presentation 30 Min
Q&A: 10 – 15 Min

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On our channel Würth Elektronik Group
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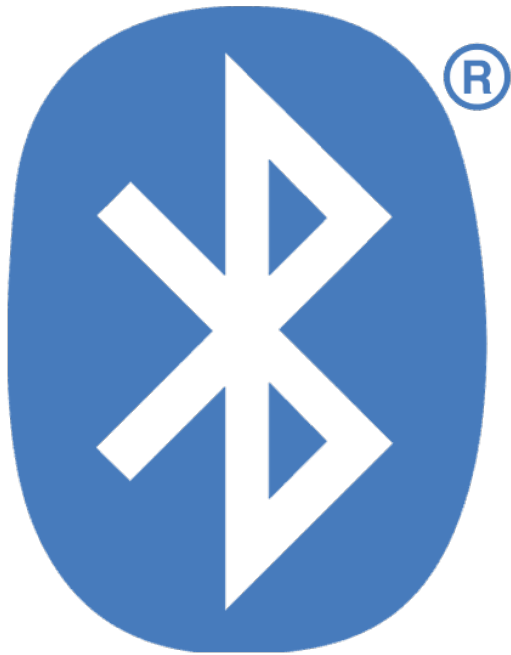


TODAY'S AGENDA

- **Bluetooth® technology evolution**
- **Bluetooth® LE fundamentals and architecture**
- **Practical applications and use cases**
- **nRF54 Series capabilities**
- **Würth Elektronik's Proteus-IV & Ophelia-IV modules**
- **Live Q&A (15 minutes)**



BLUETOOTH® – WHAT IS IT?



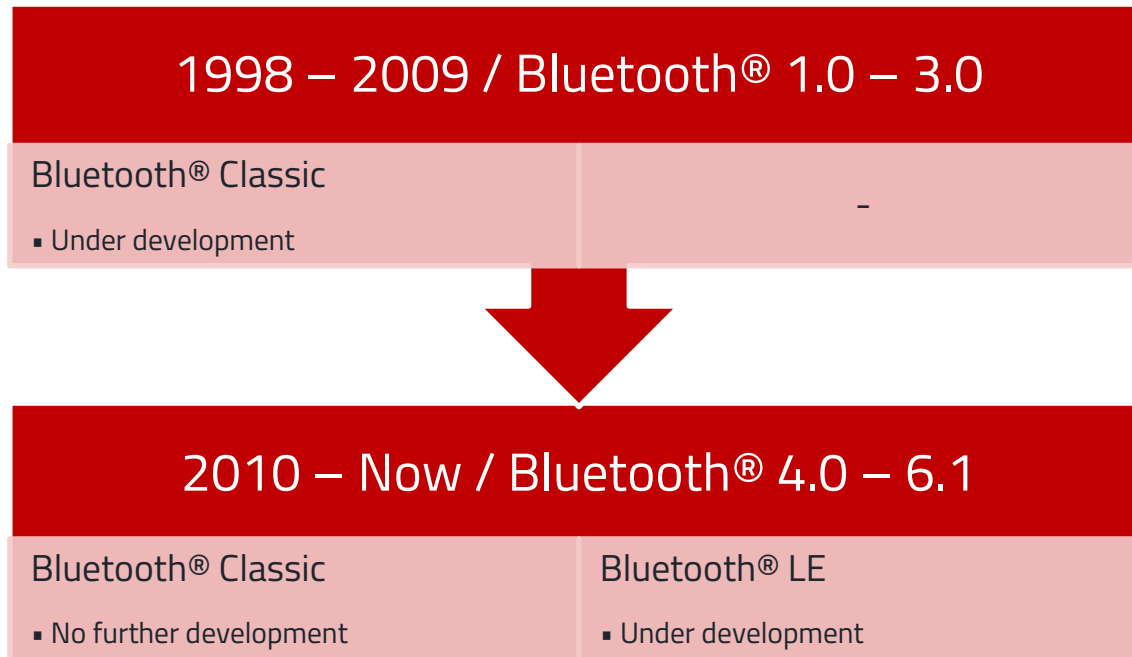
Global wireless standard for simple, secure connectivity

Goal: Substitution of cables between devices (mobiles, PC, etc.)

2.4 GHz ISM Band worldwide free of license

If you want to officially sell a Bluetooth® product,
you have to get it listed with the SIG (and pay a listing fee)

BLUETOOTH® TECHNOLOGY EVOLUTION



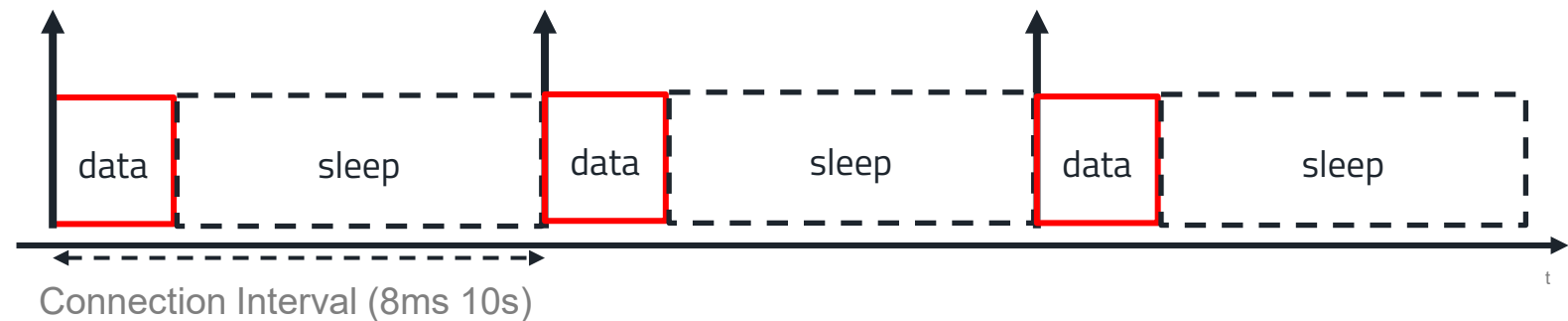
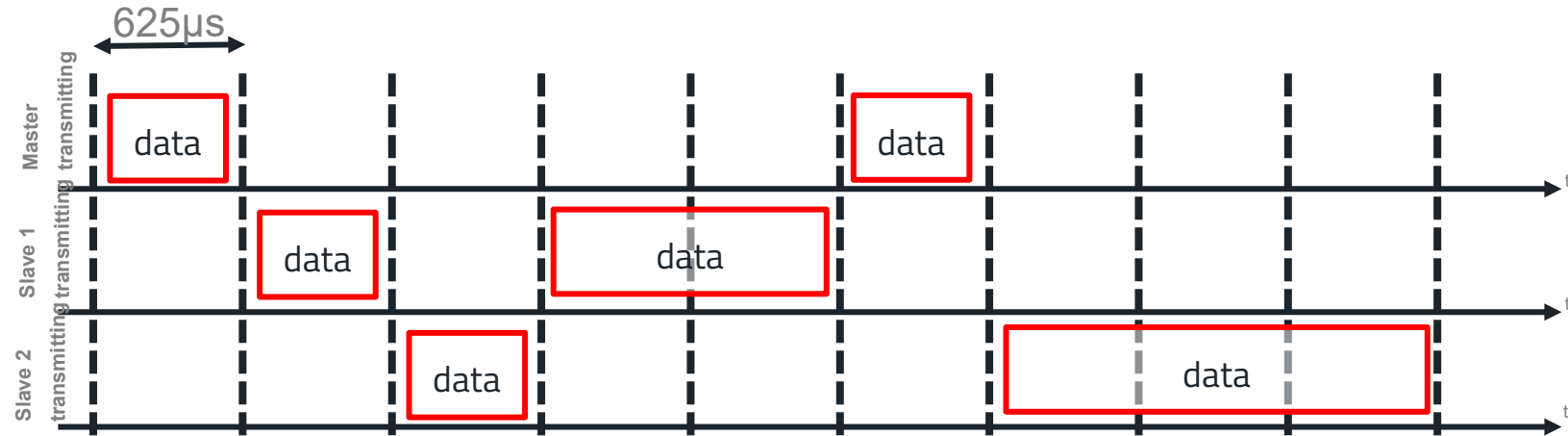
- Introduced in 1998 by the Bluetooth® SIG
 - Added more features like pairing, flow control, higher data rates, FHSS, authentication and encryption
 - Developed until version 3.0
-
- Bluetooth® LE introduced in 2010
 - Designed to cover the market of IoT devices, that are mainly battery powered
 - Development ongoing by the Special Interest Group (SIG)

BLUETOOTH® CLASSIC VS. BLUETOOTH® LOW ENERGY

- **Classic (BR/EDR)**
 - Continuous data (e.g. audio)
 - Higher power use
 - Limited support by recent smartphones
 - **Not compatible with LE**
- **LE (Low Energy)**
 - Sends data in short bursts
 - Sleep most of the time
 - Ideal for sensors and IoT
 - Supported by most smartphones
 - **Not compatible with Classic**



WHY BLUETOOTH® LOW ENERGY IS "LOW ENERGY"



CORE CONCEPTS OF BLE: ROLES



Peripheral

- **Offers connections and services**
- Defines the security level of its services and data
- **Acts as slave**
- Example: Most applications, Door control, Service interface, Light, Roller Shutter, Heart rate monitor



Central

- **Initiator for all connections with peripherals**
- **Always as master in a connection with a peripheral**
- Example: **mobile phone** at service interface, remote controller



Broadcaster



Observer

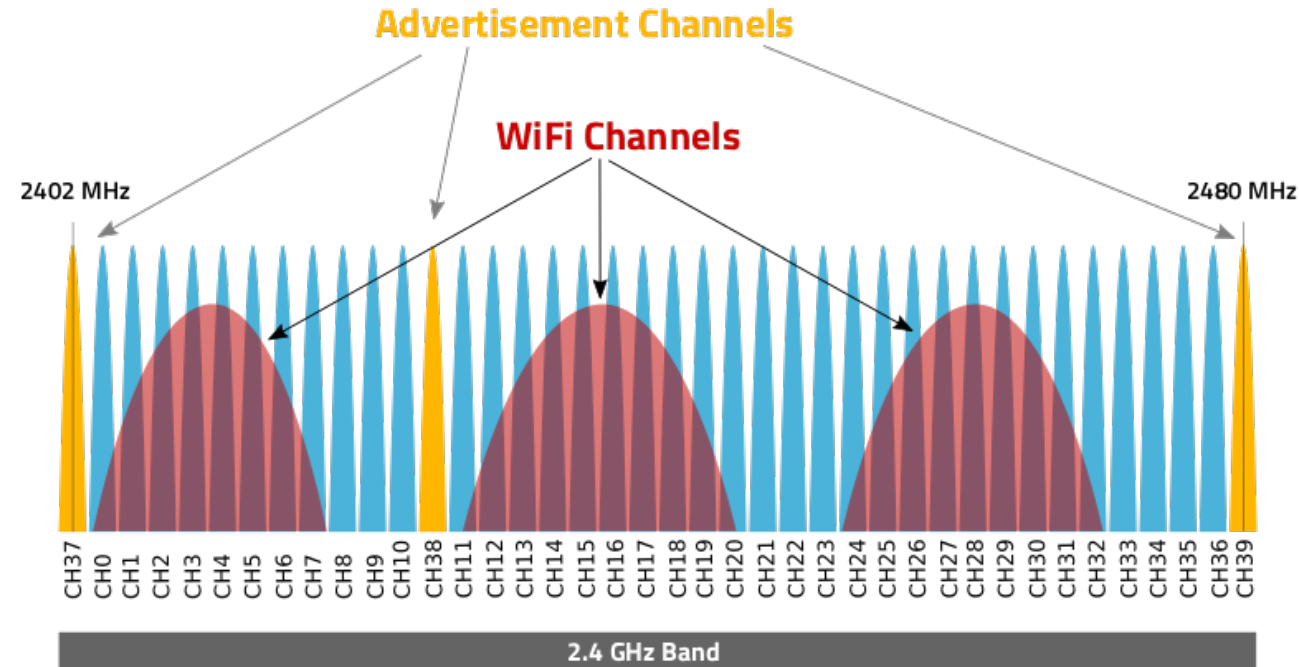
CORE CONCEPTS OF BLE: ADVERTISING & SCANNING PROCESS

Advertising (Peripheral Side)

- Broadcasts packets on 3 primary advertising channels (37 data channels, 40 total)
- Configurable interval: 20 ms to 10.24 seconds
- Packet types:
 - Connectable (allows connection establishment)
 - Non-connectable (broadcast-only, e.g., beacons)
- Scannable (allows scan response)

Scanning (Central Side)

- Listens on primary advertising channels
- Key parameters:
 - Scan window: How long to listen
 - Scan interval: How often to scan
- Faster advertising = faster discovery = faster connection



CORE CONCEPTS OF BLE: CONNECTION PROCESS

■ Connection Establishment

1. Peripheral sends connectable advertising packets
2. Central scans and discovers peripheral
3. Central sends connection request
4. Peripheral responds
5. Connection established → devices switch to data channels (one of 37)



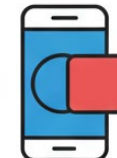
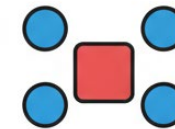
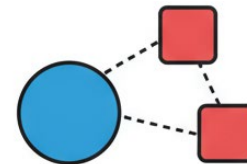
■ Connection Parameters

- Connection Interval: How often devices exchange data (7.5 ms to 4 s)
- Peripheral Latency: Peripheral can skip intervals to save power
- Supervision Timeout: Detects lost connections



■ Connection Topologies

- Central can connect to multiple peripherals
- Peripheral can connect to multiple centrals
- Smartphones act as both central and peripheral



CORE CONCEPTS OF BLE: SERVICES & CHARACTERISTICS



Characteristics

Represent individual pieces of data

Examples: Temperature reading,
battery level, LED control

Properties: Read, Write, Notify,
Indicate

Each has a unique UUID (16-bit or
128-bit)



Services

Logical grouping of related
characteristics

Example: "Environmental Service"

- Temperature characteristic
- Humidity characteristic
- Pressure characteristic

Standardized services (Battery,
Heart Rate) or custom



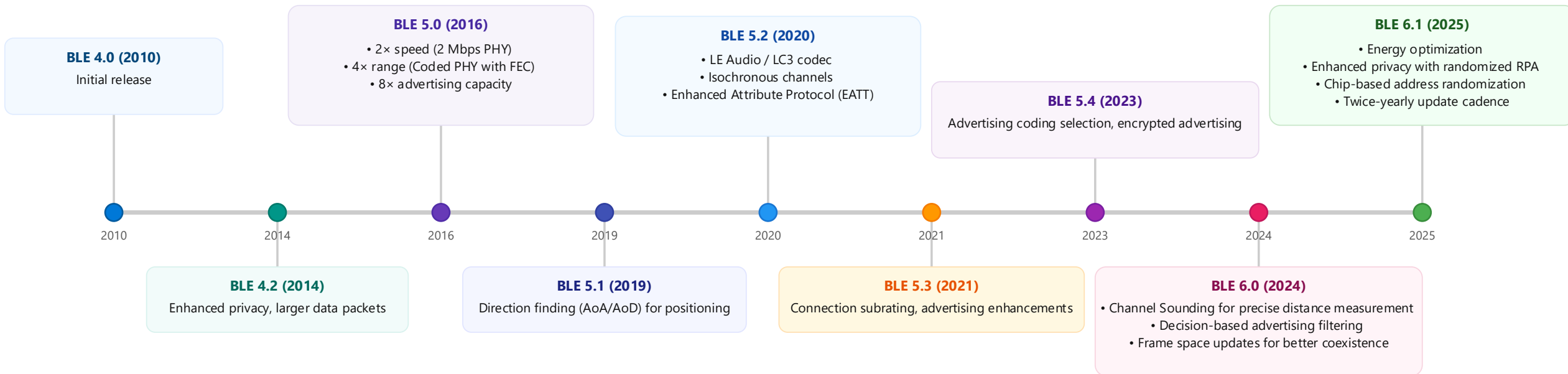
GATT Profile Architecture

Defines structure of characteristics
and services

Client-server architecture over BLE
connection

Enables interoperability between
devices

BLUETOOTH LOW ENERGY EVOLUTION



BLUETOOTH LOW ENERGY APPLICATIONS



Consumer & Wearables

Fitness trackers, smartwatches

Wireless earbuds (with LE
Audio, thanks to LC3)

Health monitors (heart rate,
glucose, blood pressure)



Smart Home

Door locks, thermostats,
lighting

Security sensors

Voice assistants



Industrial & Enterprise

Asset tracking and indoor
positioning

Condition monitoring sensors

Predictive maintenance

Warehouse logistics



Retail & Proximity

iBeacon / Eddystone beacons

Contactless payments
(alongside NFC)

In-store navigation

BLUETOOTH LOW ENERGY DESIGN CHALLENGES



Challenge 1: Power Optimization

Balancing responsiveness vs. battery life

Managing connection intervals and advertising rates



Challenge 2: Coexistence

2.4 GHz spectrum crowded with Wi-Fi, Zigbee, etc.

Interference management



Challenge 3: Range vs. Throughput

Trade-offs between distance and data rate

Application-specific optimization needed



Challenge 4: Security

Pairing and encryption complexity

Key management and secure boot

Protection against attacks



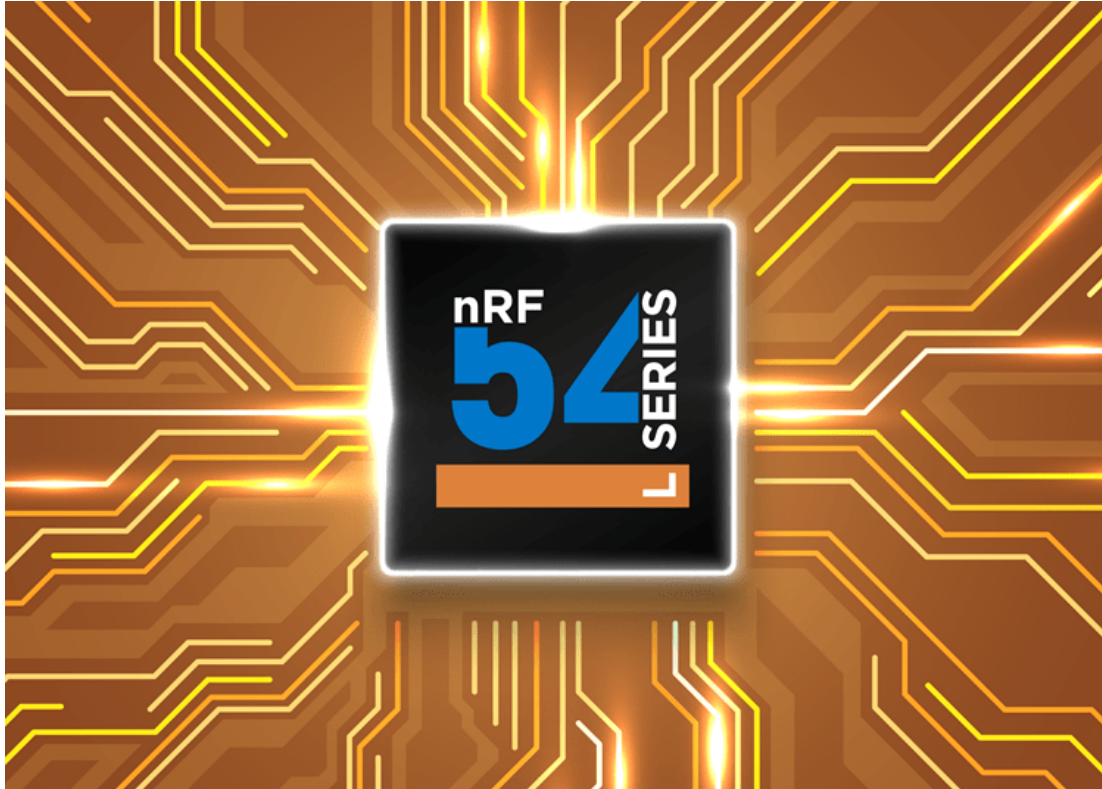
Challenge 5: RF Design & Certification

Antenna design and matching

Regulatory compliance (FCC, CE, IC)

Multi-region support

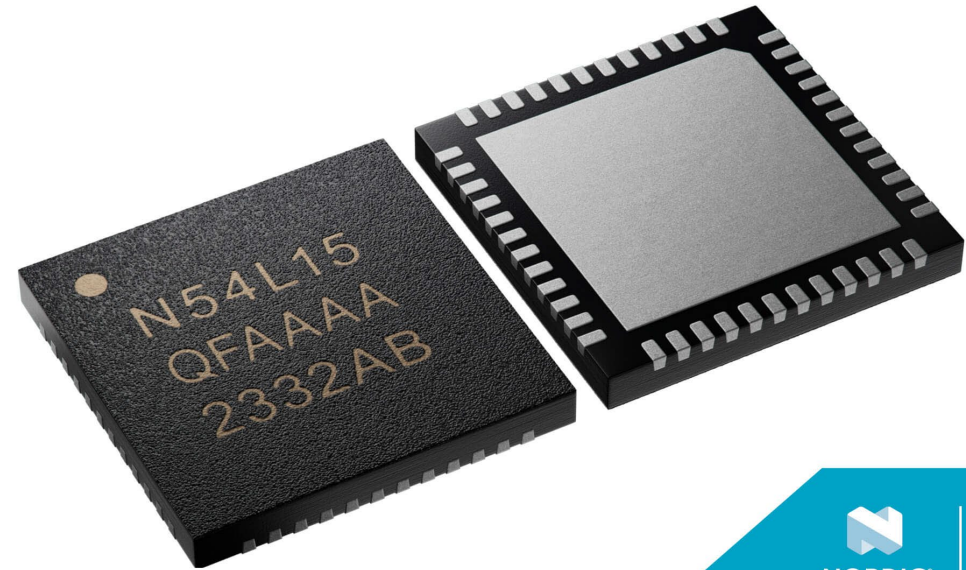
NRF54 SERIES: NORDIC SEMICONDUCTOR'S LATEST GENERATION



- Ultra-low-power multiprotocol 2.4 GHz radio
- Integrated multi-purpose MCU functionality
- 128 MHz Arm Cortex-M33 processor
- 1.5 MB NVM and 256 KB RAM
- Comprehensive set of peripherals, including new Global RTC available in System OFF, 14-bit ADC, and high-speed serial interfaces
- Secure boot, secure firmware update, secure storage
- Cryptographic accelerator with side-channel leakage protection, tamper detectors

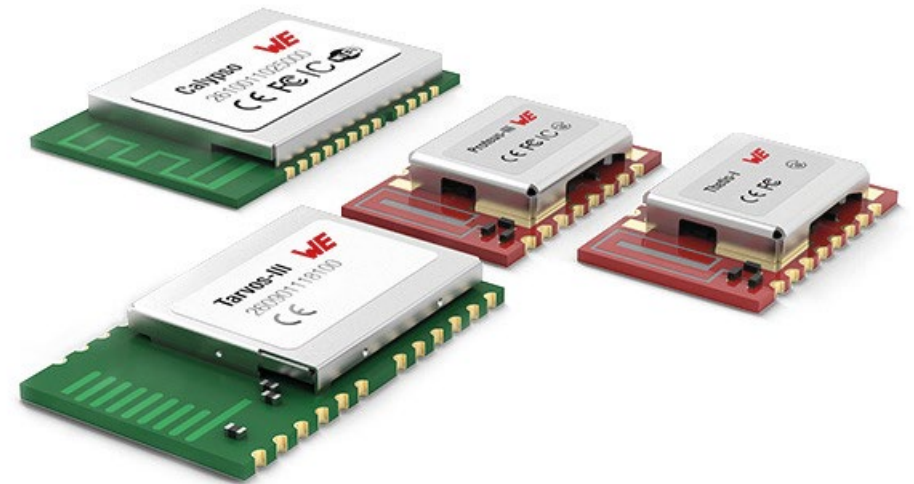
NRF54 SOLUTIONS TO COMMON CHALLENGES

- **Power Optimization**
 - Advanced power modes with sub-1 μ A sleep current
 - Efficient protocol stacks
 - DCDC converter for maximum efficiency
- **Coexistence**
 - Adaptive frequency hopping improvements
 - Coexistence interfaces for Wi-Fi coordination
- **Flexible Range/Throughput**
 - Support for all BLE PHYs: 1M, 2M, Coded (S=2, S=8)
 - Runtime switching based on application needs
- **Security**
 - Hardware-based root of trust
 - TrustZone architecture isolates sensitive operations
 - Cryptographic accelerators reduce power/time for encryption
- **RF Excellence**
 - Industry-leading RF performance
 - Pre-certified reference designs
 - Comprehensive antenna design guidelines



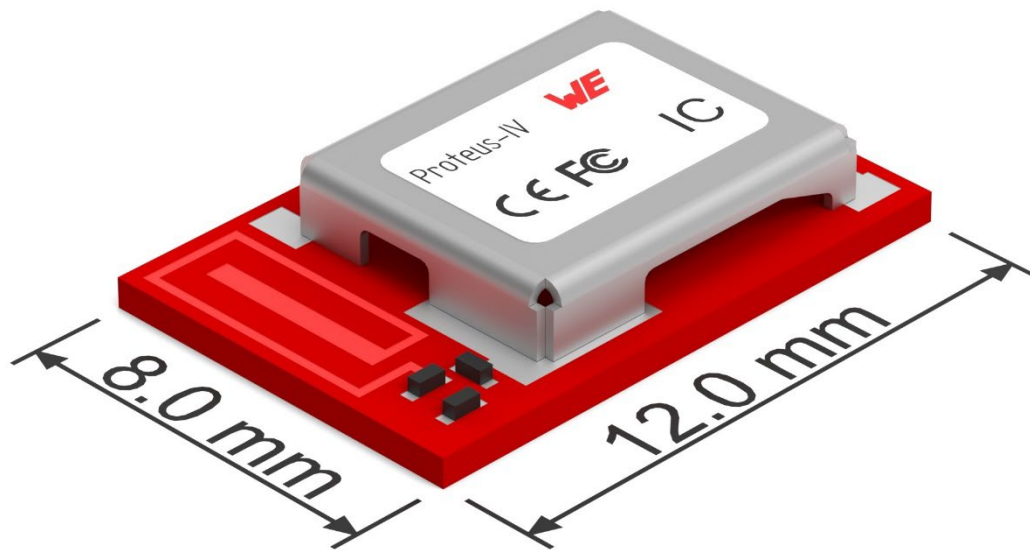
WÜRTH ELEKTRONIK WIRELESS CONNECTIVITY PRODUCTS

- **Vision: Simplify wireless integration for engineers**
- **Our Approach**
 - Pre-certified modules (FCC, CE, IC)
 - Ready-to-use firmware
 - Comprehensive development support
 - SDK and example code
- **Product Portfolio**
 - **Proteus Series:** A ready-to-use Bluetooth® Low Energy module with pre-installed firmware. Supports all Bluetooth LE 6.0 roles and enables fast integration into your application.
 - **Ophelia Series:** A flexible development platform without pre-installed firmware. Ideal for custom firmware development using the nRF Connect SDK and Zephyr RTOS. Bluetooth® LE and other protocols can be integrated depending on your project needs.
 - Other: Wi-Fi, cellular, and combo modules
- **Development Ecosystem**
 - Evaluation boards and reference designs
 - Software SDK with examples
 - Comprehensive documentation
 - Expert technical support



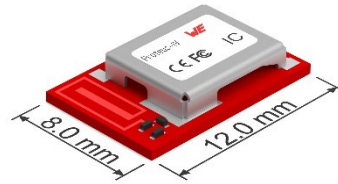
INTRODUCING PROTEUS-IV

Next-Generation BLE Module from Würth Elektronik



- **Chipset:** Nordic nRF54L15 (Cortex-M33 @ 128 MHz)
- **Size:** 12 × 8 × 2 mm
- **Protocols:** Bluetooth® LE 6.0, Thread, Zigbee, Matter, NFC, IEEE 802.15.4
- **Memory:** 1.5 MB Flash / 256 KB RAM
- **Output Power:** Up to +8 dBm
- **Power Consumption:** TX 10 mA / RX 3.2 mA / Sleep < 1 μ A
- **Security:** Secure boot, firmware update, storage, crypto engine
- **GPIOs:** Up to 29 (Ophelia-IV)
- **Certifications:** CE, FCC, IC, Bluetooth

PROTEUS-IV OPERATING MODES



Transparent Mode

- Wireless serial cable replacement
- Data automatically transmitted when ETX characters received (default: \r\n)
- Perfect for simple applications no command parsing required

Command Mode Peripheral

- Act as BLE server
- Full control over advertising, connections, security
- Binary command protocol via UART
- Multiple simultaneous connections supported
- Real-time connection status and RSSI

Command Mode Central

- Act as BLE client
- Scan for nearby devices and initiate connections
- Exchange data with peripherals
- Ideal for gateway applications

Config Mode

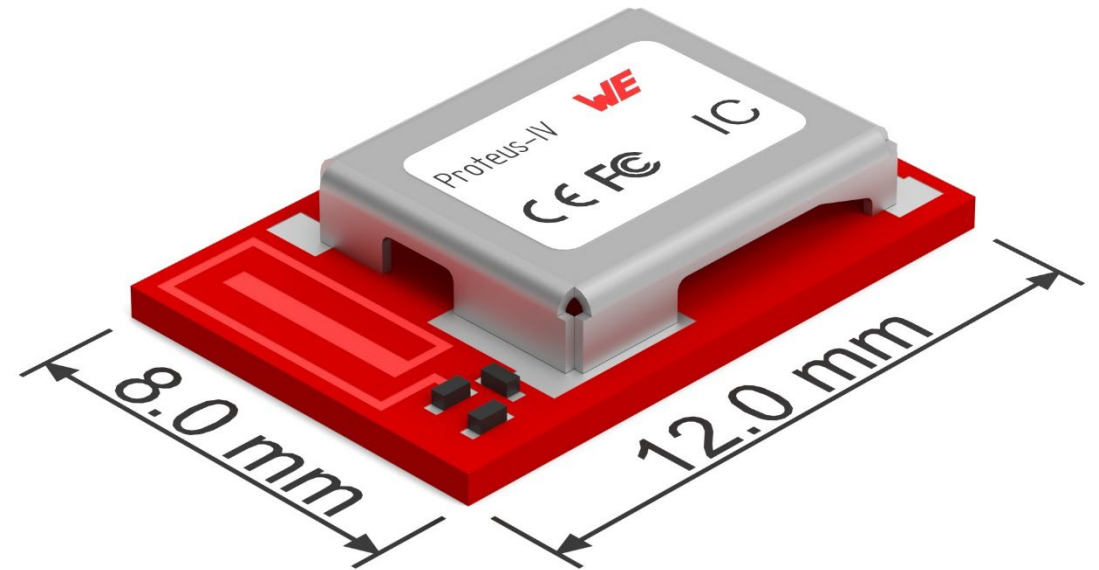
- Always operates at 9600 baud, 8N1, no flow control
- Safe mode for recovery and initial configuration
- Radio disabled during configuration

FOTA Mode

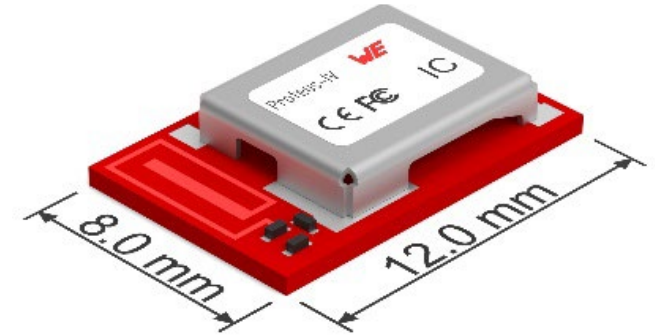
- Wireless firmware updates via BLE
- Uses Simple Management Protocol (SMP)
- Compatible with nRF Connect Device Manager

FLEXIBILITY & CUSTOMIZATION OPTIONS

- **Standard Firmware**
 - Rich command set covering all common BLE operations
 - Configurable parameters stored in flash:
 - UART settings, TX power, device name
 - Advertising intervals, connection parameters
 - Security settings (JustWorks, passkey, etc.)
- **Custom Firmware Capability**
 - Full access to nRF54L15 capabilities:
 - Custom GATT services and characteristics
 - Advanced security features (TrustZone, hardware crypto)
 - Channel Sounding (HADM High Accuracy Distance Measurement)
 - Direction Finding (AoA/AoD)
 - Extended advertising
 - Multi-protocol operation (BLE + Thread/Matter)
 - Custom protocols
- **Development Support**
 - Wireless Connectivity SDK with STM32 examples
 - Application notes and reference implementations
 - Technical support from Würth Elektronik
- **Strategy: Start simple with standard firmware, scale to custom implementation as needed**



PROTEUS-III VS. PROTEUS-IV



Module	Proteus-III	Proteus-IV
Bluetooth® Version	5.1	6.0 (ready for 6.1)
Sleep Current	<1 μ A	<0.6 μ A
Chipset	Nordic nRF52840	Nordic nRF54L15
SDK Platform	nRF5 SDK (maintenance)	nRF Connect SDK (active dev)
Security	Basic	Enhanced
Product Lifecycle	Mature (Released in 2020)	Long-term future (Release soon)

RECOMMENDATION: START NEW DESIGNS WITH PROTEUS-IV

CURRENT WÜRTH ELEKTRONIK BLE MODULE PORTFOLIO

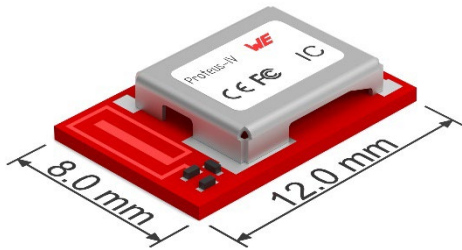
■ **Proteus-e**

- Target: Low cost, compact size applications
- Ultra-compact footprint (7 x 9 mm)
- Essential BLE features
- Cost-optimized for high volume
- **Bluetooth® 5.1**



■ **Proteus-IV**

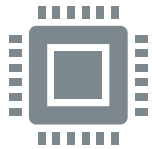
- Target: Full-featured, future-proof designs
- Latest nRF54L15 technology
- Comprehensive feature set
- Maximum flexibility (standard + custom firmware)
- Best choice for new designs
- **Bluetooth® 6.0**



Your Priority	Choose
Smallest size	Proteus-e
Lowest cost	Proteus-e
Simple BLE connectivity	Proteus-e
Latest technology	Proteus-IV
Future-proof design	Proteus-IV
Advanced features	Proteus-IV
Custom firmware needs	Proteus-IV
Long product lifecycle	Proteus-IV

RECOMMENDATION: START NEW DESIGNS WITH PROTEUS-IV

COMPLETE DEVELOPMENT SUPPORT



Hardware

Evaluation boards with USB interface

Breadboard-compatible breakout boards

Complete reference designs



Software

Wireless Connectivity SDK

Example applications for common microcontrollers

UART terminal tools

Configuration utilities



Documentation

Comprehensive datasheets

Application notes

Step-by-step tutorials

API reference



Support

Technical support team

Online forums and community

Training webinars and videos

Custom firmware development services

WHY CHOOSE WÜRTH ELEKTRONIK FOR BLE?



Pre-certified modules

Faster time-to-market, reduced certification costs



Latest technology

nRF54 Series SoCs with Bluetooth® 5.4 / 6.0 features



Flexible firmware

From simple transparent mode to fully custom implementations



Complete ecosystem

Hardware, software, documentation, examples



Expert support

Engineering assistance when you need it



Proven reliability

Würth Elektronik quality standards



Cost-effective

Competitive pricing with Proteus-IV



Long-term commitment

Active SDK development, future-proof designs



**WÜRTH
ELEKTRONIK**
MORE THAN
YOU EXPECT

Questions

& Answers



We are here for you now!
Ask us directly via our chat or via E-Mail.

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