

Dräger Bluetooth Platform

Dräger BT-modules

BT-01 & BT-02

Datasheet

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1 Product Overview

1.1 Functional description

Primary intended purpose of the Dräger BT-modules is to provide Bluetooth 5.1 low energy communication capability to Dräger products by populating a Dräger BT-module at production lines on product PCB's and flashing an appropriate BLE-firmware to the module.

Technical use case of the BT-module is to operate as a communication gateway between the product MCU wired to a serial UART port and a peer device connected via Bluetooth low energy (BLE).

The Dräger BT-module hardware is based on the Nordic Semiconductor nRF52840 chip that includes an integrated 2.4 GHz transceiver with +8 dBm output power and powerful Arm® Cortex®-M4 with FPU processor.

The BT-modules usage is supported by Dräger BLE-platform firmware, which provides a set of defined services to configure BLE-settings, control of BLE-connections to peer devices and to transmit / receive payload associated with established BLE-connections. The services can be accessed from products by defined service messages on the UART-interface.

For universal and transparent gateway communication of any content, the *Dräger GATT UART Service* is provided, which can be accessed by the "Passthrough" service from the UART-interface and by the GATT Service from connected BLE-peers.

For products, which need to communicate with specific GATT services given by existing peer devices, the BLE platform firmware architecture supports optional extension of GATT-service integrations and corresponding service handlers for routing the content to corresponding service-messages on the UART-interface.

Furthermore, the Dräger BT-modules are designed to fulfill the ATEX, IECEx requirements.

1.2 Hardware variants

Driven by the ATEX, IECEx requirements, the reduced limit of capacitance and inductance have been considered at the hardware circuitry design to enable the modules as integration option for product that need to fulfil these standards.

The primary scope is Bluetooth low energy, but flexible radio hardware that covers prospects by options to utilize BT 5.1 functionality (long range EDR/BR, low energy mode, mesh-networking) has been considered.

Initially two hardware variants of the Dräger BT-module have been developed to provide suitable solution for two different product integration scopes:

- Variant A: small overall package, no external antenna option, no pin-routing constraints
- Variant B: pin-compatibility to Telit S42 modules; option for external antenna connection

This results in BT01 module (9x11mm) for variant A and BT02 module (17x10mm) for variant B use cases.

1.2.1 BT01 (9 x 11 mm)

The Dräger module contains the nRF52840 Chipset from Nordic Semiconductor. Due to space requirements a small footprint ceramic loop antenna is used. Note that in this variant there is no option to use an external antenna. In addition to that, a low frequency crystal (32,768 kHz) is placed on the module.

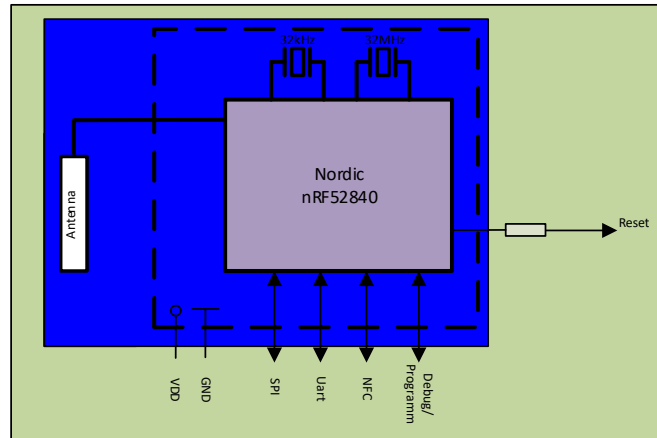


Figure 1.2-1:Block Diagram Dräger BT Modul 9x11mm

Key features are:

- small size 11x9mm,
- ceramic antenna on PCB

1.2.2 BT02 (17 x 10 mm)

The 17x10mm Dräger BT Module variant shall be used in existing projects as a replicant for actual used BT-Modul Telit S42. The Dräger BT Module is pin compatible with the Telit S42 but features more functionality by having four times more memory capacity and supports more BT5 features.

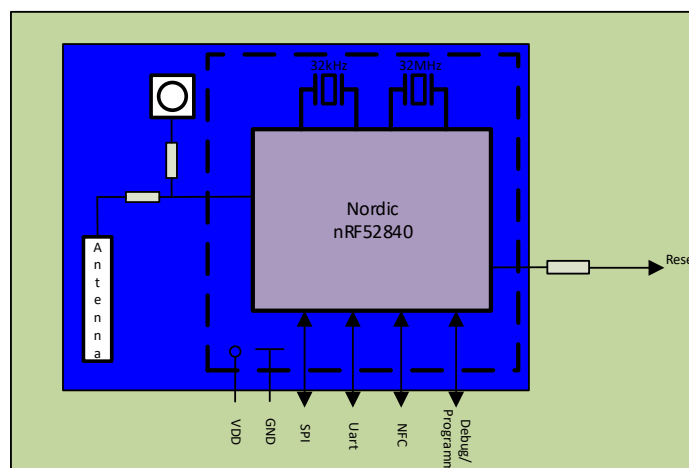


Figure 1.2-2:Block Diagram Dräger BT Modul 17x10mm

Key features are:

- medium size 10x17mm
- Telit S42 compatible pad footprint
- prepared for external antenna

1.3 Software architecture

The software designed for the Dräger BT-modules is dedicated to being flashed and process on the nRF52840 ARM-Cortex 4 chips from Nordic, which is populated on the BT-module. In general, the BT-modules in conjunction with the Dräger BLE-Firmware operate as a communication gateway for Dräger products. The product application firmware controls and communicates to the BT-module via service-messages on a serial UART-line - the BLE-firmware transfers the communication-payload to GATT-communication services associated to the BLE-stack. The BLE-Firmware is based on a Dräger BLE software platform core and optional product specific extensions. For an overview of the included software architecture, refer to the decomposition figure below.

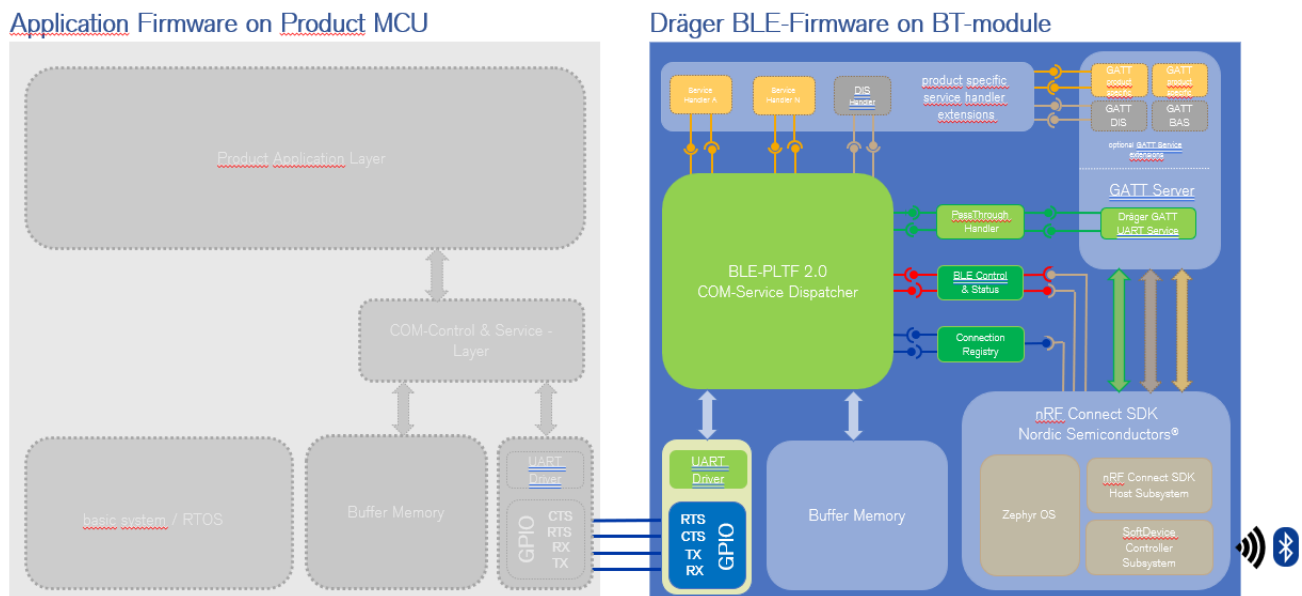


Figure 1.3-1: software architecture with decomposition of BLE-Firmware hosted on Dräger BT-modules

1.3.1 nRF Connect SDK

This software package includes the complete Bluetooth-Stack implementation for the nRF52840 chip. The Bluetooth-Stack is provided by Nordic Semiconductors and contains the Host- and Soft-Controller implementations for the radio hardware realized within the chip.

These software instances are registered pre-qualified designs at the Bluetooth-SIG, which is an advantage for the mandatory product qualification process at the Bluetooth-SIG, to get confirmation for selling products associated with the Bluetooth label and Bluetooth compatibility statement.

1.3.2 Zephyr OS

The Host- and Soft-Controller instances of the nRF Connect SDK package are designed to be driven by a Zephyr OS.

The baseline of Zephyr OS is provided and maintained by an open-source project community, but Nordic selects dedicated versions, maintains specific settings to assure reliable and robust BLE-Stack behavior and includes this Zephyr OS variants into their nRF Connect SDK packages.

Since the Zephyr OS offers a huge set of generic software system features, some provided features will be considered and used by the Dräger BLE platform core application as well. (i.e. net_buf for buffer-handling)

1.3.3 Dräger BLE platform core

The Dräger BLE platform core includes software components that realize a generic gateway-application between the service-layer interface to the product for control requests and status exchange with the Nordic BLE-Stack and the routing of communication payload by associated handler. The handlers transfer the data to corresponding GATT-services for transmission via BLE and vice versa received data from the BLE-Stack towards the COM Service Dispatcher.

The COM Service Dispatcher is the heart of the application, which performs the dispatching of service-messages and routes the identified services to corresponding service handlers and vice versa.

The handlers take care to perform the individual operations requested by the corresponding services. There are control services to configure settings of the BLE-Stack, to enable/disable BLE advertising / scanning activities and to control the connection state with peer devices. The core supports handling of simultaneous BLE-connections up to a maximum amount of 20.

The included “Passthrough” service is a generic RX/TX data-transfer service for transparent data-payload without any specific data content format, like a serial data-stream on a UART-line. This service is dedicated as preferred data-transport channel for any communication use cases on Dräger systems. This service is associated to the “Dräger GATT UART service”, which is compliant for any data in format of a serial data-stream. The product application and connected peer devices need to take care about an application layer protocol within their implementation context to encode/decode the data-content transferred by this service.

1.3.4 Product specific service extensions

It is obvious, that some products may come up with the demand to communicate with other GATT-services, defined or expected from existing peer devices.

For these cases, the Dräger BLE software architecture supports expandability by optional integration of a GATT-Client or additional GATT-services and characteristics hosted on the GATT-Server. The additional corresponding service-handlers, which utilize these specific GATT-services need to be registered at the service-dispatcher with the association of a unique service-message ID of the service-layer definition.

In any case, this results into a product specific variant of the BLE-firmware and may result into additional product qualification effort with the Bluetooth-SIG to approve conformity with considered GATT-services.

The radio approval of the BT-modules should not be affected by GATT-Service extensions.

1.3.5 Bootloader

The Dräger BLE software platform includes firmware update capability provided by mcuBoot of the Zephyr OS. It supports a 2-memory partition setup – the primary partition holds the current, valid program, the second partition could be written on a DFU-scenario utilized by Zephyrs SMP during runtime of the current program on the primary partition. The update scenario includes a consistency checkup and a signature checkup to assure only non-corrupted and authenticated updates could get activated. The decision to switch to an uploaded, validated firmware can be triggered by the connected update tool or the product application.

The interface to perform the update is configurable and could be accessed via the two physical interfaces of the gateway: a) via the serial UART-line connected to the product application. b) via Bluetooth (OTA).

1.3.6 DTM-Firmware

The DTM Firmware is a specific test application to stimulate the BLE radio hardware according to typical test cases for radio approval qualification measurements. The DTM application source code is also provided by Nordic Semiconductors to support radio approval tests for the nRF528xx chip family. For Dräger BT-modules this firmware is built as a separate variant and is currently not included in BLE-firmware applications for product use cases but based on the identical BLE-Stack. Furthermore, it is enhanced with some test commands for quality assurance on the production line of Dräger BT-modules. Please refer to [2] and [3] for details of DTM test setups and integrated DTM test options and commands with the 2-wire UART interface.

1.4 Example applications

- Dräger Personal Air Monitoring Devices (X-AM 28/5800)
- Dräger COM-Gateway to GDC (Connectivity Hub)
- Dräger Alcotest® (A4000, A6000)

2 System Features

The Dräger BLE module is engineered to provide robust and efficient communication capabilities. The following comprehensive set of features ensures that the Dräger BLE module is well-suited for diverse applications requiring reliable wireless communication and efficient power management.

2.1.1 Power Management

Designed to operate with minimal power requirements, the module necessitates only a single supply voltage for operation. All required voltages for BLE communication are internally converted, ensuring streamlined power management, and reducing external power regulation needs.

2.1.2 Reset Functionality

An external reset pin is available, providing the ability to perform hardware resets of the BLE module. This feature ensures recovery from fault conditions and maintenance of operational stability.

2.1.3 RF Antenna Interfaces

2.1.3.1 Bluetooth Communication Interface

The module supports Bluetooth communication through a 2.4 GHz RF antenna interface. It is equipped with an internal chip antenna for compact installations, while also allowing the connection of an external antenna for enhanced range or custom configurations.

2.1.3.2 NFC Integration

An RF antenna interface is provided for connecting to an external NFC antenna, enabling the module to function as an NFC-A tag. This facilitates proximity-based interactions and data exchanges.

2.1.4 Clock Accuracy

2.1.4.1 Low frequency clock

To optimize power consumption, the module incorporates an internal 32.768 kHz crystal oscillator. This enhances the accuracy of the sleep clock, thereby minimizing active power usage and prolonging battery life.

2.1.4.2 High frequency clock

A high-frequency 32 MHz crystal oscillator is included specifically for RF communication, ensuring precise and stable frequency control for reliable wireless signal transmission.

2.1.5 Flexible Interface Options

The primary integration interface for Dräger BT01 and BT02 modules is the UART interface, employing RX/TX lines and optional RTS/CTS handshake lines for flow control with the microcontroller of the integrating product. Additional IO ports of the nRF52840 SoC are routed to connectable pads on the Dräger BLE-module PCB, serving as supplemental IOs for product-specific applications, enhancing customization and integration flexibility. These GPIO pins support a variety of interfaces, including protocols such as UART (Universal Asynchronous Receiver-Transmitter), SPI (Serial Peripheral Interface), and I²C (Inter-Integrated Circuit).

3 Package and Pinning Definitions

3.1 BT01 – 9x11 mm Package

Figure 3.1-1: BT01 Module Pinout (Top View) is showing the BT01 module pinout including the required footprint, copper and copper cut-out requirements. The copper cut-out must be maintained on all layers underneath the antenna.

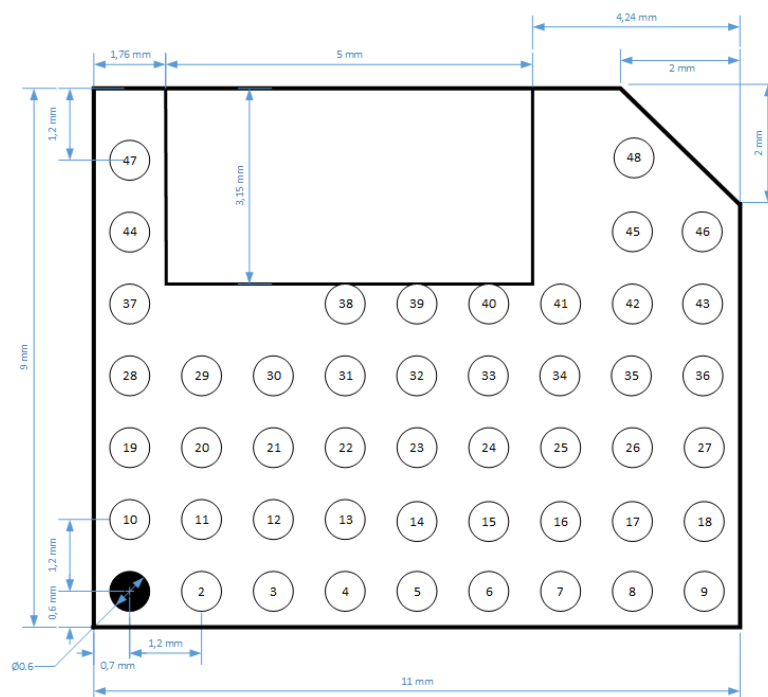


Figure 3.1-1: BT01 Module Pinout (Top View)

3.2 BT02 – 9x11 mm Package

Figure 3.2-1: BT02 Module Pinout (Top View) is showing the BT02 module pinout including the required footprint, copper and copper cut-out requirements. The copper cut-out must be maintained on all layers underneath the antenna.

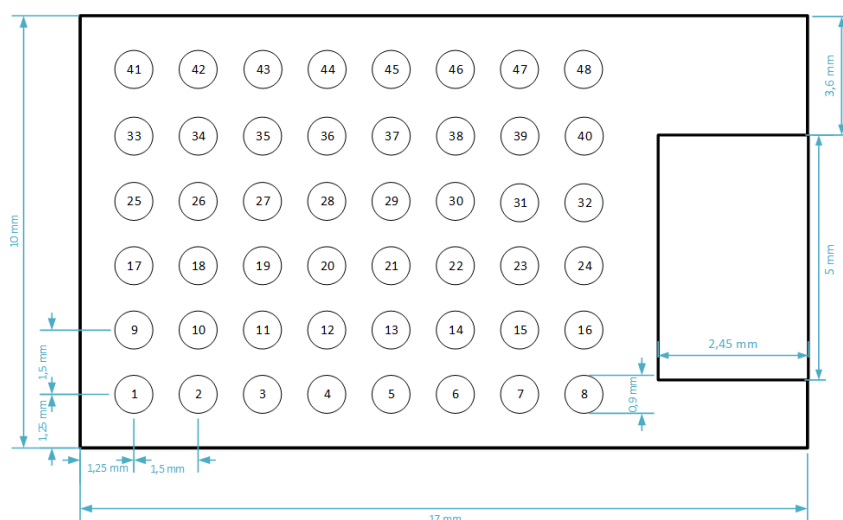


Figure 3.2-1: BT02 Module Pinout (Top View)

3.3 Library Part and Footprint

A symbol and footprint can be found in Dräger global Mentor Library:

BT-Modul	Part Number	Dataset
BT01 (9 x 11mm)	3711863	10002160
BT02 (17 x 10mm)	3709318	10000560

Table 1: Footprint Part-Numbers

3.4 Port Functions and Pin Assignment List

Table 2 – shows the available port pins on the Dräger BLE modules BT01 and BT02. And provides information regarding the pin assignments to above shown packages.

nRF Pin Name	Dräger Module pin		Function 1	Function 2	Function 3
	BT01	BT02			
GND	1, 3, 6, 8, 9, 12, 19 - 24, 28 - 30, 37 - 48	7, 8, 15, 16, 24, 29 - 32, 37 - 40, 47	Ground	-	-
NFC1 / P0.09	10	43	NFC antenna connection	Digital I/O (Standard drive only)	
NFC2 / P0.10	11	44	NFC antenna connection	Digital I/O (Standard drive only)	
P0.02 / AIN0	32	21	Digital I/O (Standard drive only)	Analog Input	
P0.03 / AIN1	31	13	Digital I/O (Standard drive only)	Analog Input	
P0.04 / AIN2	36	36	Digital I/O	Analog Input	
P0.05 / AIN3	35	2	Digital I/O	Analog Input	
P0.06 / IO	-	25	Digital I/O	-	
P0.07 / TRACECLK	25	28	Digital I/O	DEBUG Trace buffer clock	
P0.08 / IO	-	1	Digital I/O	-	
P0.11 / TRACE2	18	17	Digital I/O	DEBUG Trace buffer TRACEDATA [2]	
P0.12 / TRACE1	27	42	Digital I/O	DEBUG Trace buffer TRACEDATA [1]	
P0.13 / IO	17	4	Digital I/O	-	
P0.14 / IO	16	18	Digital I/O	-	
P0.15 / IO	-	26	Digital I/O	-	
P0.16 / IO	15	23	Digital I/O	-	
P0.17 / IO	14	3	Digital I/O	-	
P0.18 / nRESET	7	33	Digital I/O	External device reset pin	
P0.20 / IO	-	35	Digital I/O	-	

nRF Pin Name	Dräger Module pin		Function 1	Function 2	Function 3
	BT01	BT02			
P0.21 / IO	-	46	Digital I/O	-	
P0.22 / IO	-	41	Digital I/O	-	
P0.25 / IO	-	45	Digital I/O	-	
P0.26 / IO	-	9	Digital I/O	-	
P0.27 / IO	-	19	Digital I/O	-	
P0.28 / AIN4	33	27	Digital I/O (Standard drive only)	Analog Input	
P0.30 / AIN6	34	20	Digital I/O (Standard drive only)	Analog Input	
P0.31 / AIN7	-	34	Digital I/O (Standard drive only)	Analog Input	
P1.00 / TRACE0	13	5	Digital I/O	DEBUG Trace buffer TRACEDATA [0]	Serial Wire Output (SWO)
P1.09 / TRACE3	26	10	Digital I/O	DEBUG Trace buffer TRACEDATA [3]	
SWDCLK	4	22	Serial Wire Debug Clock input		
SWDIO	5	11	Serial Wire Debug I/O		
Vcc	2	6, 14	Supply Voltage		
N.C.	-	48	Not connected		

Table 2 – Pin Assignment List

Note: Standard drive only I/O Pins are low frequency I/O pins with a signal frequency up to 10 kHz.

4 Electrical specifications

4.1 Absolute maximum ratings

The following specified absolute maximum ratings shall not be exceeded under all circumstances otherwise the module might be destroyed.

Symbol	Description	min	max	Unit
V_{CC}	Supply voltage	-0,3	3,9	V
$t_{rise_V_{CC}}$	Maximum rise time of Supply Voltage (0 V to 1,7 V)		60	ms
V_{IN_IO}	Digital interfaces input voltage ($V_{CC} \leq 3.6V$)	-0,3	$V_{CC} + 0,3$	V
V_{IN_IO}	Digital interfaces input voltage ($V_{CC} > 3.6V$)	-0,3	3,9	V
V_{GND}	System Ground		0	V
I_S	Operating current	0	35	mA
I_{NFC}	Max. NFC input current		80	mA
RF_{IN}	RF input level		10	dBm
$T_{Storage}$	Storage Temperature Range	-40	85	°C
n_{Flash}	Flash Write and Erase cycles	10.000		Cycles
t_{ret}	Data Retention Time (at 85°C)	10		years

Table 3: Absolut maximum operating condition

4.2 Maximum ESD ratings

Parameter	Min	typ.	Max	Unit	remarks
ESD sensitivity on all pins			1	kV	human body model class 1C according to JEDEC JS001
			500	V	charged device model according to JESD22- C101
ESD indirect contact discharge			4	kV	According to EN 61000-4-2

Table 4: maximum ESD ratings

4.3 Recommended operating conditions

Unless otherwise specified, all given parameters are specified for an ambient temperature of 25°C with a supply voltage of 3.3V.

Symbol	Description	min	typ.	max	Unit
V_{CC}	Supply voltage	2,5		3,6	V
V_{POR}	Vcc Supply voltage threshold for power-on reset	1,75			V
T_{amb}	Operating temperature range	-40	25	85	°C
$T_{junction}$	Junction temperature			90	°C

Table 5 : Recommended operating conditions

4.3.1 Current consumption

The following consumption values have been taken with the Power Profiler tool from Nordic and a communication test-setup of two nRF52840 DK-Boards operating the Dräger BLE platform firmware. The power consumption depends on the individual settings of intervals and payload size of transferred data, therefore the summarized values provide an overview about typical ranges in dependency to a set of chosen settings but must not be considered as fixed reference for any product.

Settings: max. output power = 0 dBm

Mode	Description	accumulated Charge	typical max Current
Idle	no BLE communication Duration: 120 sec.	3,71 ... 3,99 mC	16,47 mA
Advertising	Adv. Interval: 1 sec, Duration: 120 sec, Frame size: 14 bytes "name" 12 bytes MSD	4,33 ... 5,41 mC	16,07 mA
Scanning	Scan. Interval: 900 ms, Window: 150 ms Duration: 120 sec,	215,03 ... 215,93 mC	18,3 mA
Passthrough	Payload: 100 x 1kByte Connection interval: 100ms Connection interval: 200ms	22,87 ... 24,72 mC	23,20 mA
	Payload: 200 x 0,5kByte Connection interval: 100ms Connection interval: 200 ms	23,25 ... 25,26 mC	23,9 mA
	Payload: 400 x 0,25kByte Connection interval: 100ms Connection interval: 200 ms	29,70 ... 33,79 mC	23,8 mA

Table 6 : Current consumption

4.3.2 RF-Performance

4.3.2.1 Receiver Sensitivity

$V_{cc} = 2,5 \text{ V to } 3,6 \text{ V}$, $T_{ambient} = +20^{\circ}\text{C}$

Measured conducted according to “Bluetooth Core Specification v5.4 – RFPHY TS.p23”

Symbol	Description	min	typ.	max	Unit
$P_{sense_IT_SP_1M_BLE}$	Sensitivity, 1 Mbps BLE ideal transmitter, packet length ≤ 37 bytes, BER=1E-3		-92		dBm
$P_{sense_IT_LP_1M_BLE}$	Sensitivity, 1 Mbps BLE ideal transmitter, packet length ≥ 128 bytes, BER=1E-4		-91		dBm
$P_{sense_IT_SP_2M_BLE}$	Sensitivity, 1 Mbps BLE ideal transmitter, packet length ≤ 37 bytes		-89		dBm
$P_{sense_IT_BLE_LE125k}$	Sensitivity, 125 kbps BLE mode		-100		dBm
$P_{sense_IT_BLE_LE500k}$	Sensitivity, 500 kbps BLE mode		-96		dBm

Table 7: Receiver Sensitivity

4.3.2.2 Transmit Power

$V_{cc} = 2,5 \text{ V to } 3,6 \text{ V}$, $T_{ambient} = +20^{\circ}\text{C}$

Measured conducted according to “Bluetooth Core Specification v5.4 – RFPHY TS.p23”

Symbol	Description	min	typ.	max	Unit
LP_RF	max. output power over Antenna with 8 dBm Power Level	4	6	8	dBm

Table 8: Transmit Power

IMPORTANT HINT: Please refer to chapter 8.2 for further information about limitations of the transmit power setting.

4.3.3 Startup times

The typical start-up times after Power-On Reset (POR), Hardware reset via nRESET or Software reset are:

Symbol	Description	min	typ.	max	Unit
$t_{total_start-up}$	Total start-up time		1518		ms
$t_{Bootloader_start-up}$	Start-up time of the bootloader		460		ms
$t_{bl_loading_fw}$	Firmware loading time of the bootloader		620		ms
$t_{fw_start-up}$	Start-up time of the firmware		430		ms
$t_{init_communication}$	Time until communication is available after firmware start-up		8		ms

Table 9 - Start-up times

4.3.4 LFXO crystal specifications

Symbol	Parameter	typ.	Unit
F _{NOM_LFXO}	Nominal Low Frequency Oscillator Frequency	32,768	kHz
F _{TOL_LFXO_BLE}	Low Frequency Oscillator Tolerance	± 25 + ±3 / year	ppm

Table 10: LFXO crystal specification

4.3.5 nRESET pin

Parameter	Min	typ.	Max	Unit	remarks
Internal Pull Up resistance		13		kOhm	
RESET duration		55		ms	

Table 11: nRESET pin parameters

4.3.6 Digital pins

Symbol	Parameter	Min	typ.	Max	Unit
V _{IN_Low}	Low Level Input Area	0		0,3 x V _{CC}	V
V _{IN_High}	High Level Input Area	0		0,7 x V _{CC}	V

Table 12: digital pins parameter

4.3.7 BT01 Radiation patterns

The radiation patterns of the BT01 module are available for internal use only. Please refer to ARAS document 11405050.

4.3.8 BT02 Radiation patterns

The radiation patterns of the BT02 are dependent from the attached external antenna. Please refer to the antenna datasheet.

5 Exploration Tests

5.1 Data Throughput

Since Bluetooth Low Energy (BLE) is designed for constraint components with limited energy, a set of parameters comes along to configure the communication as an optimized tradeoff between communication use cases and the corresponding energy consumption. The set of parameters includes configurable options like connection interval, peripheral-latency and max. payload packet size and many other details, which affect the overall possible throughput. The following section summarizes the most important parameters and provides an overview of their impact on throughput in conjunction with some typical settings and gives examples of payload sizes.

Anyway, the BT-module operates as gateway, therefore the weakest chain link limits the maximum throughput capability of the gateway– this includes also the UART-communication to the product controller.

In case the UART supports bi-directional communication with reactive hardware-handshake RTS/CTS lines and a high baud rate setting > 500 kbps, the UART is typically not the limiting instance.

If not specified otherwise, the following settings were used.

Parameter	Setting value	Unit
Connection Interval (BLE)	100	ms
Peripheral Latency (BLE)	0	-
LL MTU (BLE)	251	bytes
L2CAP / ATT MTU (BLE)	498	bytes
Payload Size (Application)	1024	bytes

Table 5.1-1: default settings & pre-conditions of data throughput explorations

5.1.1 Buffer configuration

The gateway functionality requires buffer capabilities to assure intermediate storage of RX/TX communication frames. This is necessary to avoid data loss of incoming receive events on both physical interfaces, while the COM-dispatcher performs its task to route the frames to corresponding handlers.

Based on optimization analysis to achieve the maximum throughput, following buffer configurations for BLE RX/TX frames have been derived and established:

- CONFIG_BT_BUF_ACL_TX_COUNT ≥ 25
- CONFIG_BT_BUF_ACL_RX_COUNT ≥ 25

5.1.2 Peripheral Latency

The Peripheral Latency is a BLE parameter that defines the acceptable tolerance of unused connection intervals by the peripheral before the connection loss detection is triggered. This feature is intended to reduce energy consumption on a BLE peripheral if no data content update is present.

The value of the parameter is given as a factor of connection intervals within the range [0...499] and could be modified dynamically by the product application during runtime via the service interface.

The default setting of the BLE-platform architecture is 7 but could be adjusted to product demands for each product firmware individually.

5.1.3 Payload size of packages to transmit via BLE

The size of the packages to transmit via the passthrough services has the highest impact on the data-rate. Larger packets have an advantage of less overhead on packet-header and arbitration but at a specific point larger packets have diminishing returns.

Below is a chart, which shows the effect of the package size on BLE throughput. The measurements were taken when sending from a BLE device to the product firmware. A connection interval of 100ms was used.

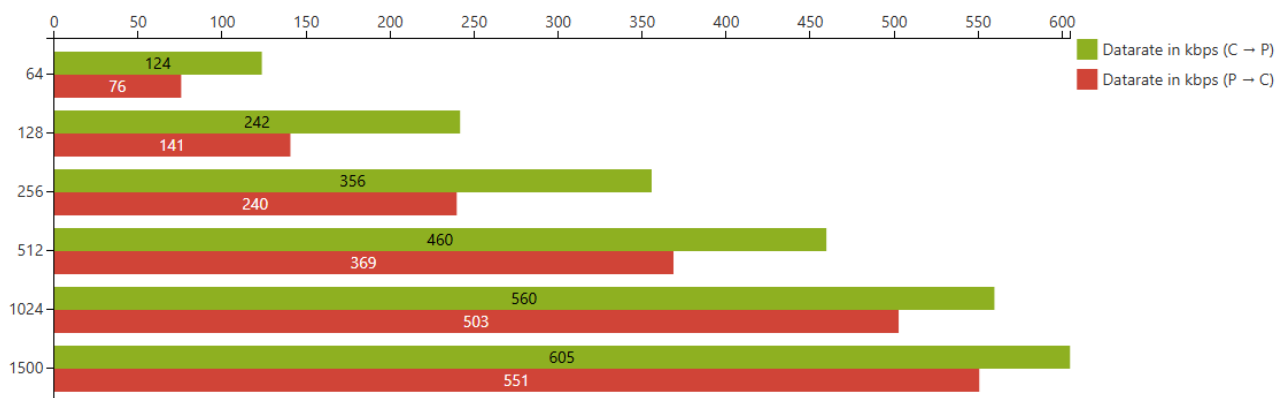


Figure 5.1-1: data-rate in dependency to payload sizes.

Observed deviations of data-rates are not caused by the BLE roles only (C=Central; P=Peripheral), but in conjunction with associated BLE GATT Client and BLE GATT Server instances associated to a role.

payload size [bytes]	data-rate as Central with a GATT-Client [kbps]	data-rate as Peripheral with a GATT-Server [kbps]
64	124	76
128	242	141
256	356	240
512	460	369
1024	560	503
1500	605	551

Table 13: data-rate in dependency of payload packet size

5.1.4 Connection Interval

The connection interval is a BLE parameter that defines the periodic time interval, when connected peers are scheduled to perform communication. The parameter is negotiated during connection establishing scenarios, between BLE Peripheral and BLE-Central devices. The BLE peripheral could suggest a preferred setting – the BLE central will admit the concluded setting.

5.1.4.1 Throughput with payload chunks of 1024 bytes

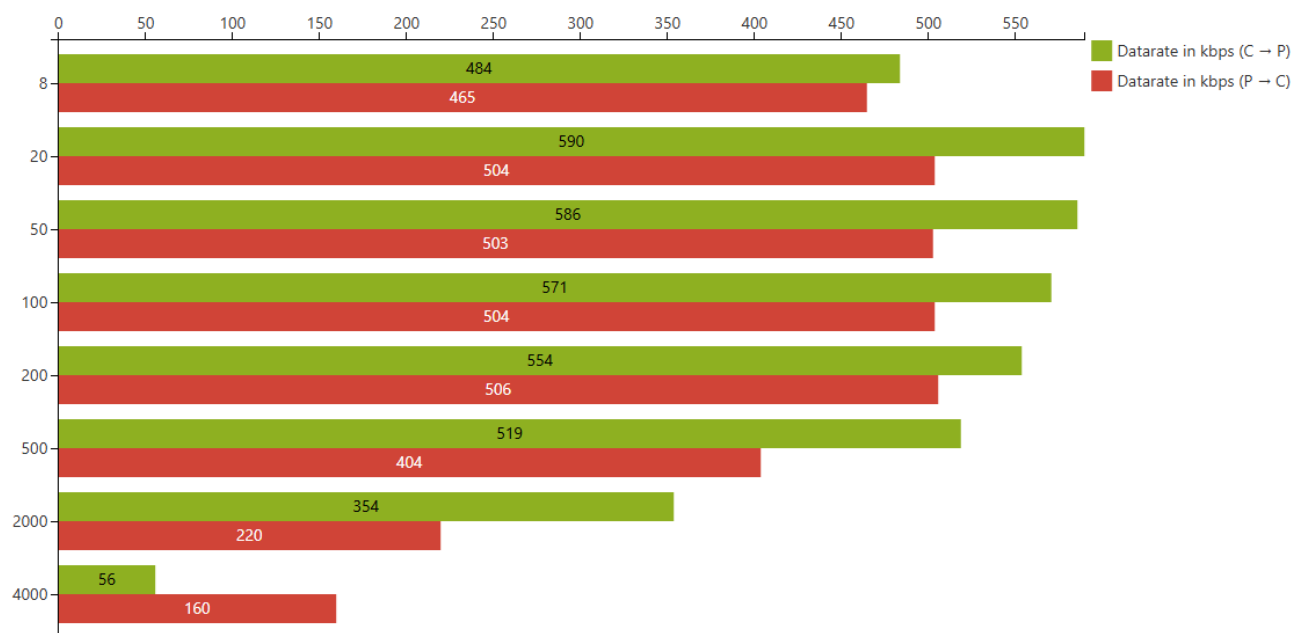


Figure 5.1-2: data-rates in dependency of connection interval with payload-chunks of 1024 bytes

Observed deviations of data-rates are not caused by the BLE roles only (C=Central; P=Peripheral), but in conjunction with associated BLE GATT Client and BLE GATT Server instances associated to a role.

connection interval [ms]	data-rate as Central with a GATT-Client [kbps]	data-rate as Peripheral with a GATT-Server [kbps]
8	484	465
20	590	504
50	586	503
100	571	504
200	554	506
500	519	404
2000	354	220
4000	56	160

Table 14: data-rates in dependency of connection interval with payload-chunks of 1024 bytes

5.1.4.2 Throughput with payload chunks of 32 bytes

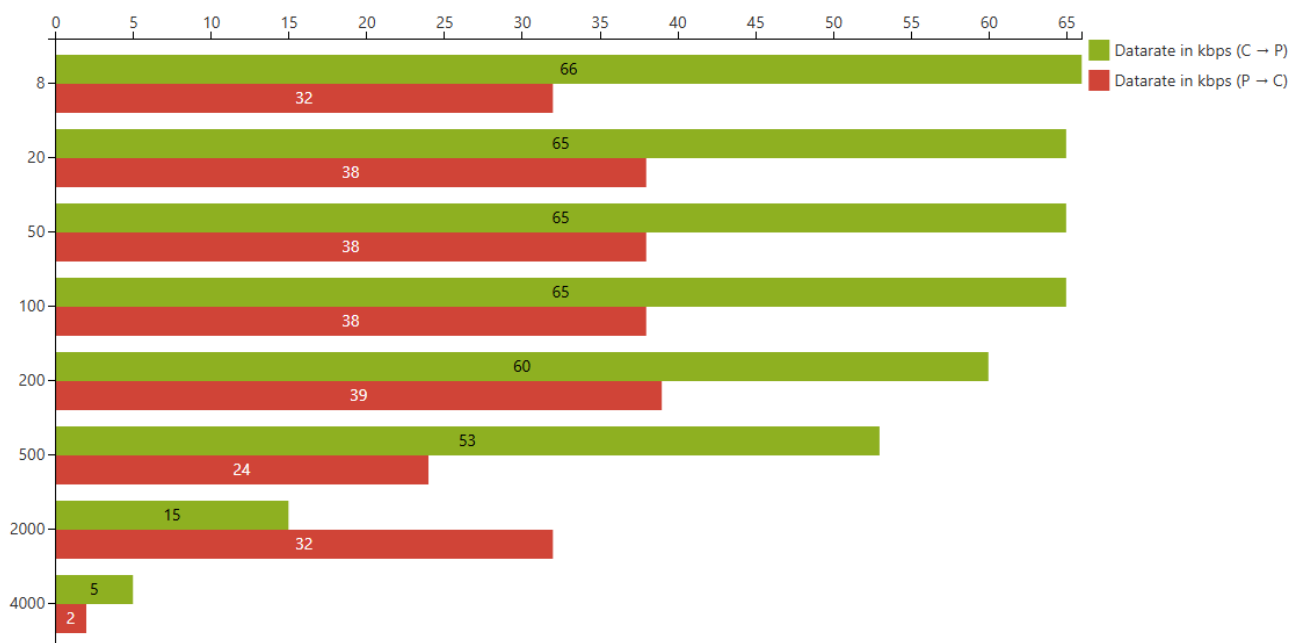


Figure 5.1-3: data-rates in dependency of connection interval with payload-chunks of 32 bytes

Observed deviations of data-rates are not caused by the BLE roles only (C=Central; P=Peripheral), but in conjunction with associated BLE GATT Client and BLE GATT Server instances associated to a role.

connection interval [ms]	data-rate as Central with a GATT-Client [kbps]	data-rate as Peripheral with a GATT-Server [kbps]
8	66	32
20	65	38
50	65	38
100	65	38
200	60	39
500	53	24
2000	15	32
4000	5	2

Table 15: data-rates in dependency of connection interval with payload-chunks of 32 bytes

6 Mechanical specifications

6.1 Maximum height BT01

The maximum height of BT01 module is 3.16mm. During integration into the final product also consider, that solder paste adds additional height.

For portable host devices take care about the minimum distance mentioned in FCC approval between antenna and contactable surface of the device. (see chapter 10.2.3)

6.2 Maximum height BT02

The maximum height of BT02 module is 3.16mm. During integration into the final product also consider, that solder paste adds additional height.

7 Reliability Tests

The following reliability tests were performed during module validation, while all tested modules were stored at room temperature and humidity for at least one hour before starting the tests.

Item	Test	Limit	Condition
1	Heat-Shock/Temperature Cycling Test	electrical parameters should be within the specification	At -40°C and 85°C for 1h/cycle Total 100 cycle
2	Temperature Humidity Storage		At 60°C, 85%r.H.,100h
3	Low Temperature Storage		At -40°C, 100h
4	High Temperature Storage		At 85°C, 100h

Table 16: Reliability Tests

In case the final product has higher validation needs to the previous tests, there is a risk, that the Bluetooth module might fail. Please report successfully performed tests exceeding the given limits to the module responsible.

8 Limitations

This section summarizes known limitations associated with the Dräger BT-modules.

8.1 No compliance for Safety Integrity Level (SiL) applications

The BT-Modules and the Dräger BLE-Software are not engineered in consideration of any SiL-requirements or associated engineering process qualities of IEC61508 or IEC61511.

Given by impact of physical environmental conditions, any established Bluetooth connection by Dräger Bluetooth modules is appropriate to guarantee reliability of the data communication within a defined time-tolerance. Therefore, the Bluetooth communication must not be used for any SiL-relevant real-time system communication.

Anyhow the technology could be used to transfer safety-critical content in context of maintenance or service use cases. The protection of completeness, consistency and authentication of content could be achieved by usage of proper transport- and application layer protocol as well as signature-checkup on transferred content. (i.e.: Firmware-Updates, download of logger or upload of configuration data)

8.2 Setting of maximal transmitting radio output power

The setting of the maximal transmitting radio output power for the nRF52840 SoC is configurable by a static parameter given within the nRF Connect SDK software at compile-time.

The setting impacts the possible radio range, human body exposure considering equal environmental conditions and of course the energy consumption of the module at comparable communication use cases.

IMPORTANT: The radio approval and validated human exposure conformity for the pre-certified BT-modules will become not applicable, if the maximum radio power output setting is increased above the configured value used and validated by the performed confirmation tests for the BT-modules.

To achieve a radio approval and human exposure conformity with increased settings, extra effort in time and costs must be considered by the products. Even the risk rises, that conformity for human exposure might not be achievable at all.

It is not admitted to BLE-platform developers to change the setting of this parameter for a specific product BLE-firmware without a confirmed change request, signed by responsible product stakeholders. The confirmation document shall include an unambiguous statement about the mentioned consequences and risk.

9 Soldering profile

The recommended soldering profile can be found in the following graph. While modifying the given soldering profile to meet other component requirements ensure that the maximum temperature does not exceed 250°C and that the temperature above 220°C is present for at least 20 seconds, but not longer than 50 seconds.

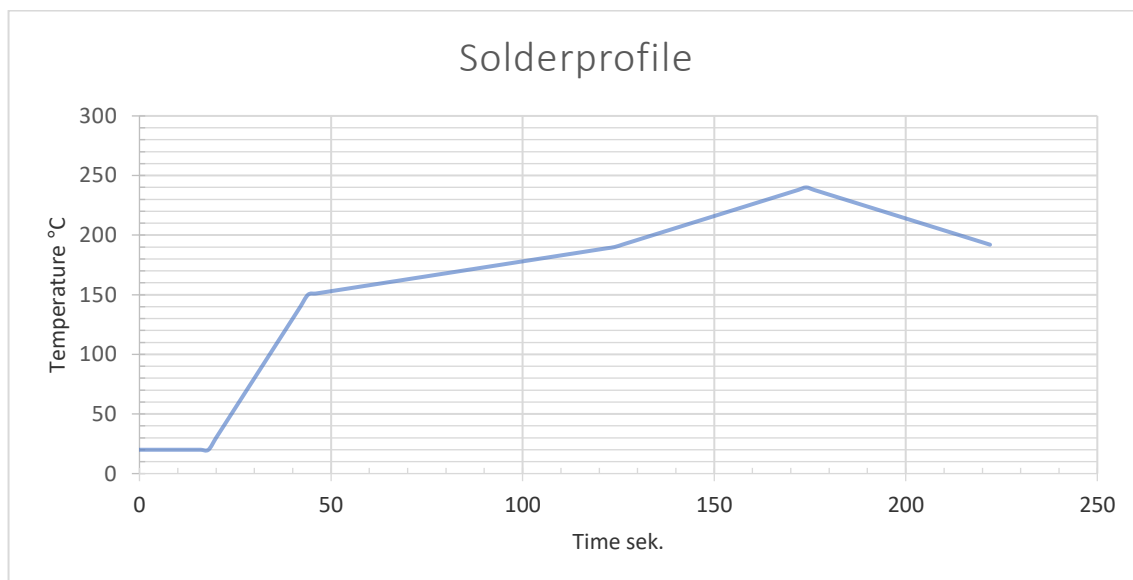


Table 17: Solder profile

Note: Nordic Semiconductor recommends a maximum of three soldering steps for the nrF52840 chip. Since the chip has already been soldered once during module production, a maximum of two soldering steps may be performed during production of the final product.

10 Approvals

10.1 Approval information in production

Due to small size of the modules, it is not possible to laser all approval information for all countries on the shield can for BT01 and BT02. Therefore, some information is lasered on the shield can, an external shield can label was created and an approval label for the package was created.

10.1.1 Shield can BT01



Figure 10.1-1 - picture of BT01 Shield can with laser marking

10.1.2 Package approval label BT01

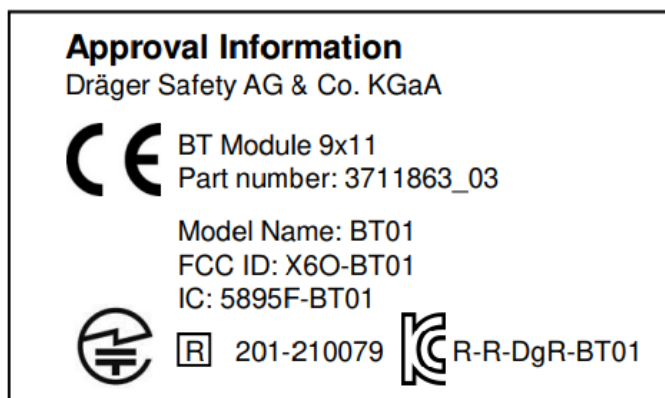


Figure 10.1-2 - Approval label for packaging BT01

The approval label can be found under the document number 1136286.

10.1.3 Shield can BT02



Figure 10.1-3 -picture of BT02 Shield can with laser marking

10.1.4 Package approval label BT02

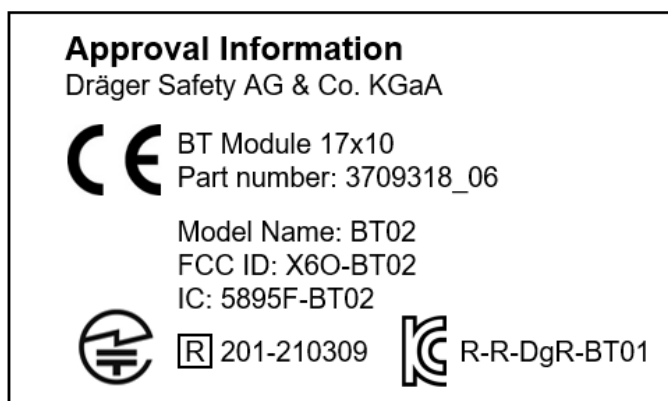


Figure 10.1-4 - Approval label for packaging BT02

The approval label can be found under the document number 11149795.

10.2 Federal Communicators Commissions for US (FCC)

The Modules (BT01 and BT02) with the equipped antennas comply to the requirements of Class 2 digital devices of part 15 of the FCC rules.

The Transmitter is subjected to the following conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

The module is not for sale and the user manual integration instructions are internal confidential manufacturing documents.

10.2.1 List of approved Antennas for BT01

Manufacturer	Part-Number	Type	Frequency Band	max. Gain (dBi)
TDK	ANT016008LCS2442MA1	Chip Antenna	2,4 GHz	-2dBi

Table 18: List of approved Antennas BT01

10.2.2 List of approved Antennas for BT02

Manufacturer	Part-Number	Type	Frequency Band	max. Gain (dBi)
TDK	ANT016008LCS2442MA1	Chip Antenna	2,4 GHz	-2dBi
Amoris	SRF2W021	External	2.4 GHz – 2.5GHz	-1.3dBi
		Antenna	4.9 GHz – 5.9 GHz	-1.2dBi

Table 19: List of approved Antennas BT02

10.2.3 FCC ID BT01

The 9x11mm BT01 module has been tested to fulfill the FCC requirements.

Model Name: BT01

FCC ID: X6O-BT01

Due to the Module size, the FCC identifier is displayed in the specification and must also be displayed in the instruction manual of the device. It cannot be displayed readable on the module's label due to the limited size.

- The following information must be indicated on the host device of this module.

Contains Transmitter Module FCC ID: X6O-BT01

or

Contains FCC ID: X6O-BT01

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

When installing it in a mobile equipment.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment and meets the FCC radio frequency (RF) Exposure Guidelines. This equipment should be installed and operated keeping the radiator at least 20cm or more away from person's body.

When installing it in a portable equipment.

It is necessary to take a SAR test with your set mounting this module.

Class II permissive change application is necessary using the SAR report.

To comply with RF exposure conditions the host device incorporating the BT01 must ensure a separation distance with at least of 6.5436 mm measured between the Antenna and outside of the housing.

10.2.4 FCC ID BT02

The 17x10mm BT02 module has been tested to fulfil the FCC requirements.

Model Name: BT02

FCC ID: X6O-BT02

Due to the Module size, the FCC identifier is displayed in the specification and must also be displayed in the instruction manual of the device. It cannot be displayed readable on the module's label due to the limited size.

- The following information must be indicated on the host device of this module.

Contains Transmitter Module FCC ID: X6O-BT02

or

Contains FCC ID: X6O-BT02

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

When installing it in a mobile equipment.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment and meets the FCC radio frequency (RF) Exposure Guidelines. This equipment should be installed and operated keeping the radiator at least 20cm or more away from person's body.

When installing it in a portable equipment.

It is necessary to take a SAR test with your set mounting this module.

Class II permissive change application is necessary using the SAR report.

10.3 Innovation, Science, and Economic Development (ISED) for Canada

The Modules (BT01 and BT02) are licensed to meet the regulatory requirements of ISED.

Due to the Module size, the IC identifier is displayed in the specification and must also be displayed in the instruction manual of the device. It cannot be displayed readable on the module's label due to the limited size.

This device contains license-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's license-exempt RSS(s). Operation is subject to the following two conditions:

1. This device may not cause interference.
2. This device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

1. L'appareil ne doit pas produire de brouillage.
2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

10.3.1 List of approved Antennas for BT01

Manufacturer	Part-Number	Type	Frequency Band	max. Gain (dBi)
TDK	ANT016008LCS2442MA1	Chip Antenna	2,4 GHz	-2dBi

Table 20: List of approved Antennas BT01

10.3.2 List of approved Antennas for BT02

Manufacturer	Part-Number	Type	Frequency Band	max. Gain (dBi)
TDK	ANT016008LCS2442MA1	Chip Antenna	2,4 GHz	-2dBi
		External	2.4 GHz – 2.5GHz	-1.3dBi
Amoris	SRF2W021	Antenna	4.9 GHz – 5.9 GHz	-1.2dBi

10.3.3 License ID BT01

BT01

License ID: IC: 5895F-BT01

Due to the Module size, the identifier is displayed in the specification and must also be displayed in the instruction manual of the device. It cannot be displayed readable on the module's label due to the limited size.

10.3.4 License ID BT02

BT02

License ID: IC: 5895F-BT02

Due to the Module size, the identifier is displayed in the specification and must also be displayed in the instruction manual of the device. It cannot be displayed readable on the module's label due to the limited size.

10.4 KC Certification for BT01 and BT02

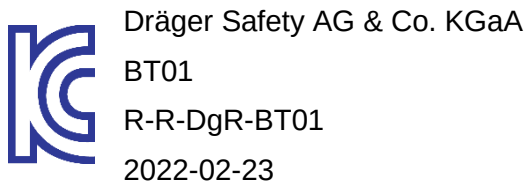
10.4.1 KC Certification BT01

EE8B-A771-51B4-76A6

방송통신기자재등의 적합등록 필증 Registration of Broadcasting and Communication Equipments	
상호 또는 성명 Trade Name or Registrant	Dräger Safety AG & Co. KGaA
기자재명칭(제품명칭) Equipment Name	BT Module
기기부호/추가 기기부호 Equipment code /Additional Equipment code	LARN8
기본모델명 Basic Model Number	BT01
파생모델명 Series Model Number	
등록번호 Registration No.	R-R-DgR-BT01
제조자/제조국가 Manufacturer/Country of Origin	Dräger Safety AG & Co. KGaA / 독일
등록연월일 Date of Registration	2022-02-23
기타 Others	
위 기자재는 「전파법」 제58조의2 제3항에 따라 등록되었음을 증명합니다. It is verified that foregoing equipment has been registered under the Clause 3, Article 58-2 of Radio Waves Act. 2022년(Year) 02월(Month) 23일(Day) 국립전파연구원장 Director General of National Radio Research Agency ※ 적합등록 방송통신기자재는 반드시 "적합성평가표시" 를 부착하여 유통하여야 합니다. 위반시 과태료 처분 및 등록이 취소될 수 있습니다.	



10.4.2 KC Mark BT01



10.4.3 KC Certification BT02

EESB-A771-51B4-76A6

방송통신기자재등의 적합등록 필증 Registration of Broadcasting and Communication Equipments	
상호 또는 성명 Trade Name or Registrant	Dräger Safety AG & Co. KGaA
기자재명칭(제품명칭) Equipment Name	BT Module
기기부호/추가 기기부호 Equipment code /Additional Equipment code	LARN8
기본모델명 Basic Model Number	BT01
파생모델명 Series Model Number	BT02
등록번호 Registration No.	R-R-DgR-BT01
제조사/제조국가 Manufacturer/Country of Origin	Dräger Safety AG & Co. KGaA/독일
등록연월일 Date of Registration	2022-02-23
기타 Others	
위 기자재는 「전파법」 제58조의2 제3항에 따라 등록되었음을 증명합니다. It is verified that foregoing equipment has been registered under the Clause 3, Article 58-2 of Radio Waves Act. 2023년(Year) 06월(Month) 26일(Day) 국립전파연구원장 Director General of National Radio Research Agency ※ 적합등록 방송통신기자재는 반드시 "적합성 평가표시" 를 부착하여 유통하여야 합니다. 위반시 과태료 처분 및 등록이 취소될 수 있습니다.	



10.4.4 KC Mark BT02

 Dräger Safety AG & Co. KGaA
BT02
R-R-DgR-BT01
2022-02-23

10.5 European Conformity According to RED (2014/53/EU)

The Dräger modules described in this Product Specification comply with the standards according to the RED (2014/53/EU) articles:

The maximum output power is +10 dBm within a frequency range of 2.402 MHz to 2.480MHz.



EU-Konformitätserklärung EU-Declaration of Conformity

Dokument Nr. / Document No. 11150230-01



Wir / we Dräger Safety AG & Co. KGaA, Revalstraße 1, 23560 Lübeck, Germany

erklären in alleiniger Verantwortung, dass das Produkt
declare under our sole responsibility that the product

Dräger Bluetooth Modul 9x11 (BT01)
Dräger Bluetooth module 9x11 (BT01)

mit der EU-Baumusterprüfbescheinigung / Expertise
is in conformity with the EU-Type Examination Certificate / Expertise **202140601/AA/00**

ausgestellt von der notifizierten
Stelle mit der Kenn-Nr.
issued by the Notified Body
with Identification No.

Telefication B.V.
Wilmsdorf 50
7327 AC Apeldoorn
The Netherlands
0063

und mit den folgenden Richtlinien unter Anwendung der aufgeführten Normen übereinstimmt
and is in compliance with the following directives by application of the listed standards

Bestimmungen der Richtlinie provisions of directive		Nummer sowie Ausgabedatum der Norm Number and date of issue of standard
2014/53/EU	RED-Richtlinie RE Directive	EN 62479:2010, EN 301 489-1 V2.2.3, EN 301 489-17 V3.2.4 EN 300 328 V2.2.2, EN 62368-1:2014+A11:2017
2011/65/EU 2015/863/EU	RoHS-Richtlinie RoHS Directive	EN IEC 63000:2018

Lübeck, 2023-07-04

Ort und Datum (jjjj-mm-tt)
Place and date (yyyy-mm-dd)

Dr. Marcus Romba
Head of Electronic Engineering
Head of Product Qualification
R&D Safety

Figure 10.5-1: - Eu-DoC for Dräger Bluetooth Module 9x11mm BT01



EU-Konformitätserklärung
EU-Declaration of Conformity

Dokument Nr. / Document No. 11164345-00

Wir / we Dräger Safety AG & Co. KGaA, Revalstraße 1, 23560 Lübeck, Germany

erklären in alleiniger Verantwortung, dass das Produkt
declare under our sole responsibility that the product

Dräger Bluetooth Modul 17x10 (BT02)
Draeger Bluetooth module 17x10 (BT02)

mit der EU-Baumusterprüfbescheinigung / Expertise
is in conformity with the EU-Type Examination Certificate / **212140336/AA/00**
Expertise

ausgestellt von der notifizierten
Stelle mit der Kenn-Nr.
issued by the Notified Body
with Identification No.

Kiwa B.V.
Wilmersdorf 50
7327 AC Apeldoorn
The Netherlands
0063

und mit den folgenden Richtlinien unter Anwendung der aufgeführten Normen übereinstimmt
and is in compliance with the following directives by application of the listed standards

Bestimmungen der Richtlinie <i>provisions of directive</i>		Nummer sowie Ausgabedatum der Norm <i>Number and date of issue of standard</i>
2014/53/EU	RED-Richtlinie <i>RE Directive</i>	EN 62479:2010, EN 301 489-1 V2.2.3, EN 301 489-17 V3.2.4 EN 300 328 V2.2.2, EN 62368-1:2014+A11:2017
2011/65/EU 2015/863/EU	RoHS-Richtlinie <i>RoHS Directive</i>	EN IEC 63000:2018

Lübeck, 2023-07-XX

Ort und Datum (jjjj-mm-tt)
Place and date (yyyy-mm-dd)

Dr. Marcus Romba
Head of Electronic Engineering
Head of Product Qualification
R&D Safety

Figure 10.5-2 : Eu-DoC for Dräger Bluetooth Module 17x10mm BT02

10.6 Bluetooth SIG

The Dräger Bluetooth Platform is listed in the Bluetooth SIG Listing. See the following link:

[Launch Studio - Listing Details \(bluetooth.com\)](https://www.bluetooth.com/launch-studio/listing/details)

The SIG Registration is not fixed to the HW. Dräger listed Controller and Host Subsystems, which can be easily transferred to new products and HW.

11 Glossary

11.1 Abbreviation & Acronyms

Abbreviation	Explanation / Description
BLE	Bluetooth Low Energy
BT	Bluetooth
COM	Communication
CTS	Clear To Send (control line to synchronize communication peers, indicates a COM-request on a handshake line and expects confirmed readiness from the connected peer on RTS)
DFU	Device Firmware Update
DTM	Direct Test Mode
EDR/BR	Endpoint Detection and Response / Broadcast Receiver
ESD	Electrostatic Discharge
FCC	Federal Communications Commission
GATT	Generic Attribute Profile
GDC	Gas Detection Connect (Dräger Cloud Application)
GPIO	General Purpose Input Output (typical digital interface of microcontroller, configurable in direction and kind of its usage as input or output signal)
HW	Hardware
ID	Identifier
IO	Input/Output (digital interface of microcontrollers)
MCU	Microcontroller Unit
MTU	Maximum Transfer Unit
NFC	Near Field Communication (specific radio communication technology for very short ranges)
OS	Operating System (Software)
OTA	Over the Air
PCB	Printed Circuit Board
RF	Radio Frequency
RTS	= RFR = Ready for Receive (acknowledge line to synchronize communication peers, indicates readiness to receive as reaction on an indicated COM-request by CTS)
RX/TX	Direction of Communication: RX = Receive, TX = Transmit
SDK	Software Development Kit
SIG	Special Interest Group
SiL	Safety Integrity Level
SMP	Simple Management Protocol
SOC	System on Chip
UART	Universal Asynchronous Receiver-Transmitter

Table 21: Abbreviations& Acronyms

11.2 References

- [1] [Nordic: nRF52840_ProductSpecification_v1.10.pdf](#)
- [2] [Part F Direct Test Mode](#)
- [3] [sdk-nrf/samples/bluetooth/direct_test_mode/README.rst at v2.5.1 · nrfconnect/sdk-nrf · GitHub](#)