

BLUETOOTH®



OVERVIEW

The Origin of the Name Bluetooth® – an Example of Harmonization of Different Languages

Surprisingly, the name dates back more than a millennia to King Harald "Bluetooth" Gormsson who was well known for two things: Uniting Denmark and Norway in 958 and uniting several languages. His dead tooth, which had a dark blue/grey color, earned him the nickname Bluetooth. That way, the Bluetooth-Logo was created out of the runes for H and B.

$$\begin{array}{c}
 * \\
 \text{Nordic H}
 \end{array}
 +
 \begin{array}{c}
 \text{B} \\
 \text{Nordic B}
 \end{array}
 =
 \begin{array}{c}
 * \\
 \text{Bluetooth}
 \end{array}$$

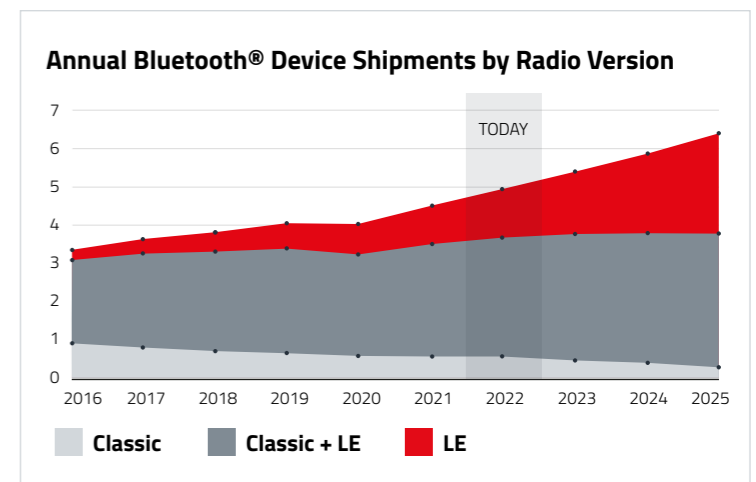
As the aim of Harald was to unite countries and languages the aim of the Bluetooth® interface was to harmonise the communication between different electronic devices.

Bluetooth® – Harmonization of Interfaces

In 1996, three industry leaders, Intel, Ericsson and Nokia, met to plan the standardization of this short-range radio technology to support connectivity and collaboration between different products and industries.

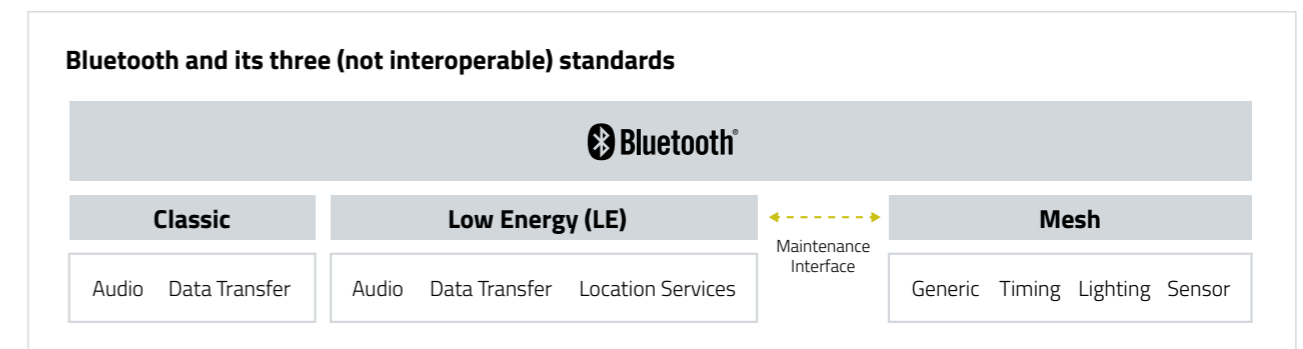
The Amount of Devices is rising steadily

With the success of Bluetooth® connectivity also the number of devices is rising steadily. In 2019 about 4 billion Bluetooth® devices were shipped worldwide. The early classic standard is decreasing while Bluetooth® Smart or also called Bluetooth® Low Energy is fast-growing. Bluetooth® can be found of course in every Phone, Tablet and PC. Connected Devices, Smart Building, Smart Industry, Smart Home and Smart City are the key markets for Bluetooth® Applications.



Bluetooth® as Industrial Communication Interface

Especially in the industry there is a need for easy connecting to different devices by Phone or Tablet. With no need of a display in the device itself, as the Smart Device is used for it, an immense potential of cost reduction is reachable.



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BLUETOOTH® STANDARDS & VERSIONS

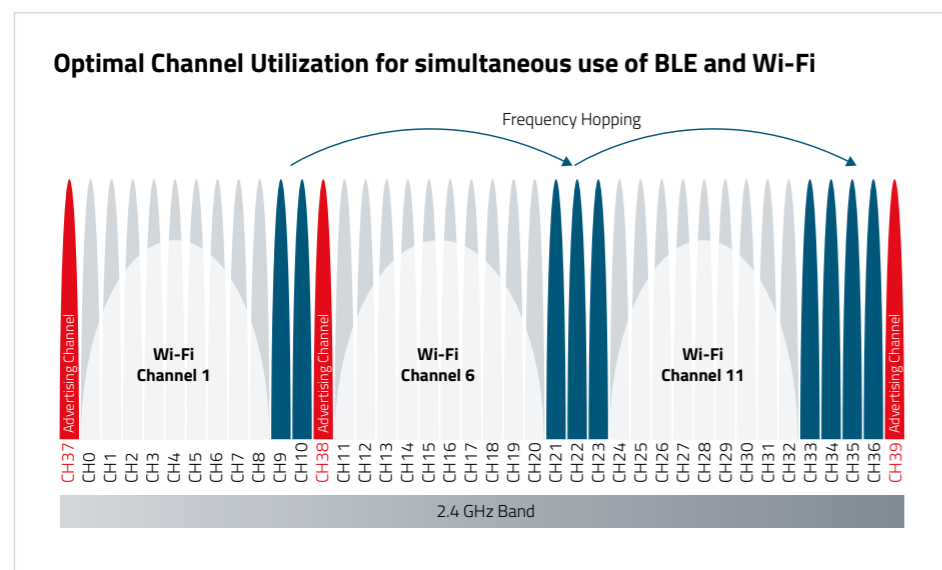
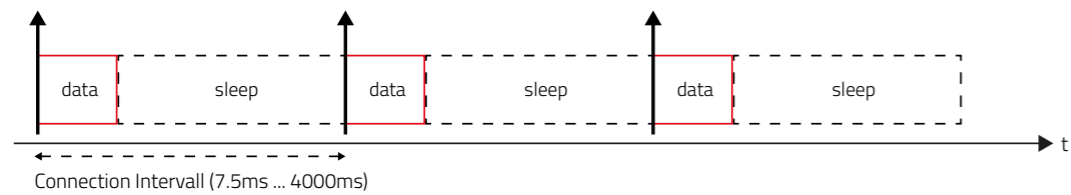
Bluetooth® Classic

- Introduced in Bluetooth® version 1.0
- Bluetooth® Classic versions are backward compatible
- 79 channels with 1MHz bandwidth (2.402 – 2.480 GHz)
- One master, up to 7 slaves
- Time (TDMA) and frequency (FHSS) synchronization done by master
- Slave may send data only if polled by master
- Last enhanced version 3.0. still available but not updated any more



Bluetooth® Low Energy

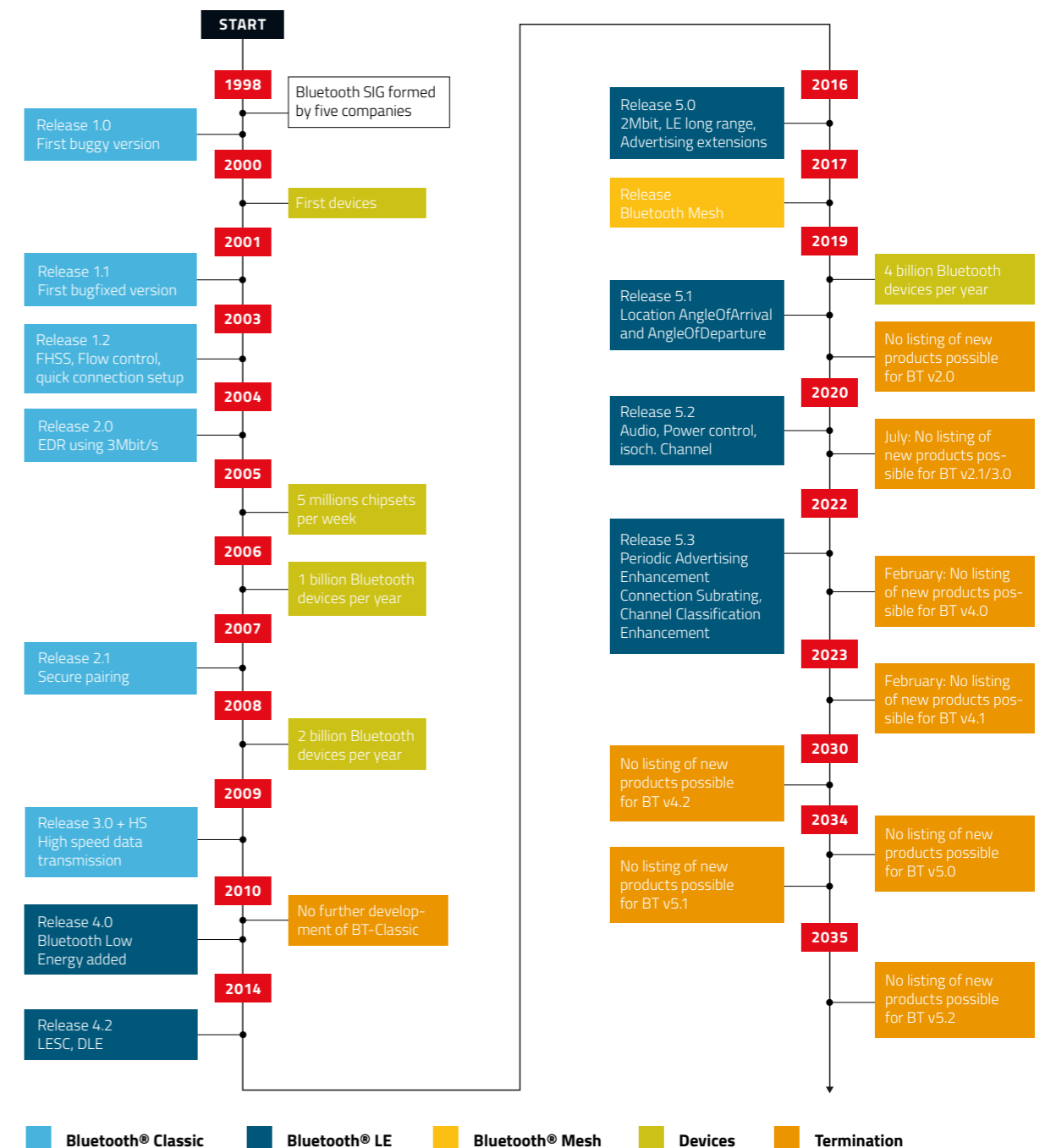
- Defined from Bluetooth® version 4.0 onwards
- Designed for IoT and battery operated applications
- Bluetooth® LE versions are backward compatible
- 40 channels with 2 MHz bandwidth (2.402 – 2.480 GHz)
- Lower transmitting power
- Mainly short connections (to save battery lifetime)
- Different application roles and profiles: Broadcaster, Observer, Peripheral, Central



Bluetooth® Low Energy

- Generic Attribute Profile (GATT) is a generic "language" between Bluetooth® LE devices
- Custom GATT profiles: Amber SPP-like (Serial Port Profile) e.g. Bidirectional transmission of arbitrary data
- Predefined GATT profile:
 - Battery service profile, e.g. Shares value x in percentage 0% (discharged) - 100% (fully charged)
 - Notification service when status changes
 - Link loss service: e.g. Alerts after timeout, or link is lost or user alert

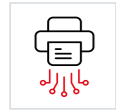
History of Bluetooth®



Withdrawal: Specifications withdrawn by the Bluetooth® SIG are not maintained and will no longer be available for download on the Bluetooth® public website. Members are not permitted to complete qualifications/declarations for any product using those withdrawn specifications.

BLUETOOTH® LOW ENERGY IN GENERAL

Bluetooth® LE roles – connection based



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

Bluetooth® LE roles – connection less



Broadcaster

- Only transmits advertising events
- Example:** Sensor beacon



Obeserver

- Only receives advertising events
- Example:** Beacon receiver

Bluetooth® LE 4.0

- First version of Bluetooth® LE
- Low energy as protocol stack specified
- 31 Bytes per radio data packet (→ low throughput)
- Output power lower than 10 mW (10 dBm)

Bluetooth® LE 4.1

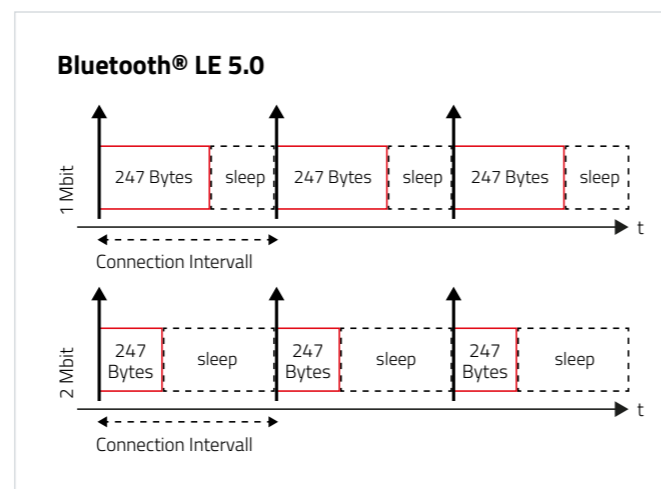
- Better coexistence with 4G radio
- Optimisation of Bluetooth® LE behaviour through configurability of parameters (time interval for reconnection)
- Central and peripheral functions in one device
- New profiles, like IPSP (Internet Protocol Support Profile) for IPv6

Bluetooth® LE 4.2

- (Optional) Data length extension (DLE) to support packets up to 255 Bytes (→ higher throughput)
- (Optional) Additional secure pairing modes (Low Energy Secure Connections - LESC)

Bluetooth® LE 5.0

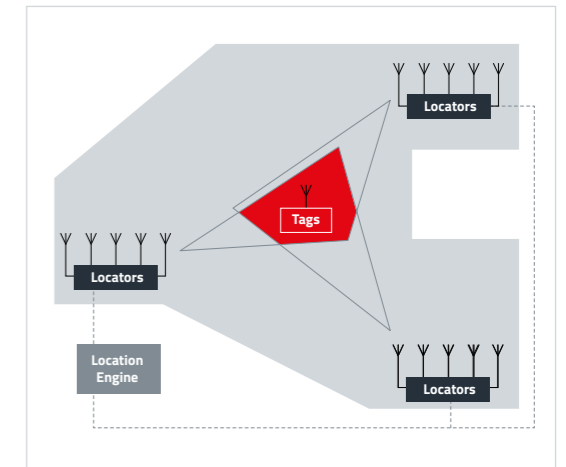
- (Optional) Large advertising packets
- (Optional) New frequency hopping sequence for better coexistence
- (Optional) Increased maximum output power to 100 mW for higher range
- (Optional) 2 MBit/s phy data rate
- (Optional) Higher range due to LE Coded radio (Long Range mode)



i All versions are downwards compatible.

Bluetooth® LE 5.1

- (Optional) Faster connection setup by GATT caching to save the discovery step
- (Optional) Advertising enhancements
- (Optional) Bluetooth® direction finding to detect the direction of a radio signal:
 - Angle of arrival (AoA) for item finding applications
 - Angle of departure (AoD) for indoor positioning applications



Bluetooth® LE 5.2

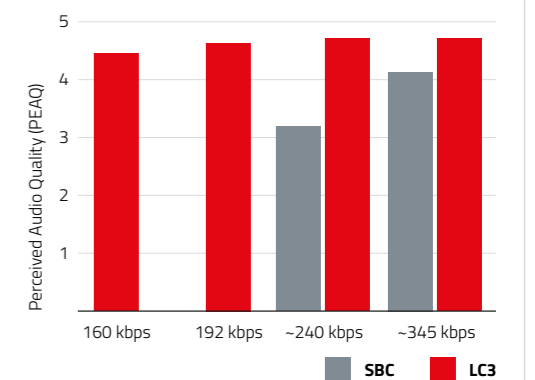
- (Optional) Enhanced Attribute Protocol Sharing radio sources of different profiles in one data packet
- (Optional) Adaptive power control to save power and reduce interference Monitor the RSSI and request the transmitter to reduce/increase its power
- (Optional) LE Isochronous Channels: allows the communication of time-bound data to one or more devices for time-synchronized processing discard data of radio packet after time to live (TTL)
- (Optional) New audio profiles (LE Audio)

Bluetooth® LE 5.2 Audio

- Multistream
 - Independent, synchronous streams
 - More robust and better stereo
- New applications
 - Connect hearing aid to PC, smart phone or TV
 - Broadcast audio sharing, e.g. for cinemas, theaters, airports,...
- Higher quality and less power consumption

	Original	LE Audio	Classic Audio
Codec	None	LC3 (Low Complexity Communication Codec)	SBC (Low Complexity Subband Codec)
Throughput	1.5Mbit/s	192kbit/s	345kbit/s
Energy consumption (radio)	Very High	Low	High
Audio quality	Very High	High	Medium

Bluetooth® Codec Comparison – Standard Stereo Listening Test



Bluetooth® LE 5.3

- (Optional) Periodic Advertising Enhancement
 - Twice detected advertising packets are dropped during reception to save current
- (Optional) Connection Subrating
 - In periods with low traffic a connection may be slowed down temporarily to save current
- (Optional) Channel Classification Enhancement
 - Now the peripheral can also provide a black list of noisy radio channels

BLUETOOTH® SPECIAL INTEREST GROUP (SIG)

Different Memberships

Promoter Members

Have considerable influence over both, the strategic and technological directions of Bluetooth® (Apple, Intel, IBM,...).

Associate Members

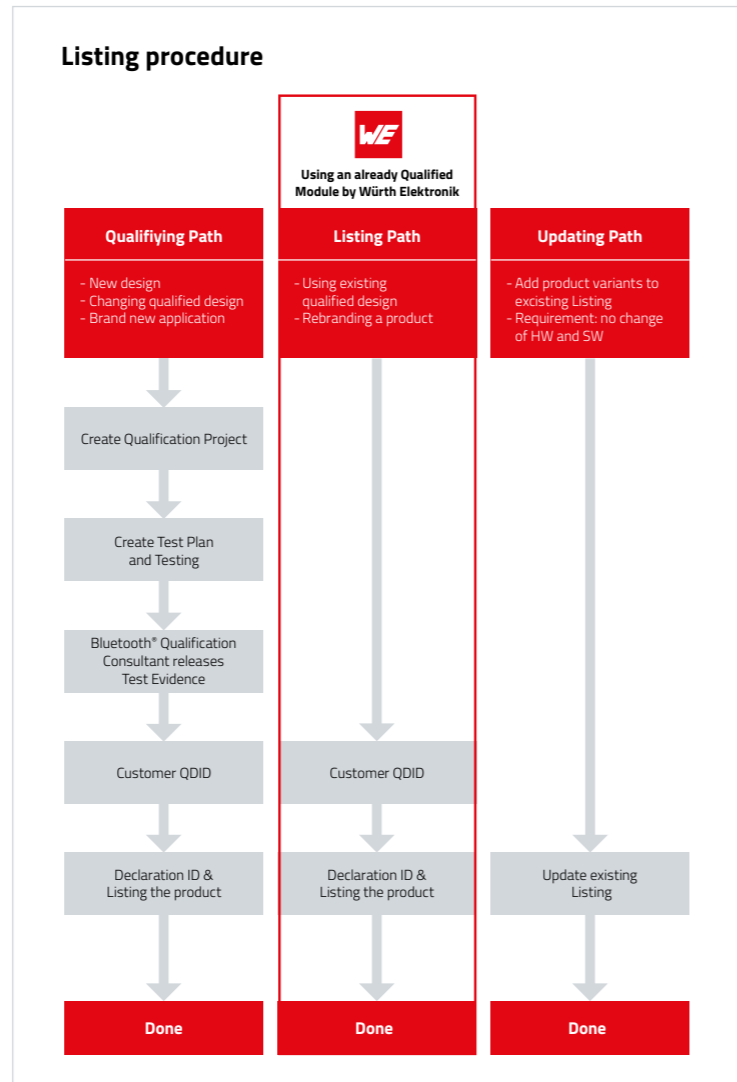
Get early access to draft specifications and are eligible to participate and gain a voting seat in working groups and committees. Furthermore, to work with other Associate and Promoter members on enhancing existing specifications.

Adopter Members

Use published Bluetooth® wireless specifications and Bluetooth trademarks.

Listing - Qualification and Declaration

- The Bluetooth® listing consists of qualification and declaration
- The qualification process is one of the most important aspects of **Bluetooth® technology, supporting interoperability** and conformity to the Bluetooth® specifications
- Bluetooth® Qualification Consultants (BQCs) are available to support members through the processes
- Qualification means the whole process including tests
- Members of the Bluetooth® SIG must complete the qualification and declaration process for their Bluetooth® enabled product to demonstrate and declare compliance
- The distributor is responsible to ensure that the required listing is performed
- A Listing is possible, if an already qualified product is used. Then there is no measuring or testing effort, only declaration and information work to be done
- BT Listing USD 9.600 per end device



Reasons for Bluetooth® in Industry

- ✓ Smart and innovative
- ✓ Robust and open communication
- ✓ Use smart device as display
- ✓ Worldwide common standard

PRODUCT OVERVIEW

	Proteus-e	Proteus-I	Proteus-II	Proteus-III
Order Code (PCB Antenna)	2612011024000*	2608011024000	2608011024010	2611011024000*
Order Code (RF-Pad)		2608011124000	2608011124010	
Chipset	nRF52805	nRF52832		nRF52840
Bluetooth® Standard	5.1	4.2	5.0	5.1
Output Power [dBm]		4		8
Power Consumption Rx [mA]	6.8	5.4		7.7
Power Consumption Tx [mA]	9.3	7.5		18.9
Power Consumption Sleep [µA]	0.3	0.4		0.4
Supply Voltage min - max [V]		1.8 - 3.6		
op. Temp [°C]		-40 ... +85		
Max Datarate [Mbps]	2	1	2	2
Payload [byte]	243	243	964	964
measured Throughput [kbps]	100	80	257	343
Antenna (PCB, RF-Pad, SAS*)	SAS*	PCB / RF-Pad		SAS*
Long range Mode		-		✓
LoS Range (Int / ext. Antenna) [m]	30 / 350	50 / 100		100 / 400
LoS Test Conditions	2 m height, Two-ray ground-reflection, TX and RX antenna gain = 0 dB			
Interface	UART			
SPP-like Profile	✓	✓	✓	✓
USB-Radio Stick	-	-	✓	✓
FOTA	-	✓	✓	✓
Additional GPIO	2	-	-	6
Certification	CE, FCC, IC, TELEC			



Setebos-I Radio Module 2.4 GHz with Proprietary and Bluetooth® LE 5.1 Radio Protocol

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Proteus Connect

The most important benefit of Bluetooth® LE Connections is mostly a mobile app. With the Proteus-App we provide you a fast and easy way of testing and also a base for your own app.

- Smart-Device Mobile App for easy testing for Android and iOS
- Scan – Connect – Transmit Commands directly
- Development files available on GitHub
- Build your own App on base of Proteus-App

we-online.com/Proteus-App



GET IT ON
Google Play

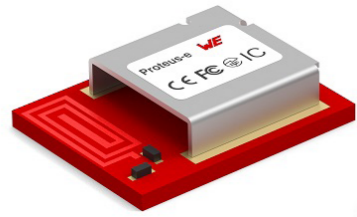


Download on the
App Store

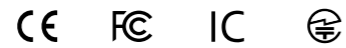
GitHub



OUR SLIM-VERSION: BLUETOOTH® LOW ENERGY 5.1



Proteus-e
Bluetooth® Low Energy 5.1 Standard



Characteristics



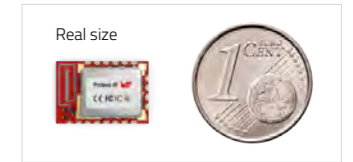
- Bluetooth® 5.1 qualified end product
- Miniaturized design - 7 x 9 x 2 mm
- 64 MHz Arm® Cortex®-M4 processor
- Nordic Semiconductor SoC nRF52805
- 192 kB flash memory, 24 kB RAM
- Up to 4 dBm output power
- 1 Mbit and 2 Mbit radio
- Payload size of up to 243 bytes
- Command –based and transparent UART interface
- Serial data transmission (Smart Serial Profile)
- Peripheral function
- Free definition of advertising packets
- 2 pins for remote GPIO access
- Smart antenna selection (2-in-1 Module)
- CE, FCC, IC, TELEC certification

 we-online.com/Proteus-e

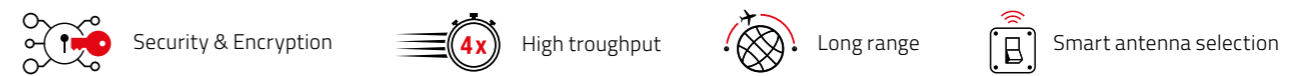
OUR FASTEST: BLUETOOTH® LOW ENERGY 5.1



Proteus-III / Proteus-III SPI
Bluetooth® Low Energy 5.1 Standard with
2 MBit PHY and Coded PHY (long range)



Characteristics



- Bluetooth® 5.1 qualified end product
- Nano SIM size - 8 x 12 x 2 mm
- ARM® Cortex®-M4 32-bit processor with FPU, 64 MHz
- Nordic Semiconductor SoC nRF52840
- 1 MB flash memory, 256 kB RAM
- Up to 8 dBm output power for higher range
- 1 Mbit and 2 Mbit radio and long range modes
- High throughput mode, 4 times higher throughput with payload size of up to 964 bytes
- Scan and Connect in long range mode
- Improved throughput with transparent UART interface (Peripheral only mode)
- Serial data transmission (Smart Serial Profile)
- LE Secure Connections (LESC)
- Connect (1:n / n:1) as central or peripheral
- 6 configurable digital GPIOs (local & remote)
- Smart antenna selection (2-in-1 Module)
- Also available as proprietary radio module (Thyone-I)
- CE, FCC, IC, TELEC certification

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Webinar:
Bluetooth® LE - new adaptations



BLUETOOTH® CLASSIC



Puck-I
Bluetooth® Classic Radio Module

CE FC IC



Characteristics

- Bluetooth Classic Audio
- Small form factor
- Bluetooth® SPP Profiles

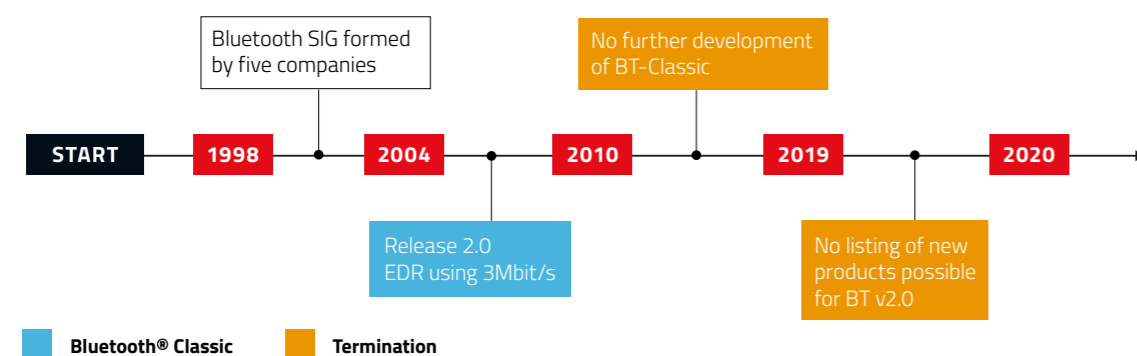
- Embedded Bluetooth® 2.0 RF module (Class 2)
- Former: BlueNicecom4 (AMB2301)
- Digital AUDIO interface (PCM interface)
- Integrated profiles: SPP, GAP, SDAP
- Supported profiles: DUN, FAX, FTP, HSP, HFP, OPP, SYNC, BIP, BPP
- Small form factor
- Integrated PCB antenna
- UART interface with programmable baud rate
- Quick-Start Evaluation Kit available
- EN 300 328 compliant

IMPORTANT NOTE

As it is not possible to add or change a listing based on the withdrawn Bluetooth® Specification 2.0 this module is not recommended for new designs.

- It is the customers responsibility to list its products with BT SIG
- Würth Elektronik still sells the products to customers, even long term

History of Bluetooth® Classic



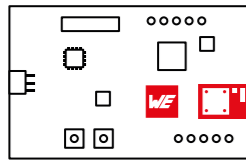
we-online.com/Puck-I



THE FUTURE IS WIRELESS

ADDED VALUES

Development Tools



Eval Boards

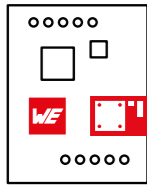
- Easy testing
- Rapid prototyping
- FTDI integrated (UART to USB)
- Pins available on header
- Current measurement



we-online.com/EVAL-BLE



More information on page 150



Mini Eval Boards

- Application-oriented, cost-effective and compact size
- USB connection with FTDI-cable possible (available as accessory)



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More information on page 150



USB-Radio Stick

- USB-FTDI-Proteus-III
- Bluetooth®-Listing included



we-online.com/USB-BLE



More information on page 150



Smart Commander

- PC-Tool for easy testing
- AT-Commands as buttons
- Monitoring UART-Communication
- Export Commands for easy integration in the former HOST-Controller
- Test Bluetooth®-App-Connectivity easily



we-online.com/SmartCommander

AppNotes



Proteus: Low Power Application With Periodic Wake-Up

we-online.com/ANR003



Proteus: How To Use The Peripheral Only Mode

we-online.com/ANR004



Proteus: High Throughput Mode

we-online.com/ANR006



Proteus Quickstart: Connect a smart phone to a Proteus

we-online.com/ANR014



Proteus-III: Advanced Developer Guide

we-online.com/ANR009



Proteus-III: Remote GPIO control – How To

we-online.com/ANR020



Proteus-E Advanced Developer Guide

we-online.com/ANR024



Proteus-E Quickstart

we-online.com/ANR025



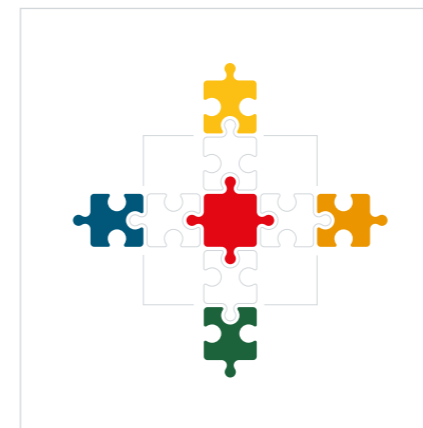
Bluetooth® Listing Guide

we-online.com/ANR027



nRF Connect

we-online.com/ANR030



Software Development Kit

- Typically as C-Files, for mobile Apps platform specific languages
- For comfortable coding of:
 - The HOST-controller system
 - PC Applications & Mobile Apps
- Code examples in Application notes and Manuals



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