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nRF8002

Single-chip *Bluetooth*® Low Energy Proximity Solution

Product Specification 1.1

Key Features

- Fully qualified *Bluetooth* low energy 4.0 peripheral device
- Single chip solution for *Bluetooth* low energy proximity applications
- Integrated *Bluetooth* low energy profiles and services
- Configurable I/Os for application behavior
- Ultra-low power consumption
- Coin-cell battery operation
- Low cost 16 MHz ±50 ppm crystal
- On-chip 32 kHz RC oscillator
- Single 1.9-3.6 V power supply
- Low cost external BOM
- Temperature range -25 to +70°C
- Compact 5x5 mm QFN32 package
- RoHS compliant

Applications

- Proximity applications
- Key fobs
- Watches

2013-09-16

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Datasheet status	
Objective Product Specification	This product specification contains target specifications for product development.
Preliminary Product Specification	This product specification contains preliminary data; supplementary data may be published from Nordic Semiconductor ASA later.
Product Specification	This product specification contains final product specifications. Nordic Semiconductor ASA reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.

Contact details

For your nearest dealer, please see www.nordicsemi.com

Main office:

Otto Nielsens veg 12
7004 Trondheim
Phone: +47 72 89 89 00
Fax: +47 72 89 89 89
www.nordicsemi.com

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Revision History

Date	Version	Description
September 2013	1.1	• Updated section 10.1 on page 35 and chapter 15 on page 43. • Fixed minor issues throughout the document.
August 2012	1.0	• First release of the Product Specification (PS). • Renamed pin 32 from DCC to NC, see Figure 2. on page 7. • Changed application behavior, when the peer terminates the connection, the nRF8002 goes into connecting state, see Figure 4. on page 11. • Added chapter 2 on page 6, *Bluetooth* Qualification ID. • Added section 6.4 on page 29, Configuration in production • Fixed minor issues throughout the document.
February 2012	0.7	• First release of the Preliminary Product Specification (PPS)

Contents

1 Introduction

nRF8002 is a single-chip *Bluetooth* low energy peripheral device for proximity solutions.

With a complete *Bluetooth* low energy stack along with Proximity, Find Me and, Alert Notification profiles, nRF8002 fulfills the needs for simple phone and PC accessories. It can alert you if your devices go out of range, enable security features like screen lock and give you notice of new events like incoming mail, SMS and, calls. nRF8002 also embeds a configurable application allowing you to use nRFgo Studio to configure device and I/O behavior. The I/O can interface directly with user input and output devices such as buttons, LEDs, buzzers, or vibrators.

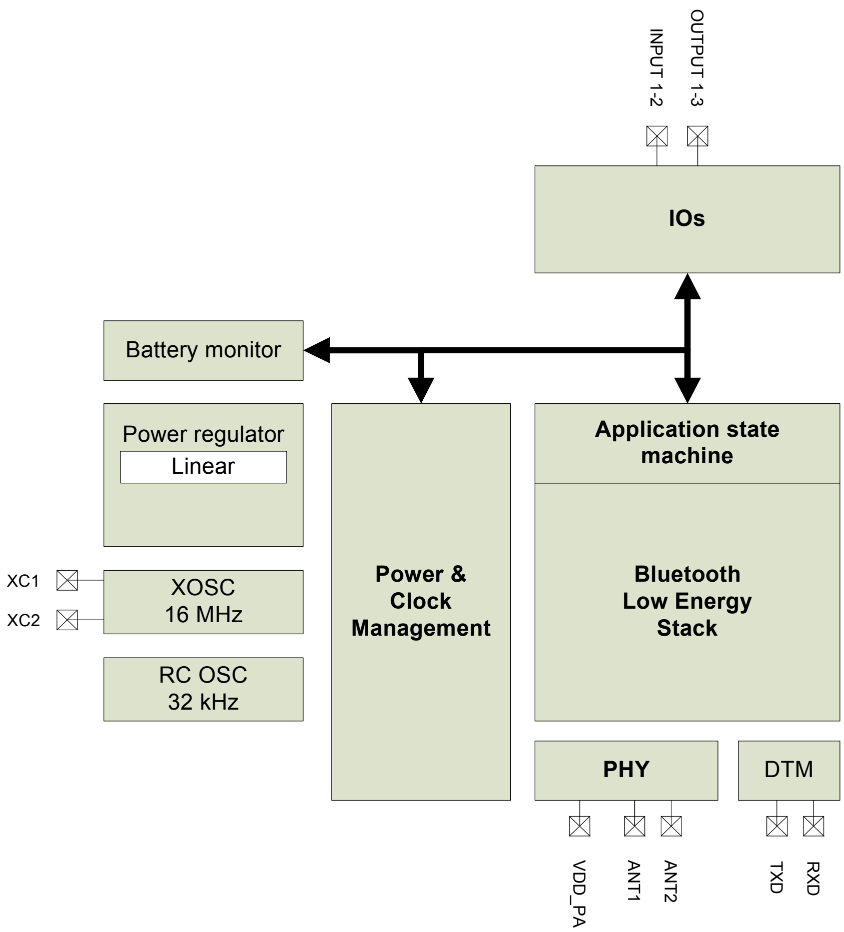


Figure 1. nRF8002 block diagram

2 *Bluetooth* Qualification ID

nRF8002 is listed as an EP-QDL on the Qualified listings page of the *Bluetooth* Special Interest Group website https://www.bluetooth.org/tpg/listings.cfm.

For details on the design qualifications, please refer to the following qualification IDs:

- B019507 - nRF8002, End Product, Single-chip *Bluetooth* low energy proximity solution.
- B019124 - uBlue Host 1.2, Nordic *Bluetooth* Low Energy Host Layer version 1.2.
- B016981 - Nordic µBlue LL, BTLE link layer stack component.
- B019518 - nRF8002_RF, *Bluetooth* low energy HW platform containing the RF PHY layer for the nRF8002 system on chip device.

3 Pin assignment

nRF8002 is available in a 5x5 mm QFN32 package. The back plate of the QFN32 capsule must be grounded to the application PCB in order to achieve optimal performance. The physical dimensions of the QFN32 are presented in chapter 13 on page 41.

Figure 2. shows the pin assignment for nRF8002 and Table 1. on page 8 describes the pin functionality.

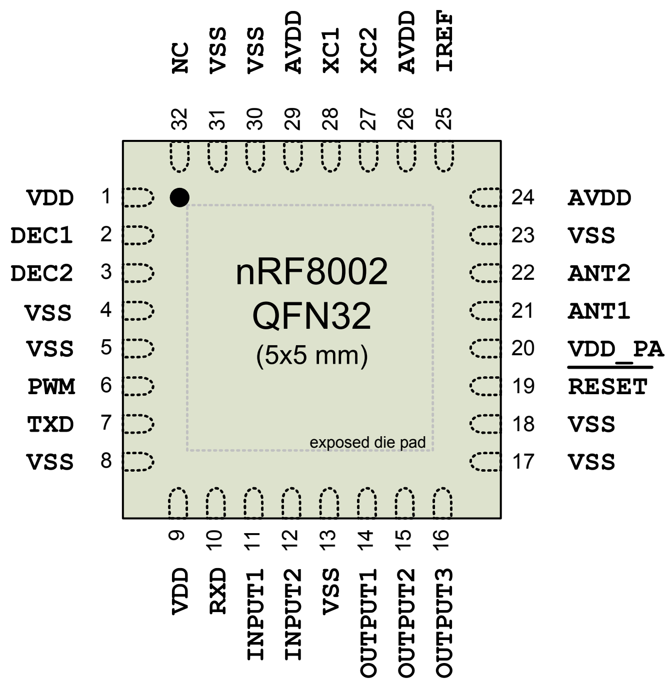


Figure 2. nRF8002 pin assignment (top view)

3.1 Pin functions

Pin	Pin name	Pin functions	Description
1	**VDD**	Power	Power supply (1.9 – 3.6 V)
2	**DEC1**	Power	Regulated power supply output for decoupling purposes only. Connect 100 nF capacitor to ground
3	**DEC2**	Power	Regulated power supply output for decoupling purposes only. Connect 33 nF capacitor to ground
4	**VSS**	Power	Ground (0V)
5	**VSS**	Power	Ground (0V)
6	**PWM**	Digital output	Programmable PWM output (range 490 Hz….516 kHz)
7	**TXD**	Digital output	UART (transmit) for *Bluetooth* low energy Direct Test Mode Interface and for configuration download. After final OTP program of configuration, pin must be set to VSS.
8	**VSS**	Power	Ground (0V)
9	**VDD**	Power	Power supply (1.9 – 3.6 V)
10	**RXD**	Digital input	UART (receive) for *Bluetooth* low energy Direct Test Mode Interface and for configuration download. After final OTP program of configuration, pin must be set to VSS.
11	**INPUT1**	Digital input	General input (if not in use this pin must be set to VSS)
12	**INPUT2**	Digital input	General input (if not in use this pin must be set to VSS)
13	**VSS**	Power	Ground (0V)
14	**OUTPUT1**	Digital output	General output
15	**OUTPUT2**	Digital output	General output
16	**OUTPUT3**	Digital output	General output
17	**VSS**	Power	Ground (0V)
18	**VSS**	Power	Ground (0V)
19	**RESET**	Digital input	Reset (active low)
20	**VDD_PA**	Power output	Regulated power supply output for on-chip RF Power amplifier
21	**ANT1**	RF	Differential antenna connection (TX and RX)
22	**ANT2**	RF	Differential antenna connection (TX and RX)
23	**VSS**	Power	Ground (0V)
24	**AVDD**	Power	Analog power supply (1.9 – 3.6 V DC)
25	**IREF**	Analog output	Current reference terminal. Connect a 22 kΩ 1% resistor to ground
26	**AVDD**	Power	Analog power Supply (1.9 – 3.6 V)
27	**XC2**	Analog output	Connection for 16 MHz crystal oscillator. Leave unconnected if not in use
28	**XC1**	Analog input	Connection for 16 MHz crystal or external 16 MHz reference
29	**AVDD**	Power	Analog power supply (1.9 – 3.6 V DC)
30	**VSS**	Power	Ground (0V)
31	**VSS**	Power	Ground (0V)
32	**NC**	-	Not connected
Exposed die pad	**VSS**	Power	Ground (0V), connect to VSS

Table 1. nRF8002 pin functions

4 Operation

This chapter describes the power-up sequence for nRF8002 and the modes it can enter and also a state diagram that illustrates the operating states and their behavior. Configuration data can be stored in RAM or non-volatile memory (also called One Time Programmable memory, or OTP) in nRF8002.

4.1 Power up

Power up is defined as when nRF8002 is powered up for the first time (the battery is inserted) or the chip is reset. When nRF8002 is powered up its behavior depends on whether a custom configuration has been pre-programmed into the non-volatile memory (OTP). If the OTP contains a valid configuration, nRF8002 starts with these configuration settings and is ready for operational use.

In Configuration mode, nRF8002 can receive the configuration generated by nRFgo Studio. The nRF8002 configuration decides profile, application and I/O behavior. RAM is used during development to enable repeated configuration downloads. Each time nRF8002 is reset, or power is removed, it returns to a non-configured state and you can choose to enter DTM or download a new configuration.

If there is no valid configuration available in OTP, nRF8002 will start in either Direct Test Mode (DTM) or Configuration mode, depending on the first byte received on the UART:

- If the first byte received on the UART is `0xFF`, nRF8002 starts in Configuration mode.
- If the first byte received on the UART is NOT `0xFF`, nRF8002 starts in DTM mode.
  See chapter 7 on page 32 for more information on DTM.

Note: When the chip is in DTM or Configuration mode it will rapidly drain the battery, as it does not use power management in these modes.

Once development is finished final configuration can be downloaded to non-volatile memory (OTP) from nRFgo studio or saved to file for use in factory programming tools.

Note: If configuration is programmed into OTP, DTM mode is no longer accessible.

When the configuration is available in OTP, the UART is disabled.

4.2 Power up sequence flow chart

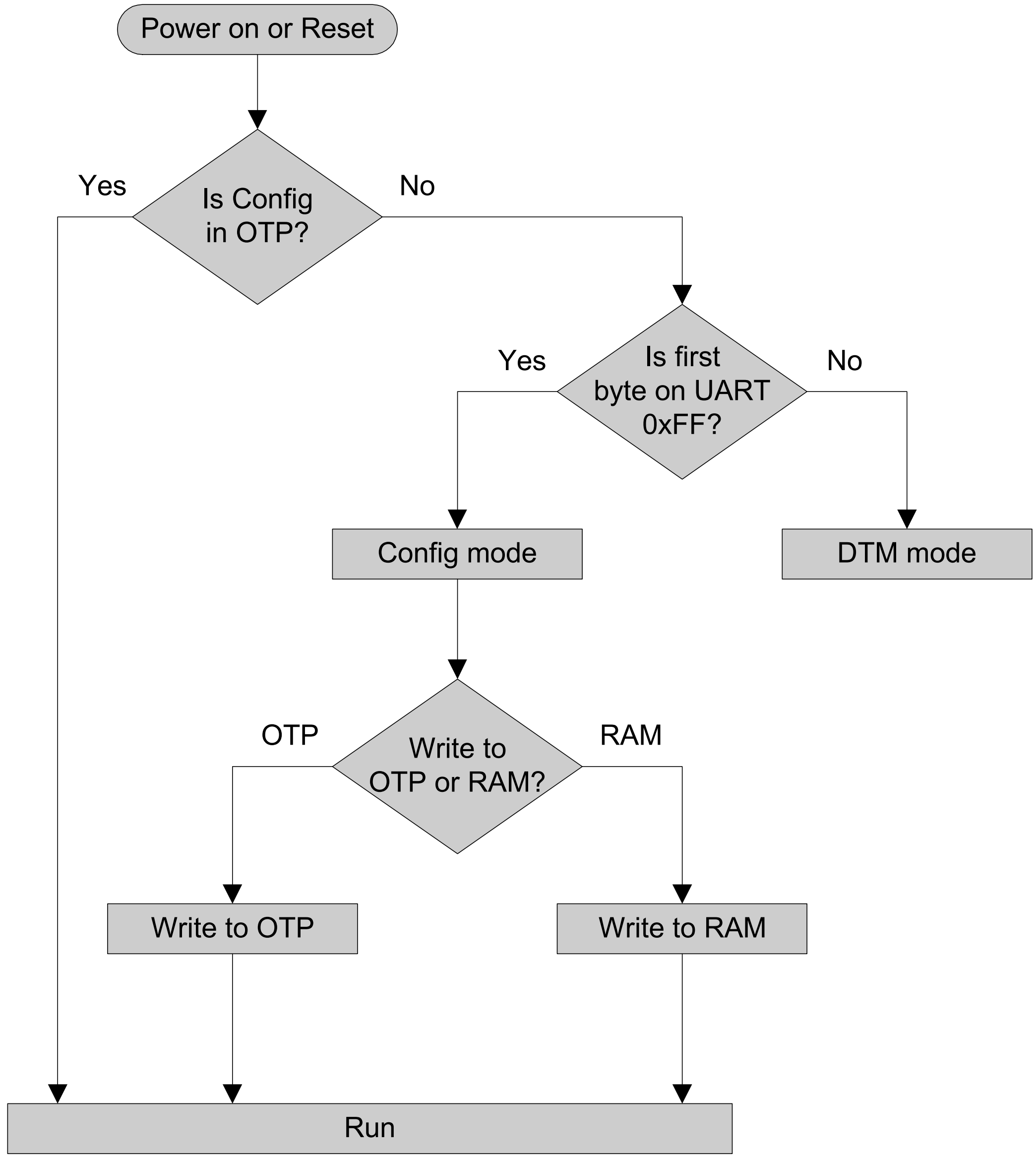


Figure 3. Power up sequence flow chart

4.3 State diagram

Figure 4. defines nRF8002's different operating states and their behavior. For details on the configuration parameters, see chapter 8 on page 33.

Legend:

"Timeout"	=	Non-configurable state (always italicized)
GAP.SysStateBonding	=	A pre-defined output action that can be configured (always below the line)
GAP.SysActionConn	=	A pre-defined input action that can be configured (always above the line)

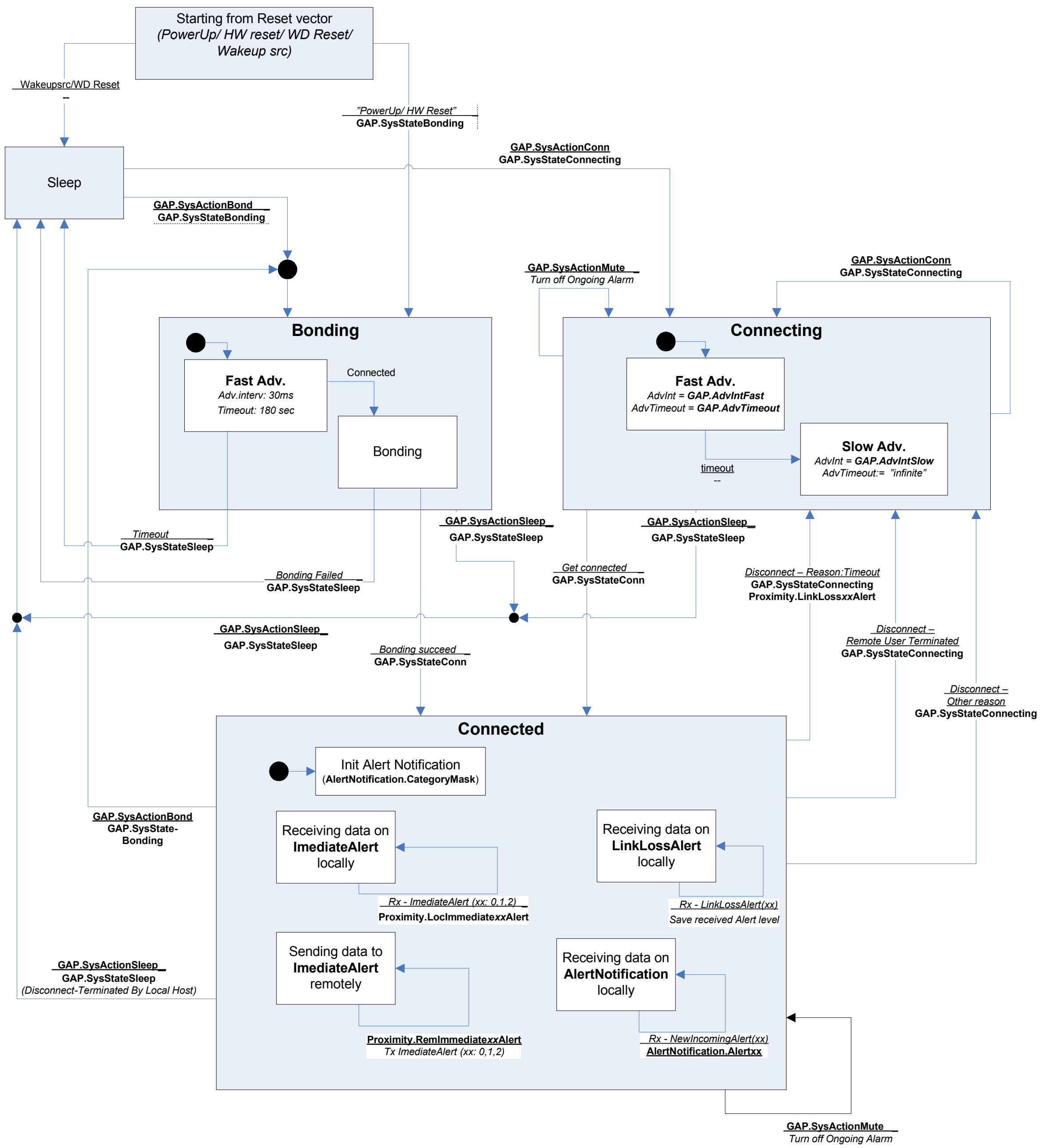


Figure 4. State diagram

5 nRF8002 profiles and services

nRF8002 offers Battery Status, TX power, Link Loss and, Immediate Alert services. It also implements the Find Me and Alert Notification profiles for use with a peer device that supports Alert Notification and Immediate Alert services. When a connection is established with a peer device, nRF8002 automatically performs the service discovery and enables the corresponding application functionality.

5.1 Generic Access Profile (GAP) parameters

nRF8002 implements the Generic Access Profile (GAP) using the following parameters, (see chapter 6.1 on page 14 for more information):

- Configurable advertising intervals
- Device name characteristic
- Device security: Just Works
- Minimum encryption key size: 7 bytes
- Maximum encryption key size: 16 bytes
- TX power
- Preferred peripheral connection parameters characteristic

When a connection is established but the connection interval is not within the set parameters, nRF8002 responds by initiating the Connection Parameter Update procedure as described in the *Bluetooth* Core Specification Ver. 4.0, Vol. 3.0, Part C, GAP, section 9.3.9. If the peer does not change the connecting interval, nRF8002 will disconnect.

5.2 Profiles and services

This section describes the services that are available on nRF8002, and the services it will try to discover on a peer device.

5.2.1 nRF8002 local services

The service and characteristics that are available on nRF8002 are defined in Table 2. below.

Attribute type	UUID	Value	Properties
Primary Service	**0x2800**	**GAP (0x1800)**	**Read**
Characteristic Declaration	0x2803	Device Name (0x2A00)	Read
Characteristic Value - Device Name	0x2A00	"nRF8002"	Read/Write
Characteristic Declaration	0x2803	Appearance (0x2A01)	Read
Characteristic Value - Appearance	0x2A01	0x0000	Read
Characteristic Declaration	0x2803	PPCP (0x2A04)	Read
Characteristic Value – PPCP	0x2A04	Conn $_{min}$, Conn $_{max}$, Slave Latency, Timeout	Read
Primary Service	**0x2800**	**GATT (0x1801)**	**Read**
Primary Service	**0x2800**	**DEVICE INFORMATION (0x180A)**	**Read**
Characteristic Declaration	0x2803	Manufacturer Name (0x2A29)	Read
Characteristic Value – Manufacturer Name	0x2A29	"NordicSemi"	Read
Characteristic Declaration	0x2803	Model Number (0x2A24)	Read
Characteristic Value – Model Number	0x2A24	"nRF8002"	Read
Characteristic Declaration	0x2803	Firmware revision (0x2A26)	Read

Attribute type	UUID	Value	Properties
Characteristic Value – Firmware revision	0x2A26	This will be set to the nRF8002 firmware version number	Read
Characteristic Declaration	0x2803	Software revision (0x2A28)	Read
Characteristic Value – Software revision	0x2A28	Configurable by nRFgo Studio	Read
Primary Service	**0x2800**	**IMMEDIATE ALERT (0x1802)**	**Read**
Characteristic Declaration	0x2803	Alert Level (0x2A06)	Read
Characteristic Value – Alert Level	0x2A06	<Value>	Read/ WriteWithoutResponse
Primary Service	**0x2800**	**LINK LOSS (0x1803)**	**Read**
Characteristic Declaration	0x2803	Alert Level (0x2A06)	Read
Characteristic Value – Alert Level	0x2A06	<Value>	Read/Write
Primary Service	**0x2800**	**TX POWER (0x1804)**	**Read**
Characteristic Declaration	0x2803	TxPower (0x2A07)	Read
Characteristic Value – TxPower	0x2A07	<0x00>	Read
Primary Service	**0x2800**	**BATTERY (0x180F)**	**Read**
Characteristic Declaration	0x2803	BatteryLevel (0x2A19)	Read
Characteristic Value – BatteryLevel	0x2A19	0x64 (=100%)	Read/Notify
Char Descriptor - CCCD	0x2902	< Configuration>	Read/Write

Table 2. Services and characteristics on nRF8002

5.2.2 nRF8002 profiles and remote services

nRF8002 automatically carries out service discovery on a peer device and attempts to discover the services defined in Table 3.

Attribute type	UUID	Value	Properties
Primary Service	**0x2800**	**GATT (0x1801)**	**Read**
Characteristic Declaration	0x2803	Service Changed (0x2A05)	Read
Characteristic Value – Service Changed	0x2A05	<... *Service change values* …>	Indicate
Char Descriptor – CCCD	0x2902	<Configuration>	Read/ Write
Primary Service	**0x2800**	**IMMEDIATE ALERT (0x1802)**	**Read**
Characteristic Declaration	0x2803	Alert Level (0x2A06)	Read
Characteristic Value – Alert Level	0x2A06	<Value>	Read/ WriteWithoutResponse
Primary Service	**0x2800**	**ALERT NOTIFICATION (0x1811)**	**Read**
Characteristic Declaration	0x2803	Supported New Alert Category (0x2A47)	Read
Characteristic Value – Supported New Alert Category	0x2A47	<Value>	Read
Characteristic Declaration	0x2803	New Alert (0x2A46)	Read
Characteristic Value – New Alert	0x2A46	<0x00>	Notify
Char Descriptor – CCCD	0x2902	<Configuration>	Read/ Write
Characteristic Declaration	0x2803	Alert Notification Control Point (0x2A44)	Read
Characteristic Value – Alert Notification Control Point	0x2A44	<0x00>	Write

Table 3. Supported services/characteristics on a peer device

6 nRF8002 configuration

Profiles and services are pre-defined on nRF8002 but, you can configure input signals to generate pre-defined GAP behavior and pre-defined actions related to Profiles and Services. Output signals can be configured to generate patterns on pre-defined events that are related to Services, Profiles and, GAP behavior.

nRF8002 must be configured using the nRFgo Studio v1.12.3 or later. The configuration is downloaded through the UART, either directly from nRFgo Studio or by using the Production configuration tool available from Nordic Semiconductor. When downloading, you can choose to load the configuration into volatile memory (RAM) for development purposes or non-volatile memory (OTP) for production.

Note: If loaded into non-volatile memory (OTP) you cannot reconfigure nRF8002.

nRF8002 can be configured to respond to different input pin pulses and to issue different output patterns depending on the *Bluetooth* service and profile behavior.

Use the nRF8002 configuration tool in nRFgo Studio to change and download new configurations that match your application needs by setting the configuration in RAM. A default configuration is available in nRFgo Studio for download to your nRF8002 device. The default configuration is made to work with the development kit.

6.1 Profile and Service configuration

nRF8002 contains an integrated set of *Bluetooth* profiles and services. The application behavior of these profiles and services can be connected to Input signal (ISIG) and Output signal (OSIG) events.

6.1.1 General settings

6.1.1.1 Generic Access Profile (GAP) and hardware settings

nRF8002 allows the following configuration of hardware and GAP settings through the nRFgo Studio:

Name	Resolution	Description
`GAP.LocalName`	N/A	Local Name of the device: 0 - 20 bytes (UTF-8 sting) (no null termination)
`GAP.Appearance`	N/A	Appearance characteristic
`GAP.TxPowerConn`	N/A	Output Power of nRF8002 in connection or advertising to a bonded device, Steps: -18, -12, -6, 0 dBm
`GAP.AdvIntSlow`	625 µs	Background advertising Interval - Slow Adv. n – Background (Range:32…16384)
`GAP.AdvIntFast`	625 µs	Fast advertising Interval - Fast Adv. n – Fast (Range: 32…16384)
`GAP.AdvTimeout`	1 s	Timeout for Fast Adv. Up to 180 sec, 1 sec resolution. Only available in connecting state.
`GAP.ConnIntMin`	1.25 ms	Minimum Connection Interval: 250 ms – 2 sec, must be less than `GAP.ConnIntMax`
`GAP.ConnIntMax`	1.25 ms	Maximum connection Interval: 250 ms – 2 sec, must be more than `GAP.ConnIntMin + 12.5 ms`
`GAP.ConnTimeout`	1.25 ms	Connection Supervision Timeout.

Table 4. GAP and hardware configuration settings

6.1.1.2 GAP state to OSIG configuration

nRF8002 allows the following configuration of OSIG events when entering the different states defined in GAP through the nRFgo Studio:

Name	Action
`GAP.SysStateBonding`	Output Pin, pattern number, inverted, enable/disable
`GAP.SysStateConnecting`	Output Pin, pattern number, inverted, enable/disable
`GAP.SysStateConnected`	Output Pin, pattern number, inverted, enable/disable

Table 5. GAP state to OSIG Configuration

6.1.1.3 GAP state to ISIG configuration

nRF8002 allows the following configuration of ISIG events to enter different GAP states through the nRFgo Studio:

Name	Action
`GAP.SysActionBond`	Input pin, Press Event
`GAP.SysActionConnecting`	Input pin, Press Event
`GAP.SysActionSleep`	Input pin, Press Event
`GAP.SysActionMute`	Input pin, Press Event

Table 6. GAP state to ISIG Configuration

6.1.2 Profiles

6.1.2.1 Device information settings

nRF8002 allows the following configuration of Device Information settings through the nRFgo Studio:

Name	Units	Description
`DeviceInfo.ManufacturerName`	n/a	The name of the manufacturer of the device 0 - 20 bytes (no null termination)
`DeviceInfo.ModelNumber`	n/a	The model number that is assigned by the device vendor 0 - 20 bytes (no null termination)
`DeviceInfo.FirmwareRevision`	n/a	The firmware revision of the nRF8002 device (this is non-configurable)
`DeviceInfo.SoftwareRevision`	n/a	The Software revision of the device

Table 7. Description of device information settings

6.1.2.2 nRF8002 profile and service behavior to OSIG configuration

The Proximity Alert settings (OSIG) define the output pins that are triggered on the different alarms.

Name	Action
`Proximity.LinkLossMildAlert`	Output pin, pattern number, inverted, enable/disable. Link Loss with Mild Alert active.
`Proximity.LinkLossHighAlert`	Output pin, pattern number, inverted, enable/disable. Link Loss with High Alert active.
`Proximity.LocImmediateOffAlert`	Output pin, pattern number, inverted, enable/disable. Local Off Alert.
`Proximity.LocImmediateMildAlert`	Output pin, pattern number, inverted, enable/disable. Local Mild Alert.
`Proximity.LocImmediateHighAlert`	Output pin, pattern number, inverted, enable/disable. Local High Alert.
`AlertNotification.CategoryMask`	See Alert Notification Service (0 disables all alerts) (UINT16 bit mask).
`AlertNotification.Alert 1`	AlertCategory Id bit mask to set which Category that should trigger this OSIG.
…..	
`AlertNotification.Alert 4`	AlertCategory Id bit mask to set which Category that should trigger this OSIG.

Table 8. Profile and service behavior to OSIG Configuration (OSIG)

6.1.2.3 nRF8002 profile and service behavior to ISIG configuration

The Proximity signaling actions (ISIG) define which input signals should be used to send an alarm:

Name	Description
`Proximity.RemImmediateOffAlert`	Input pin, Press Event Trigger Remote Off Alert
`Proximity.RemImmediateMildAlert`	Input pin, Press Event Trigger Remote Mild Alert
`Proximity.RemImmediateHighAlert`	Input pin, Press Event Trigger Remote High Alert

Table 9. Profile and service behavior to ISIG Configuration (ISIG)

6.1.2.4 Battery configuration

The battery voltage level defines when an alarm will be triggered:

Name	Resolution	Description
HW.BatteryVoltageLevel0	3.52 mV	Voltage corresponding to battery 80% (Everything above will get reported as 100%) (BatteryState = Good Level)
HW.BatteryVoltageLevel1	3.52 mV	Voltage corresponding to battery 60% (BatteryState = Good Level)
HW.BatteryVoltageLevel2	3.52 mV	Voltage corresponding to battery 40% (BatteryState = Good Level)
HW.BatteryVoltageLevel3	3.52 mV	Voltage corresponding to battery 20%. (BatteryState = Critically Low Level)
HW.Battery_40_percent	OSIG	Output signal generated when battery level is reaching 40%.
HW.Battery_20_percent	OSIG	Output signal generated when reaching battery level is reaching 20%.

Table 10. Battery configuration

6.1.2.5 Mute

The mute action lets a user stop a OSIG event (for example, to silence an audible alarm). You can configure which input signal generates the mute action and which Output signal(s) that is turned off by this action.

The mute action is only available when nRF8002 is in connected mode.

6.2 Input Signals (ISIG)

Two input pins (ISIG) can be configured on nRF8002.

6.2.1 Configuration of the Input Signal (ISIG)

Through configuring the Input Signals (ISIG), they can be converted into events used to control behavior on nRF8002.

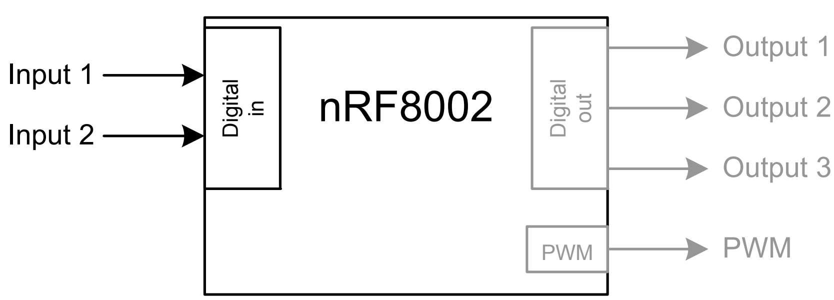


Figure 5. Block diagram showing the input pins

6.2.2 Input polarity

The input polarity can be set individually for each of the input pins. Table 11. below describes the expected behavior (Input Signal).

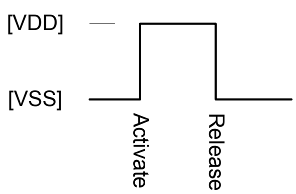
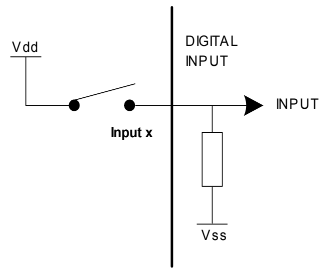
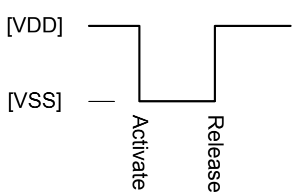
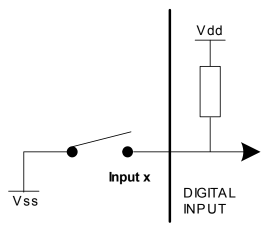
Polarity	Input signal	Schematic	Description
Active High			The input line is initiated by a VSS-to-VDD transition. The input pin is configured to logic level 0 using an internal pull down resistor.
Active Low			The input line is initiated by a VDD-to-VSS transition. The input pin is configured to logic level 1 using an internal pull up resistor.

Table 11. Input signal behavior

6.2.3 Events generated from the inputs

Each input line can generate the following four events:

- Activation Trigger Event
- Short Press Event
- Medium Press Event
- Long Press Event

The Activation Trigger Event is generated every time the input line is activated (see section 6.2.2 on page 18). Depending on the time it takes before the input line is released (length of the pulse), nRF8002 will generate one of three events: a Short, Medium, or a Long press event. Minimum time before an input is released is 50 ms, for detection of a valid trigger and subsequently a press event.

For nRF8002 to distinguish between these three events, the user has to specify two timer values, as defined in Table 12. The two timer values are common for both input lines.

Timer	Description
t1	Distinguishes between a short and a medium press.
t2	Distinguishes between a medium and a long press.

Table 12. Timer values

Decoding an input pulse using t1 and t2 will generate the following event:

- All pulses will generate an Activation Trigger event at the start of the pulse.
- An input pulse that has ended before reaching **t1** will be decoded as a Short Press.
- An input pulse that is active when reaching **t1** but has ended before reaching **t2** will be decoded as a Medium Press.
- An input pulse that is active when reaching **t2** will be decoded as Long Press.

6.2.4 OSIG events generated by the inputs

Generating an OSIG event from an input signal is a good way to give a user feedback that is related to the length of the pulse they have activated.

Each of the two input lines on the device has two OSIG events. The first OSIG event is generated when the input line has been active for a period equal to **t1**, the second OSIG event is generated when the input line has been active for a period equal to **t2**.

See Table 14. on page 21 for a list of the events. For configuration of the OSIG events see section 6.3.5 on page 27, OSIG activation.

6.2.4.1 Example showing ISIG event and OSIG action

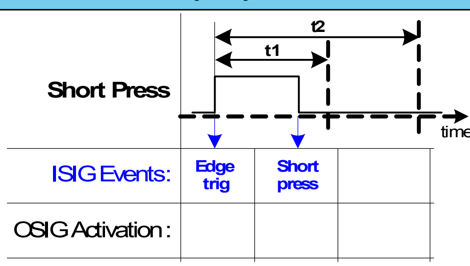
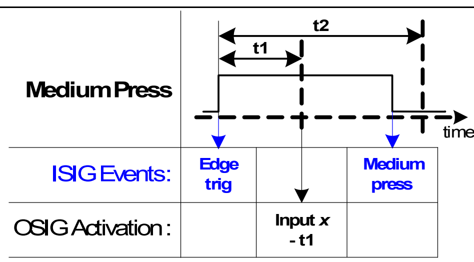
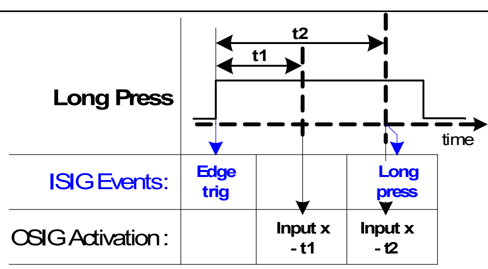
Input pulse	Description
	• Input pulse shorter than **t1**. • Gives an Activation trigger event at the start of the pulse. • Gives a Short Press Event at the end of the pulse. • OSIG Activation: none.
	• Input pulse longer than **t1**, but shorter than **t2**. • Gives an Activation trigger event at the start of the pulse. • OSIG Activation: Input x –t1 when the time **t1** is reached. • Gives a Medium Press Event at the end of the pulse.
	• Input pulse longer than **t2**. • Gives an Activation trigger event at the start of the pulse. • OSIG Activation: *Input x –t1* when the time **t1** is reached. • OSIG Activation: Input x –t2 when the time **t2** is reached. • Gives a Long Press Event at the end of the pulse.

Table 13. ISIG event and OSIG activation from Activation trigger and short, medium and, long press

6.3 Output signals (OSIG)

Four Output signals (OSIG), one of which is a PWM, can be configured on nRF8002. An Output signal (OSIG) is a Pulse Train pattern set on one of the four output pins.

6.3.1 Configuration of the Output signal (OSIG)

This section describes how the output ports are controlled by the configuration. The configuration of the output signals is defined as a Pulse Train and is defined by t1, t2 and, nt as documented in section 6.3.4 on page 23. The Pulse Train can be configured to repeat and is then defined as a Repeated Pulse Train. The action generating the OSIG is configurable and is linked to GAP, profile or, service behavior.

nRF8002 has four output ports where port 1 to 3 are digital outputs and port 4 is a PWM output, see Figure 6.

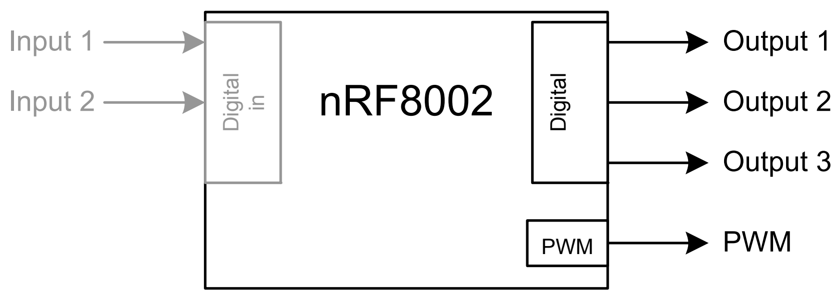


Figure 6. nRF8002's output ports

As shown in Figure 7. on page 21, the output logic is divided into four different modules:

- OSIG Pattern: a set of logical pulse patterns that can be used to generate signals on the output ports.
- OSIG Activation: translates events into OSIG actions.
- Output Handler: the engine that receives instructions from the OSIG Activation and uses this together with the OSIG Pattern and the timer ticks to generate output action.
- OSIG Output logic: translates the logical ON/OFF command received from the Output handler into voltage level on the output ports. It also controls the PWM output signal.

Note: The OSIG Pattern, Activation, and Handler modules handle logical ON/OFF signals. The OSIG Output logic module translates the logical signal into a voltage level. This is done to separate the logical behavior from the physical representation on the output port.

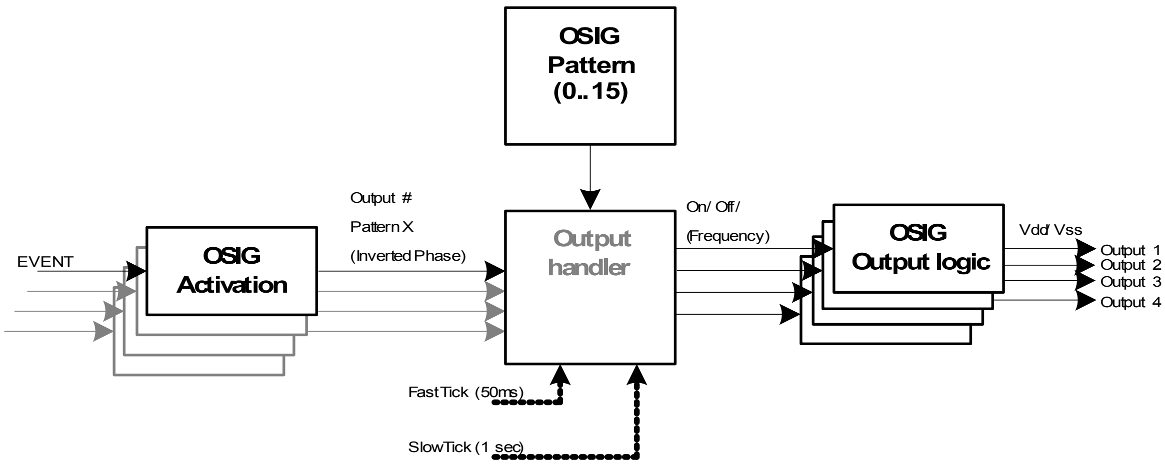


Figure 7. Output logic modules

6.3.2 Event table

Table 14. lists all the events that the user can configure to give an OSIG Activation.

Event	Description
Sleep State[1]	An event is generated when nRF8002 enters the given state.
Bond State	
Connecting State	
Connected State	
Link Loss Mild Alert	One of these events could be generated when nRF8002 detects a link loss with *Timeout.* Which of the events depends on the Link Loss alert level set by the peer device.
Link Loss High Alert	
Immediate Alert – No Alert	An event is generated when nRF8002 receives the corresponding Immediate Alert from the peer device.
Immediate Alert – Mild Alert	
Immediate Alert – High Alert	
Battery Level 40%	Events are generated every 10 minutes as long as the battery is on the actual level.
Battery Level 20%	
Alert Notification 0	Events are generated when nRF8002 receives an Alert Notification that matches the configuration set for the Alert Notification (See 6.1.2.2 on page 16).
Alert Notification 1	
Alert Notification 2	
Alert Notification 3	
ISIG – Mute Action	This event is generated by a ISIG event (as configured by the user)
ISIG Input 1 – t1	These events are given when the input port has been kept active for a period equal to the timer value (Used for giving feedback on a button press)
ISIG Input 1 – t2	
ISIG Input 2 – t1	
ISIG Input 2 – t2	

1. This event is hard-coded to turn OFF all output ports.

Table 14. Event table

6.3.3 OSIG output logic

The OSIG output logic is set individually for each of the four ports and specifies the translation from the logical representation (ON/OFF) to the voltage level (VDD/VSS). It specifies whether the logical value ON should set the port to high (VDD) or low (VSS).

For the PWM output port the frequency output will be set with 50% duty cycle when the port is ON. The first pulse will always be high (VDD).

Figure 8. Output logic on the digital and PWM ports

Figure 9. illustrates the behavior on the output pin related to the actual setting. The first row describes the behavior when the output is set to active high. Both the digital and the PWM output will then be set to VSS on Reset (power-up) and when it is set to OFF. When the output port is set ON the digital output will switch from VSS to VDD, while the PWM output will start oscillating at the specified frequency.

The second row in Figure 9. shows the reverse active low polarity.

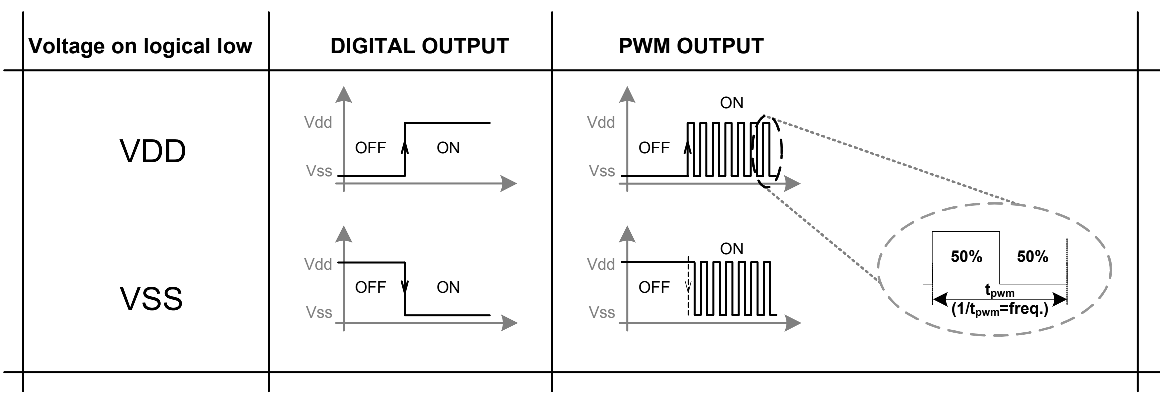


Figure 9. PWM output voltage on active high and active low

6.3.4 OSIG pattern

The OSIG pattern is a table where the you can specify up to 15 different output patterns numbered from 1 to 15. It is also possible to invert a pattern during OSIG activation, see also Table 20. on page 27

Pattern 0 is predefined to a fixed level used to set the pin either permanently ON or OFF.

No.	t_{p1}	t_{p2}	n_p	t_t	n_t	f_{pwm}	Description
0	1	0	0	0	0	0	*Pre-configured to ON (OFF)*
1							Up to 15 patterns that should be configured by the customer
2							
…							
14							
15							

Table 15. Output patterns

The pattern specification is independent of the different output ports, that is, all patterns could be used on all the outputs.

The OSIG pattern is specified using timers (t_{xx}) and counters (n_x). In addition, there is an optional parameter [f_{pwm}] that specifies the frequency to be used in the ON period for the PWM output (Output port 4). This parameter will be ignored if the pattern is used on a digital output, but has to be specified for all patterns used on PWM.

The OSIG pattern can be specified using two different modes: Fast Tick or Slow Tick mode. The difference between them is the resolution for the two timers [t_{p1}] and [t_{p2}] that specifies the ON and OFF period.

Table 16. shows timers and counters that are defined as part of the OSIG Pattern definition:

Parameter	Value range	Description
t_{p1}	50 ms...12.75 sec[1]	Defines the period for when the output should be ON.
t_{p2}	1 sec…4 min15 sec[1]	Defines the period for when the output should be OFF.
n_p	1..127 or ∞	Defines number of times the ON-OFF period, given by $[t_{p1}]/[t_{p2}]$, should be repeated (i.e. *Pulse Train* = $n_p*([t_{p1}]+[t_{p2}])$. If $[n_p]$ is set to [∞] (infinite) the ON-OFF period will be repeated forever. For $[n_p]$ = 1 or $[n_p]$ = [∞] the parameters $[t_t]$ and $[n_t]$ are not applicable.
t_t	1..255	Delay, given in seconds, between the start of two consecutive *Pulse Trains*. This delay shall be set to a value longer than the time it takes for one *Pulse Train* to complete, i.e $[t_t] > (n_p*[t_{p1}/t_{p2}])$.
n_t	1..127 or ∞	Number of times the *Pulse Train* should be repeated before it sets the output to OFF. If $[n_t]$ is set to [∞] (*infinite*) the *Pulse Train* will be repeated forever. This pattern will be activated on the next 1 sec tick (i.e. activation could be delayed up to 1 sec). For $[n_t]$ = 1 parameters $[t_t]$ are not applicable.
f_{pwm}	490 Hz – 516 kHz	Frequency to be used for the ON period if the pattern is used to control Output Port 4. **Note:** The frequency can be set in supported steps from just a few Hz to many kHz.

1. 50 ms or 1 second resolution depending on the mode (fast tick mode or slow tick mode).

Table 16. Timers and counters description

Table 17. gives a visual description of the parameters given in Table 16. above.

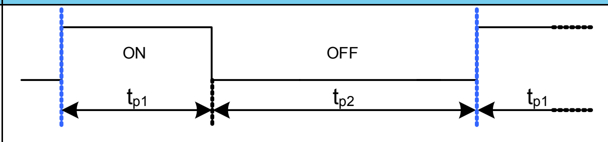
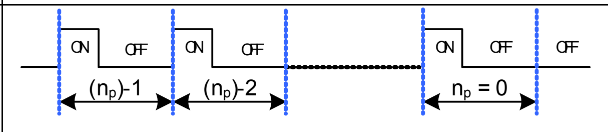
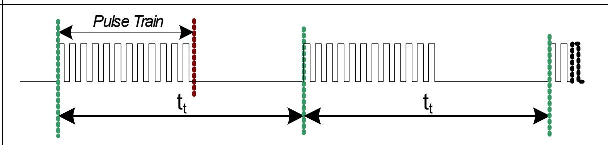
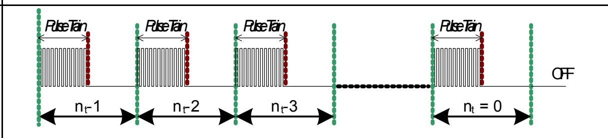
Parameter	Wave form	Description
$[t_{p1}]$ $[t_{p2}]$		Basic pulse pattern where $[t_{p1}]$ specifies the ON period and $[t_{p2}]$ specifies the OFF period
$[n_p]$		*Pulse Train* where the basic pulse pattern are repeated $[n_p]$ times
$[t_t]$		Consecutive *Pulse Trains* that are repeatedly started at interval off $[t_t]$ seconds
$[n_t]$		Consecutive *Pulse Trains* that are repeated $[n_t]$ number of times (at an interval of $[t_t]$ seconds).

Table 17. Visualization of the timers and counters

6.3.4.1 OSIG pattern generated in Fast Tick mode

If the user selects Fast Tick mode, the output pattern will be generated using 50 ms resolution on the timers: $[t_{p1}]$ and $[t_{p2}]$. The ON and OFF period could then be specified in the range from 50 ms to 12.75 s in 50 ms steps.

If nRF8002 is running patterns using Fast Tick mode the CPU needs to be active almost all the time, impacting current consumption. The only exception will be if there are periods longer than 1 sec where the output does not switch state.

Patterns that are setup to be repeated forever will be synced with the 1 sec tick. This means that there could be up to a 1 sec delay between the activation and the execution.

6.3.4.2 OSIG pattern generated in Slow Tick mode

If the user selects Slow Tick mode, the pattern will be generated using 1 sec resolution on the timers: $[t_{p1}]$ and $[t_{p2}]$. The ON and OFF period could then be specified in the range from 1 sec to 255 sec (that is 4 min 15 sec) in 1 sec steps.

Patterns running in Slow Tick mode will not need the CPU to be active all the time. How much the CPU is running depends on how often the pattern switches state between ON and OFF. A worst case scenario is if the CPU stays active for 1 second every time there is a transaction (ON-OFF or OFF-ON).