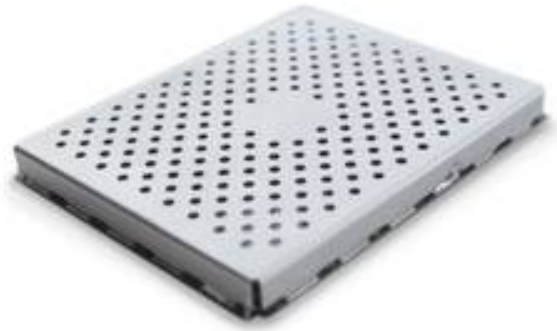

# NUR-05WL2 IMPLEMENTATION GUIDE

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Change history

| Version | Date | Author | Remarks |
|---|---|---|---|
| 0.1 | 2.1.2013 | Toni Heijari | initial version |
| 0.2 | 6.3.2013 | Toni Heijari | minor additions |
| 0.3 | 4.4.2013 | Toni Heijari | changed sections 1.3 and 4.1 |
| 1.0 | 12.6.2013 | Toni Heijari | first released version |
| 1.1 | 2.9.2013 | Toni Heijari | Changed section 11.2 and 11.3 |

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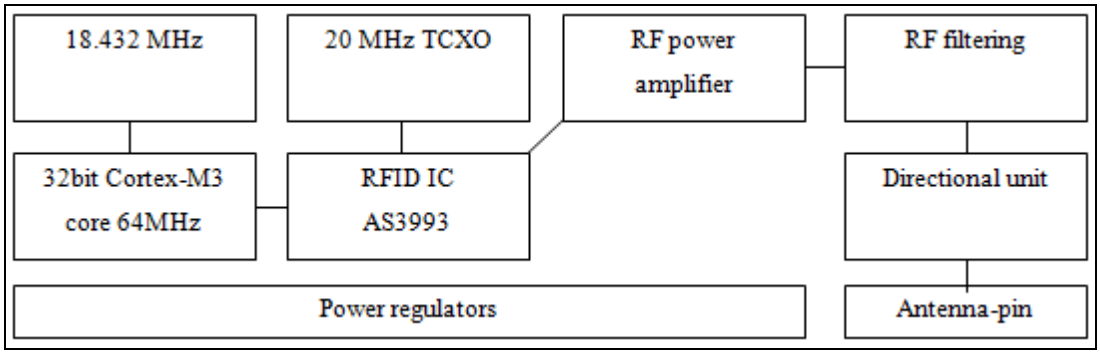
# 1 GENERAL DESCRIPTION

NUR-05WL2 is a next generation compact UHF RFID reader / writer module. It is compatible with ISO18000-6C (EPC C1G2) standard. Module fulfills ETSI, FCC and IC radio regulations. It is also compatible with DRM (dense reader mode) requirements. Maximum output power is +27dBm and it can be adjusted via SW API with 1 dB steps. Maximum sensitivity is -80dBm.

## 1.1 BLOCK DIAGRAM



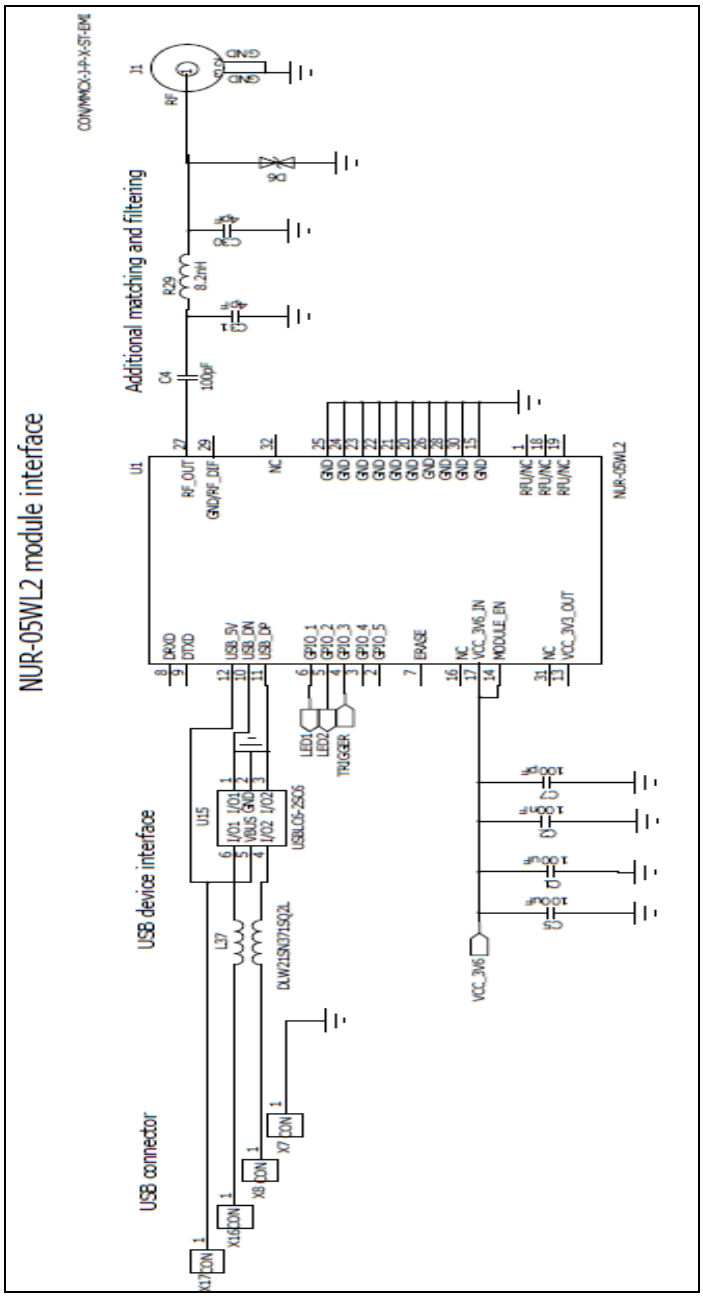

## 1.2 KEY FEATURES

- SMT compatible module with extremely small footprint
- ISO 18000-6C (EPC C1G2) full protocol support + custom commands
- Low power consumption with high noise rejection
- DRM compatible
- High performance with +27dBm output power, adjustable by 1dB steps
- Approved by ETSI, FCC and IC telecommunication organizations
- Selectable RF parameters; RX coding, link frequency and modulation
- UART and USB 2.0 communication
- 5 programmable GPIO with event trigger
- Autosensing inventory parameter support
- Increased sensitivity with automatic leakage cancelation

## 1.3 TYPICAL APPLICATION SCHEMATICS

Typical application schematic including: USB connection with ESD protection circuitry, 2 GPIO outputs for LED indicators, GPIO trigger input, NUR-05WL2 module and MMCX antenna connector.

A simple application schematic.



# 2 ELECTRICAL CHARACTERISTICS

## 2.1 ABSOLUTE MAXIMUM RATINGS

Violating these values may cause damage to the module. Also correct operation is not guaranteed if operating outside these values. NUR-05WL2 is ESD sensitive component so it must be handled with care.

| Absolute maximum ratings | Value |
|---|---|
| Operating temperature | -20°C to +55°C |
| Storage temperature (package unopened) | -30°C to +85°C |
| Supply voltage and enable | +6.0V |
| GPIO pins | +4.0V |
| Other pins | +4.0V |

## 2.2 DC CHARACTERISTICS

Typical values (VCC_3V6_IN = 3.6V @ +25°C)

| Symbol | Parameter | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| $V_{ext}$ | Supply voltage | 3.4 | 3.6 | 5.5 | V |
| $I_{ext}$ | Supply current | - | 0.8A | 1A | mA |
| $I_{source}$ | GPIO source current | - | - | 3 | mA |
| $I_{sink}$ | GPIO sink current | - | - | 6 | mA |
| $V_{low}$ | GPIO input low-level voltage | - | - | 0.8 | V |
| $V_{high}$ | GPIO input high-level voltage | 2.0 | - | - | V |
| $V_{en}$ | Module enable voltage | 1.2 | - | Supply | V |

## 2.3 RF CHARACTERISTICS

Typical values (VCC_3V6_IN = 3.6V @ +25°C)

| Symbol | Parameter | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| $S_{ens}$ | Receiver sensitivity (data sensitivity PER=0.1% / LBT sensitivity) | - | - | -70/-80 | dBm |
| $P_{out}$ | Output power | 8±2 | - | 27±2 | dBm |
| $P_{adj}$ | Power adjustment step | - | 1 | - | dB |
| $S_{11}$ | VSWR requirement | - | - | 1,5:1 | @50Ω |
| $D_{r\rightarrow t}$ | Reader to tag data rates | - | 40 / 80 | - | kbps |
| $D_{t\rightarrow r}$ | Tag to reader data rates | 20 | 64 | 320 | kbps |

## 2.4 PERFORMANCE CHARACTERISTICS

The performance of the reader module is highly dependent on the test environment, reader antenna and tag performance. Interferences from other radio sources operating in the same frequency may decrease the performance. Also the tag antenna and the tag IC may have significant effect on the values presented below. Also selected radio and inventory parameters have got a big influence to reading performance.

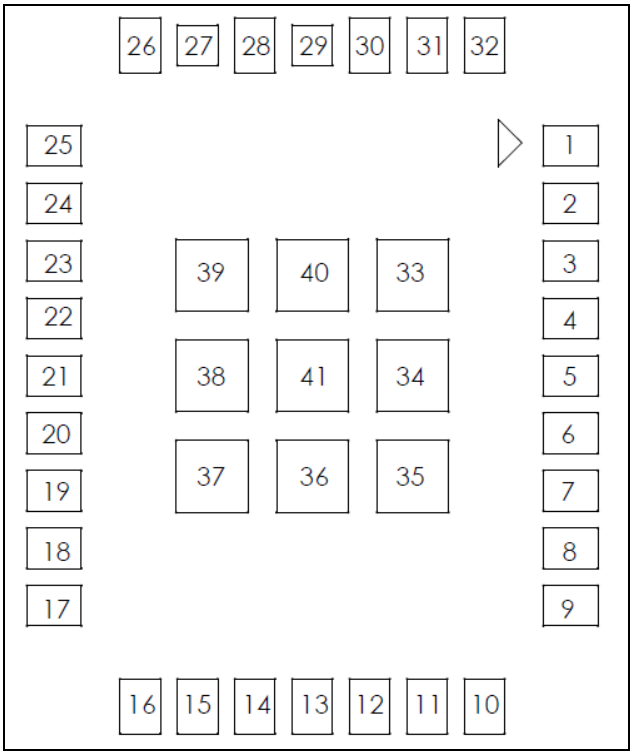
Typical values (VCC_3V6_IN = 3.6V @ +25°C)

| Symbol | Parameter | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| $R_{dist}$ | Typical reading distance with 5 dBi antenna | - | 5 | - | m |
| $R_{rate}$ | Typical reading rate | - | 200 | - | tags/s |
| $O_{temp}$ | Operation temperature | -20 | - | +55 | °C |
| $H_{rel}$ | Relative humidity | 10 | - | 95 | % |

# 3 PIN ASSIGNMENTS

## 3.1 PIN DESIGNATION

Through top view.




## 3.2 PIN MAPPING

| Pin number | Signal name | Pin type | Description |
|---|---|---|---|
| 1 | RFU | Bidirectional | RFU (do not connect) |
| 2 | GPIO_5 | Bidirectional | 3.3V GPIO |
| 3 | GPIO_4 | Bidirectional | 3.3V GPIO |
| 4 | GPIO_3 | Bidirectional | 3.3V GPIO |
| 5 | GPIO_2 | Bidirectional | 3.3V GPIO |
| 6 | GPIO_1 | Bidirectional | 3.3V GPIO |
| 7 | ERASE | Input | DNU (do not use) |
| 8 | RX | Input | Data from Host to Module |
| 9 | TX | Output | Data from module to Host |
| 10 | USB_DN | Bidirectional | USB – (device port) |
| 11 | USB_DP | Bidirectional | USB + (device port) |

| | | | |
|---|---|---|---|
| 12 | USB_DET | Input | Used only for USB detection |
| 13 | VCC_3V3_OUT | Supply output | DNU (only for testing purposes) |
| 14 | MODULE_EN | Input | Driving high will enable the module |
| 15 | GND | Supply input | Ground |
| 16 | NC | Not connected | internally not connected |
| 17 | VCC_3V6_IN | Supply input | Supply voltage input |
| 18 | RFU | Bidirectional | RFU (do not connect) |
| 19 | RFU | Bidirectional | RFU (do not connect) |
| 20 | GND | Supply input | Ground |
| 21 | GND | Supply input | Ground |
| 22 | GND | Supply input | Ground |
| 23 | GND | Supply input | Ground |
| 24 | GND | Supply input | Ground |
| 25 | GND | Supply input | Ground |
| 26 | GND | Supply input | Ground |
| 27 | RF_OUT | Bidirectional | 50Ω RF output/input |
| 28 | GND | Supply input | Ground |
| 29 | GND/RF_DIF | Bidirectional | RFU (do not connect) |
| 30 | GND | Supply input | Ground |
| 31 | NC | Not connected | internally not connected |
| 32 | NC | Not connected | internally not connected |
| 33-41 | GND | Supply input | Ground |

## 3.3 SIGNAL DESCRIPTION

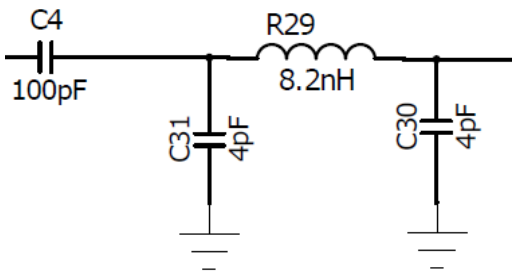
| |
|---|
| **Signal name: GND Pin number(s): 15, 20-26, 28, 30, 33-41** |
| These pins are used for grounding and to improve the thermal performance. They should be connected to Host board GND net. |
| **Signal name: GPIO_X Pin number(s): 2-6** |
| These pins are used as general purpose IO. They can be configured via SW API as input or output ports. IO voltage level is 3.3V. GPIOs have source current capability of 3mA and sink current capability of 6mA. |
| **Signal name: ERASE Pin number(s): 7** |
| This pin is used for production testing purposes only. Should not be connected. |
| **Signal name: RX Pin number(s): 8** |

| |
|---|
| This pin is used for module UART input signal. Logic level is 3.3V. If UART is used for communication the pin should be connected to the Host MCU serial TX port. |
| **Signal name: TX Pin number(s): 9** |
| This pin is used for module UART output signal. Logic level is 3.3V. If UART is used for communication the pin should be connected to the Host MCU serial RX port. |
| **Signal name: USB_DN Pin number(s): 10** |
| This pin is used as USB_D- device port. It is advised to use external ESD protection component if connected to user accessible USB connector. |
| **Signal name: USB_DP Pin number(s): 11** |
| This pin is used as USB_D+ device port. It is advised to use external ESD protection component if connected to user accessible USB connector. |
| **Signal name: USB_DET Pin number(s): 12** |
| This pin is only used for USB connection detection. It is advised to use external ESD protection component if connected to user accessible USB connector. Current is not drawn from this input pin. |
| **Signal name: VCC_3V3_OUT Pin number(s): 13** |
| This pin is connected to internal power regulator output. The pin is used for production testing and it should not be used. |
| **Signal name: MODULE_EN Pin number(s): 14** |
| Driving this pin to high will enable the NUR-05WL2 module. It is internally connected to onboard voltage regulator's enable input. The trigger level is 1.2V and the reader module will wake up in 50ms. If the external power switch is used to toggle ON and OFF, this pin can be connected directly to VCC_3V6_IN. |
| **Signal name: NC Pin number(s): 16, 31, 32** |
| These pins are internally not connected. |
| **Signal name: VCC_3V6_IN Pin number(s): 17** |
| This pin is used for power supply input for NUR-05W module. It is recommended to use 200µF (low ESR) 100nF and 100pF capacitor near the VCC_3V6_IN input pin to maintain stable operating voltage for the reader module. |
| **Signal name: RFU Pin number(s): 1, 18, 19** |
| These pins are reserved for future use. Do not connect these pins. |
| **Signal name: GND/RF_DIF Pin number(s): 29** |
| This pin is internally connected to GND. It is reserved for future use as secondary RF output. |

# 4 OEM DESIGN CONSIDERATIONS

## 4.1 RF OUTPUT AND ANTENNA REQUIREMENTS

The RF output / input impedance is 50Ω so the trace leaving from the RF_OUT pin shall be kept in that same impedance level to avoid reflections and mismatch of the RF signal. To provide an appropriate impedance match place the matching components close to RF_OUT pin. Below there is the circuit diagram that shall be utilized in the fine-tuning of the impedance match and in the additional filtering.




From the RFID reader module's point of view it is important that the used antenna has a low VSWR value. The VSWR shall be better than 1.5:1 in order to avoid decrease in the sensitivity performance of the receiver because of the TX power reflecting back from the antenna. In the NUR-05WL2 module, there is also an automatic leakage cancellation system that decreases the effect of the reflected signal, and it also improves the isolation of the RX signal from the TX signal. The automatic leakage cancellation can be triggered using SW API command. For further information on the leakage cancellation see the section 5.3.

## 4.2 POWER SUPPLY

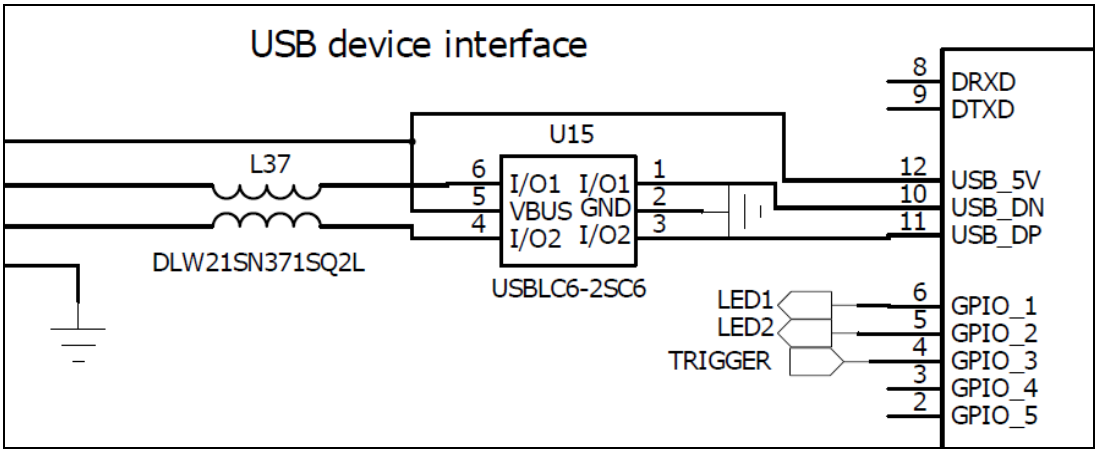
The NUR-05WL2 has internal linear power regulators for getting better power supply noise rejection. However it is still important to supply low noise and stable power to the NUR-05WL2 module. The voltage ripple should be kept under 200mVpp and it is recommended to add a minimum of 200µF low ESR, 100nF and 100pF capacitors next to the VCC_3V6_IN pin.

VCC_3V3_OUT is internal regulator output and it is used for production testing purposes. This pin should not be used to power external circuits.

## 4.3 USB DEVICE PORT

USB_DP, USB_DN and USB_DET pins are used to provide 2.0 compliant USB device port. It must be remembered that only one communication method can be used to communicate with the NUR-05WL2 module at the time. Connecting the USB will automatically prevent communication via serial port. It is advised to use external ESD protection component if connected to user accessible USB connector. Below is the typical schematics used with NUR-05WL2 module.

Typical schematics for USB connection with ESD protection.




Used components.

| Ref | Description | Manufacturer | Part code |
|---|---|---|---|
| U15 | ESD protection | ST Microelectronics | USBLC6-2SC6 |
| L37 | Common mode choke | Murata | DLW21SN371SQ2L |

# 5 RF PARAMETERS

## 5.1 TX LEVEL

The maximum output power is +27dBm (500mW). The power can be adjusted by 1dB steps. In total there are 19 steps meaning the minimum output power value is +8dBm that equals to 6mW of power. When using higher output power levels the antennas VSWR value becomes more and more important factor. High output power combined together with antenna with poor VSWR leads to a situation where significant portion of the power is reflected back to the receiver.

| TX level | Power: dBm / mW | TX level | Power: dBm / mW |
|---|---|---|---|
| 0 | 27 / 500 | 10 | 17 / 50 |
| 1 | 26 / 398 | 11 | 16 / 40 |
| 2 | 25 / 316 | 12 | 15 / 32 |
| 3 | 24 / 251 | 13 | 14 / 25 |
| 4 | 23 / 200 | 14 | 13 / 20 |
| 5 | 22 / 158 | 15 | 12 / 16 |
| 6 | 21 / 126 | 16 | 11 / 13 |
| 7 | 20 / 100 | 17 | 10 / 10 |
| 8 | 19 / 79 | 18 | 9 / 8 |
| 9 | 18 / 63 | 19 | 8 / 6 |

## 5.2 RECEIVER SENSITIVITY

The maximum LBT sensitivity is of -80dBm. The receiver can handle +5dBm of power reflecting back to RF_OUT pin without having a big impact on the performance. Tolerance to reflecting signal can be significantly increased using NUR-05WL2 leakage cancellation functionality. The receiver architecture uses direct conversion and it has an integrated AGC (automatic gain controller).

## 5.3 LEAKAGE CANCELLATION

The directional coupler of the internal leakage cancellation circuitry separates transmitted and received signals. Tuning the directional coupler increases the isolation between TX and RX signals. You may tune the directional coupler using software; there is an API function of its own for that purpose. Notice that the

tuning does not match the RF_OUT with an antenna so the good VSWR (return loss) of the antenna is an essential factor of the good performance of the system.

## 5.4 MODULATION

It is possible to use ASK (amplitude shift keying) or PR-ASK (phase reversed amplitude shift keying) modulation. Tags that are compliant with ISO18000-6C (EPC C1G2) must support both of these modulations. The PR-ASK modulation can transfer energy more efficiently to the tag because RF envelope is high more than it is using ASK modulation. By default the modulation is set to PR-ASK.

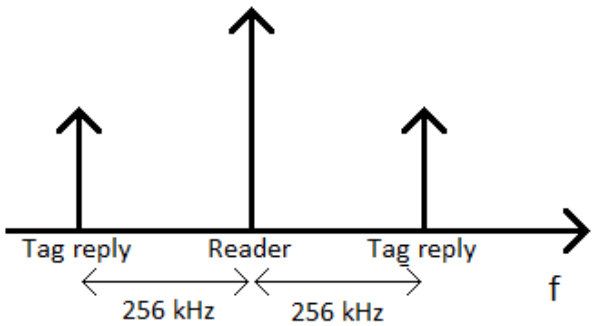
## 5.5 LINK FREQUENCY

The link frequency affects the frequency offset of tags reply in respect to reader's carrier wave. For example when used link frequency is 256 kHz, tag will reply at the frequency of reader transmission frequency ± 256 kHz. The selectable parameters are 160 kHz, 256 kHz and 320 kHz. Tags that are compliant with ISO18000-6C (EPC C1G2) must support all these parameters. The link frequency also affects tag to reader data rate which is calculated by formula below:

**Tag to reader data rate = (Link frequency / Miller coding)**

By default the link frequency is set to 256 kHz. 256 kHz or 320 kHz settings must be used when operating in DRM mode. It must be remembered that changing these parameters may cause reader to violate region or country specific radio regulations. Following is a guideline for how to choice right setting. If channel bandwidth is 200 kHz than 256 kHz or lower link frequency should be used (for example in EU). When operating in a region where 500 kHz channel bandwidth is available also 320 kHz link frequency can be used.

Spectral separation caused by 256 kHz link frequency and Miller sub-carrier encoding.




## 5.6 RX ENCODING (MILLER ENCODING)

Like stated above the Miller sub-carrier encoding scheme affects also tag to reader data rate. In practice the Miller encoding value affects the number of clock cycles that tag uses to modulate one symbol. So when using higher Miller encoding schemes tag to reader data rate will be slower but at the same time it is more robust to interferences. Also tags response spectrum is more concentrated around the link frequency when using higher Miller schemes. This allows the receiver to use narrower channel filters. Selectable values are M2, M4, M8 or FM0.

Receiver filters are optimized for M4 and M8 encoding schemes. When operating on DRM mode values 4 or 8 should be used to optimize the performance. By default Miller 4 is used. In addition to miller schemes also FM0 encoding is supported. In this case link frequency directly determines the tag to reader data rate.

Table describing different data rates.

| Link frequency (kHz) | RX encoding | Tag to reader data rate (kbps) |
|---|---|---|
| 160 | FM0 | 160 |
| 160 | M2 | 80 |
| 160 | M4 | 40 |
| 160 | M8 | 20 |
| 256 | FM0 | 256 |
| 256 | M2 | 128 |
| 256 | M4 | 64 |
| 256 | M8 | 32 |
| 320 | FM0 | 320 |
| 320 | M2 | 160 |
| 320 | M4 | 80 |
| 320 | M8 | 40 |

## 5.7 REGION

The NUR-05WL2 has predefined region settings defining frequency and channel sets for operating under different radio regulations. Globally the regulations vary depending on the country or part of the world. The below table shows the available options for the region and the respective frequency band they use. Note that the antenna also needs to be working on that same frequency.

Table showing pre-programmed countries / regions.

| Number | Country / region | Frequency / channel BW |
|---|---|---|
| 0 | ETSI / Europe | 865.6 – 867.6 MHz / 200kHz |
| 1 | FCC / North-America | 902 – 928 MHz / 500 kHz |

| | | |
|---|---|---|
| 2 | People's Republic of China | 920.5 – 924.5 MHz / 250 kHz |
| 3 | Malaysia | 919 – 923 MHz / 500 kHz |
| 4 | Brazil | 915 – 928 MHz / 500 kHz |
| 5 | Australia | 920 – 926 MHz / 500 kHz |
| 6 | New Zealand | 921.5 – 928 MHz / 500 kHz |
| 7 | Japan 250mW LBT | 916.8 – 923.4 MHz / 200 kHz |
| 8 | Japan | 916.8 – 920.4 MHz / 200 kHz |
| 9 | Custom | 840 – 960 MHz |

If you want to use custom frequencies or hop tables you need to feed parameter described below.

Table describing custom hop table parameters.

| Parameter | Value | Description |
|---|---|---|
| Frequency entry | 840 000 – 960 000 [kHz] | Defines the center frequency of the first transmit channel. |
| Channel count | 1 - 100 | Defines the number of transmit channels |
| Channel spacing | 25 * n [kHz] | Defines the frequency between transmit channels. |
| Channel time | minimum 100 ms | Defines the time that reading is ON at the same channel |
| Wait time | maximum 1000 ms | Defines the time that transmitter is silent between frequency hops |
| Tari | 1=12.5us 2=25us | Defines the Tari value |
| LF | 160 000, 256 000 or 320 000 | Defines the maximum link frequency that is used |

# 6 READING PARAMETERS

## 6.1 Q-VALUE

The Q-value defines the amount of open response slots that tags can use per one inventory round. Number of slots can be calculated by formula $2^Q$. It is advised to use twice as much slots compared to amount of tags that you have in your readers reading field simultaneously. Selectable values are 0 – 15 and value 0 means automatic Q-value adjustment. When Q=0 is used reader will automatically increase the Q-value when lots of collisions are noticed and decreased the value when there are only few collisions. By default the Q-value is set to 0.

Table indicating the relation between the Q-value and the number of open slots per round.

| Q-value | slots | Q-value | slots |
|---|---|---|---|
| 0 | automatic | 8 | 256 |
| 1 | 2 | 9 | 512 |
| 2 | 4 | 10 | 1024 |
| 3 | 8 | 11 | 2048 |
| 4 | 16 | 12 | 4096 |
| 5 | 32 | 13 | 8192 |
| 6 | 64 | 14 | 16384 |
| 7 | 128 | 15 | 32768 |

## 6.2 SESSION

There are four session options which you can use when initializing inventory round. Every session has two target states A and B. By default Gen2 tags are at state A if tag has not been read recently. When tag is read it flips to state B and doesn't reply to readers query. The table below describes the persistence of tag's state machine when using different session values. For example when using session 0 the tag will come back to state A immediately when tag power is lost. Usually tag loses the power when reader stops the inventory round or chances the channel. Persistence when tag power is ON is not defined by the ISO18000-6C when using session settings S0, S2 and S3. With session 1 the tag will keep it state over 500ms but less than 5s. With session values 2 and 3 tags will keep it states over 2s when tag power is lost. Time can vary depending what tag IC is used.

Table indicating persistence characteristics of gen2 tags.

| Flag | Persistence: tag power ON | Persistence: tag power OFF |
|---|---|---|
| S0 | indefinite | none |
| S1 | 500ms < t < 5s | 500ms < t < 5s |
| S2 | indefinite | t > 2s |
| S3 | indefinite | t > 2s |

By changing the target setting from A target to B target reader is able to read also tags that has flipped its state to B state. This would happen if tags would have been read recently using Session 1 2 or 3. NUR-05WL2 module also supports dual target mode. In that mode reader will change the target mode between inventory rounds. By default target mode A is used.

## 6.3 ROUNDS

The rounds setting defines how many query rounds is done inside one inventory round. After every inventory round the reader will send data to the Host. Selectable values are 0 – 10. Zero meaning automatic rounds adjustment. The automatic adjustment decides after every query round whether another round is necessary based on the number of data collisions. By default rounds setting is set to 0. This setting can help the reader to find all the tags that are in the readers reading field when using session 0. Because tags that are found in query round 1 doesn't replay in the following query rounds. When using session 1/2/3 this does not make any significant difference because tags that are read are quiet anyway.

Table describing relation between inventory round and query round.

| Inventory round | | | | |
|---|---|---|---|---|
| Round 1 | Round 2 | round 3 | … | Round 10 |

## 6.4 SELECTING THE RIGHT READING PARAMETERS

One approach is to test how many tags are in the readers reading field simultaneously. Keep the reader still at the position that is as close to real reading environment as possible and see how many tags are found. Based on that amount choose your open slot number to be 1.5 – 2 times larger (refer to the section 6.1). If reader will face many different tag populations auto-Q setting will be a good choice.

Besides Q-value one important parameter is session. In general it could be stated that if the size of tag population is measured in thousands rather than in hundreds it is wise to use sessions 2 or 3. Because then every tag will be read only once and that makes large tag population much faster and easier to read. When using session 2 or 3 it is advised to use Miller 8 encoding scheme to avoid data transfer errors as much as possible. Rounds 1 setting is also advised to be used with session 1 or 2 or 3. With session 0 it might be useful to use higher rounds value than 1 to be able to find all the individual tags. By default automatic (0) rounds setting is used.

Other settings like modulation, link frequency and RX-encoding has a minor impact to the reading speed of the reader. When operating in optimal environment following will apply:

***RX encoding:*** *FM0 is fastest but quite sensitive to interferences / M8 slowest but very robust*
***Modulation:*** *No effect to speed but PR-ASK has better range with some tags*
***Link frequency:*** *320 kHz is the fastest / 160 kHz is the slowest*

Guideline settings to be used with different tag populations.

| Settings | Tag population | Simultaneously in the field |
|---|---|---|
| Session 0, auto Q, auto Rounds | 1 – 100 | 1 – 100 |
| Session 1, auto Q, Rounds 1 | 100 – 1 000 | under 500 |
| Session 2/3, auto Q, Rounds 1 | 100 – 1 000 | over 500 |
| Session 2/3, auto Q, Rounds 1 | over 1 000 | over 500 |

# 7 GPIO CONFIGURATIONS

NUR-05WL2 has 5 programmable GPIOs. All of them can be used as an input or output. They can be also configured to have different predefined functions.

## 7.1 INPUT / OUTPUT

All GPIOs can be configured via SW API to be inputs or outputs. IO voltage level is 3.3V and maximum source current is 3mA and sink current 6mA. When configured as input SW API can check what the state (high / low) of the GPIO pin is. When GPIO is configured as an output the SW API can drive the GPIO pin to high or low.

## 7.2 PREDEFINED FUNCTIONS

The below table describes how the NUR-05W module GPIOs can be configured.

| I/O | Function | Action | Trigger |
|---|---|---|---|
| Output | - | - | - |
| Output | RFON | - | - |
| Output | RFIDREAD | - | - |
| Output | Beeper | - | - |
| Output | Antenna control 1 | - | - |
| Output | Antenna control 2 | - | - |
| Input | - | - | - |
| Input | - | Notify | rising/falling/both |
| Input | - | Scantag | rising/falling/both |
| Input | - | Inventory | rising/falling/both |

**RFON (GPIO type: OUTPUT)**

When GPIO is configured as “RFON” it drives high state always when power amplifier is turned on. This function can be used for example driving LED indicator.

**RFIDREAD (GPIO type: OUTPUT)**

When “RFIDREAD” function is selected will GPIO pin drive high for a short period of time after a timeout has surpassed after last successful tag reading. The timeout can be defined as a parameter for the function. If no tags were successfully read and the timeout was surpassed the pin will drive high three times. This

function can be used for example driving a LED indicator. Note that this function requires a “scan tag” or “inventory” trigger from another GPIO pin set as an input.

**Beeper (GPIO type: OUTPUT)**

When “beeper” function is used will GPIO pin drive high for a short period of time after a timeout has surpassed after last successful tag reading. The timeout can be defined as a parameter for the function. If no tags were successfully read and the timeout was surpassed the pin will drive high three times. This function can be used for example driving a beeper. Note that this function requires a “scan tag” or “inventory” trigger from another GPIO pin set as an input. GPIO is high also when sending a beep command (13) over the SW API.

**Inventory (GPIO type: INPUT)**

When “inventory” function is selected will reader start reading when it is triggered by selected GPIO. Triggering can be configured to be from falling / rising / both edges. Reader will read as long as it finds new tags. Time interval between end of reading and last found tag can be configured.

**Scantag (GPIO type: INPUT)**

When GPIO is configured as “scan tag” reader will perform just one read. Triggering can be configured to be from falling / rising / both edges

**Notify (GPIO type: INPUT)**

When GPIO is configured as “notify” will reader send notification to Host application when triggered by selected GPIO. Triggering can be configured to be from falling / rising / both edges

**Antenna control 1 (GPIO type: OUTPUT)**

When GPIO is configured as “antenna control 1” it can be used for controlling external multiplexer on the Host board to switch between two antennas. Via the SW API it’s possible to select which antennas are enabled and used or let the module automatically switch between them.

| Case (selected antenna) | antenna control 1 |
|---|---|
| 0 (antenna 1) | low |
| 1 (antenna 2) | high |

**Antenna control 1 & 2 (GPIO type: OUTPUT)**

If you want to connect up to 4 antennas and multiplex those using NUR-05WL2 module you need to configure 2 GPIOs to control the antenna switch. In this case you define one GPIO to be “antenna control 1” and second one to be “antenna control 2”. Via the SW API it’s possible to select which of the connected antennas are enabled and used or let the module automatically switch between them.

| Case (selected antenna) | antenna control 1 | antenna control 2 |
|---|---|---|
| 0 (antenna 1) | low | low |
| 1 (antenna 2) | high | low |
| 2 (antenna 3) | low | high |
| 3 (antenna 4) | high | high |

# 8 DIAGNOSTIC FUNCTIONS

## 8.1 REFLECTED POWER MEASUREMENTS

This measurement can be used to check what is the matching of the antenna(s) and feed line(s). When this function is triggered will NUR-05WL2 module put carrier wave ON at full power and then measure the absolute power level that is coming to receiver port. Attenuation in the RX-line is 11 dB and full output power is 27 dBm. Based on these two values you can determine antennas return loss (S11) value using formula below:

Antennas return loss = Power to antenna – (RX-line attenuation + reflected power meas.)
Antennas return loss = 27 – 11 – (reflected power meas.)

When leakage cancelation is used these calculations are no longer absolute return loss values because cancellation circuitry eliminates some amount of the signal reflecting back from the antenna. In this case this value is the absolute power value that is leaking into the receiver due to imperfect coupler isolation or antenna mismatch.

## 8.2 CHANNEL SCANNER

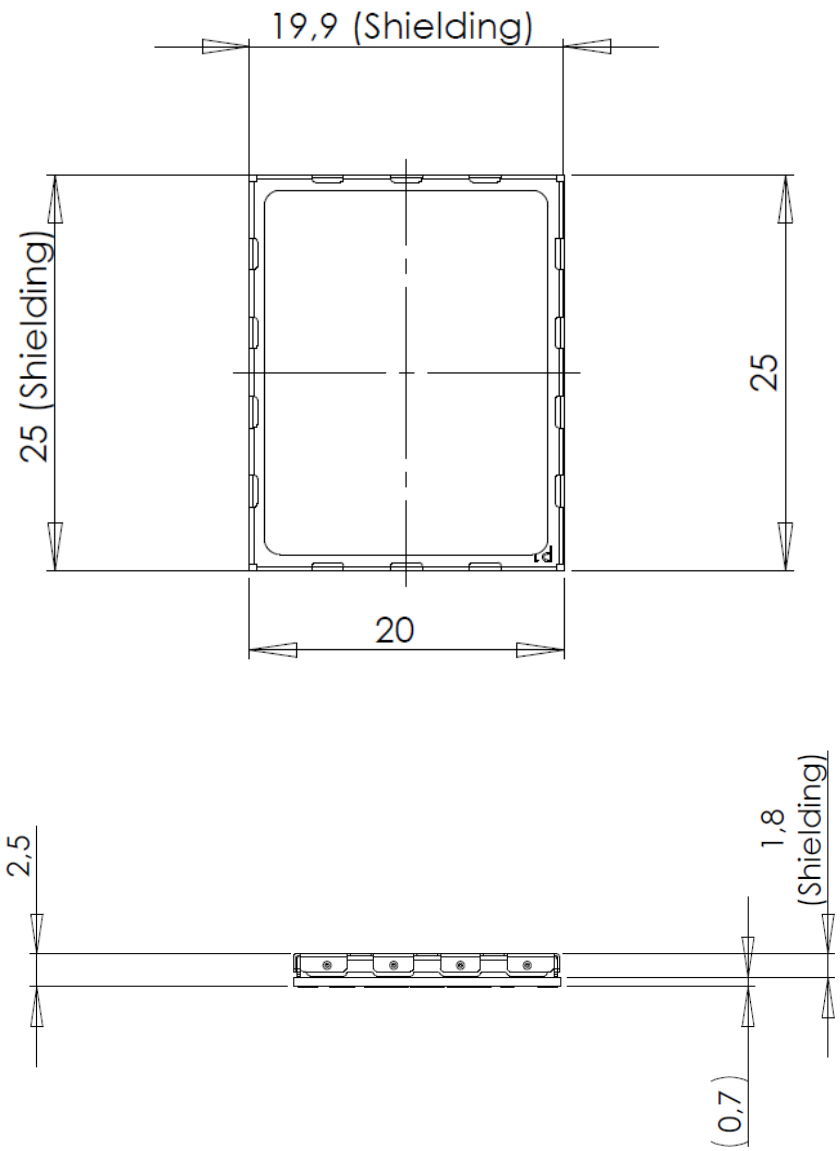
This function can be used to monitor the interferences in the current frequency band. It is also useful if you want to check if some fixed channel is in use. When you trigger this function NUR-05WL2 will scan all the channels in current region and return the RSSI-value of each channel. Returned values are absolute power levels in receiver. Loss between RF_OUT pin and receiver is 11 dB so actual values are about 11dB higher.

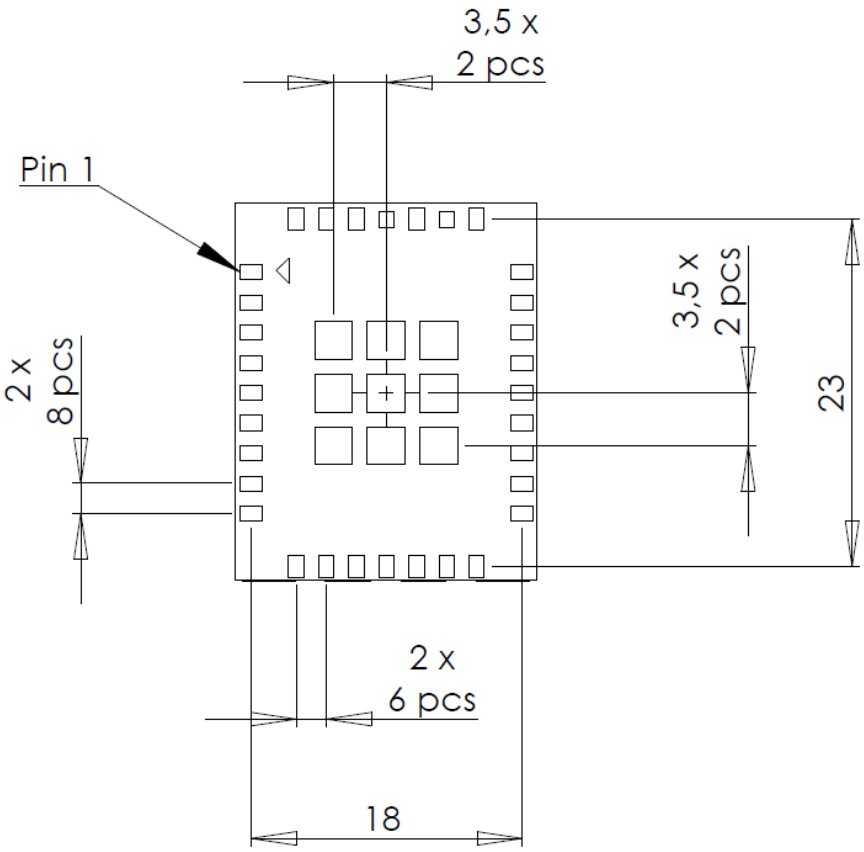
## 8.3 RECEIVED SIGNAL STRENGTH (RSSI)

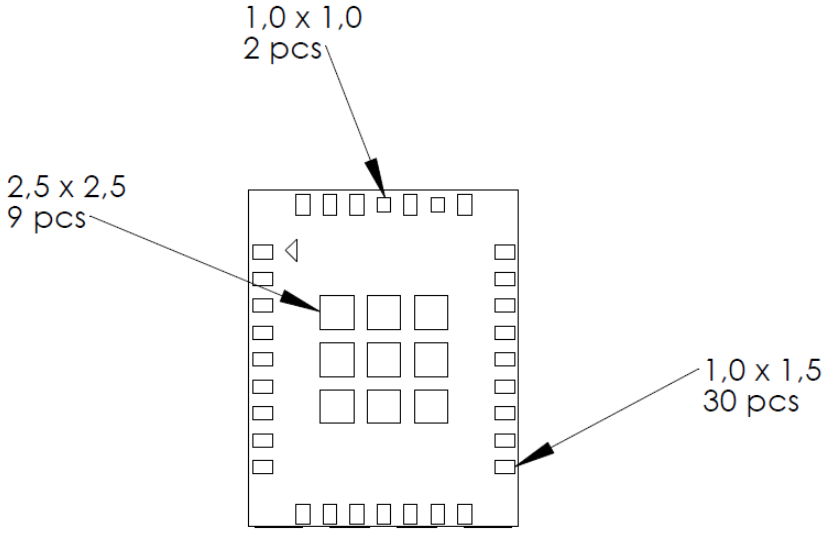
When reading a tag NUR-05WL2 module also returns received signal strength indication values if wanted. Two values are returned per one tag. One is the absolute power level (dBm) and second is the scaled power level value of the tags backscatter signal. NUR-05WL2 module automatically adjusts receiver according to output power levels. Causing that maximum and minimum absolute RSSI power levels will vary depending from the used output power levels. That is why scaled RSSI value is also available. Scale is 0 – 100.

# 9 DIMENSIONS

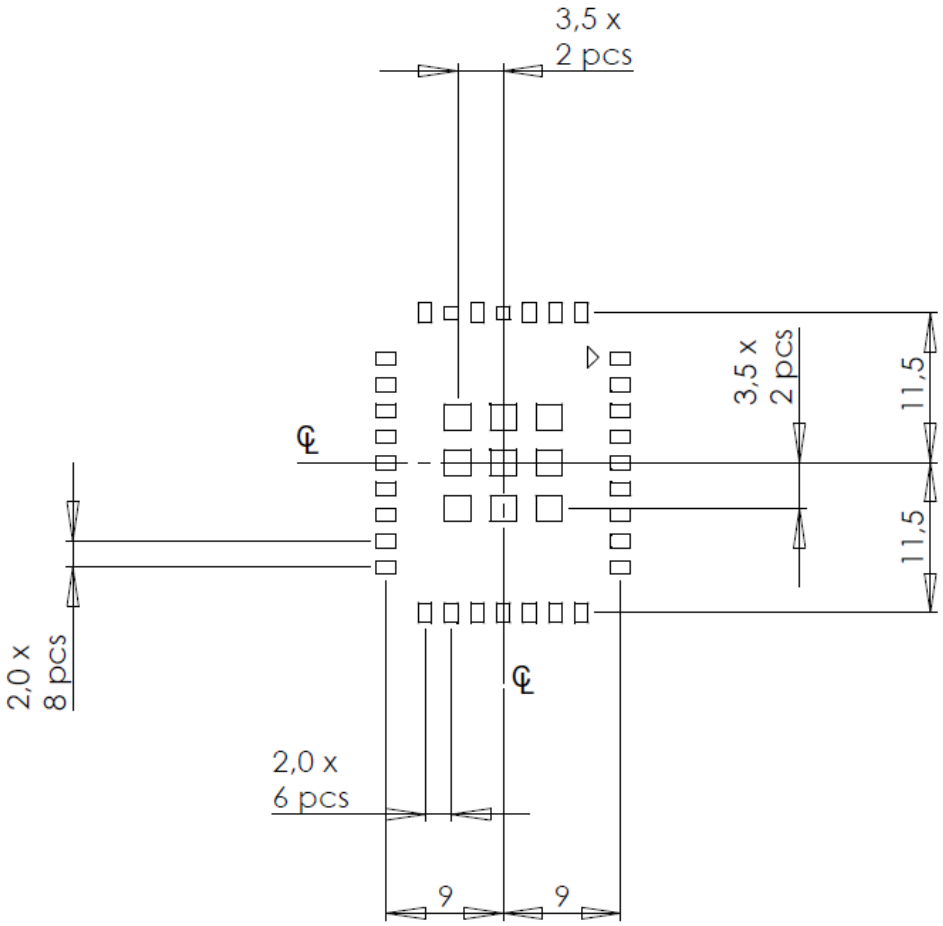
## 9.1 MECHANICAL DIMENSIONS

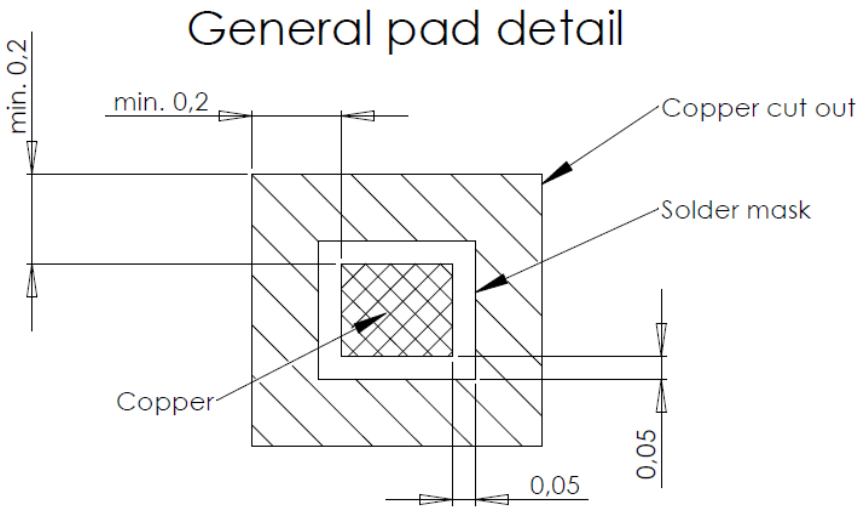


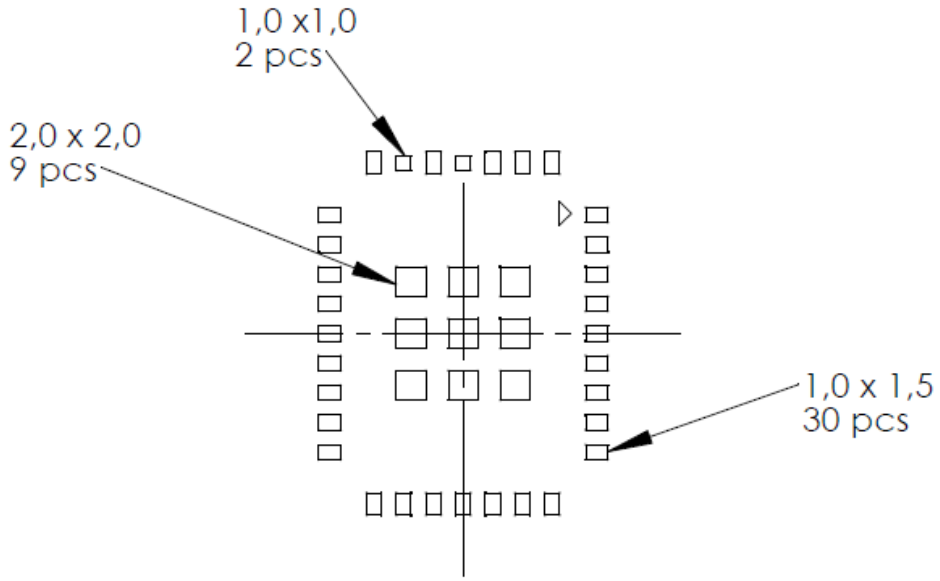

3,5 x
2 pcs
Pin 1
2 x
8 pcs
3,5 x
2 pcs
23
2 x
6 pcs
18


1,0 x 1,0
2 pcs
2,5 x 2,5
9 pcs
1,0 x 1,5
30 pcs

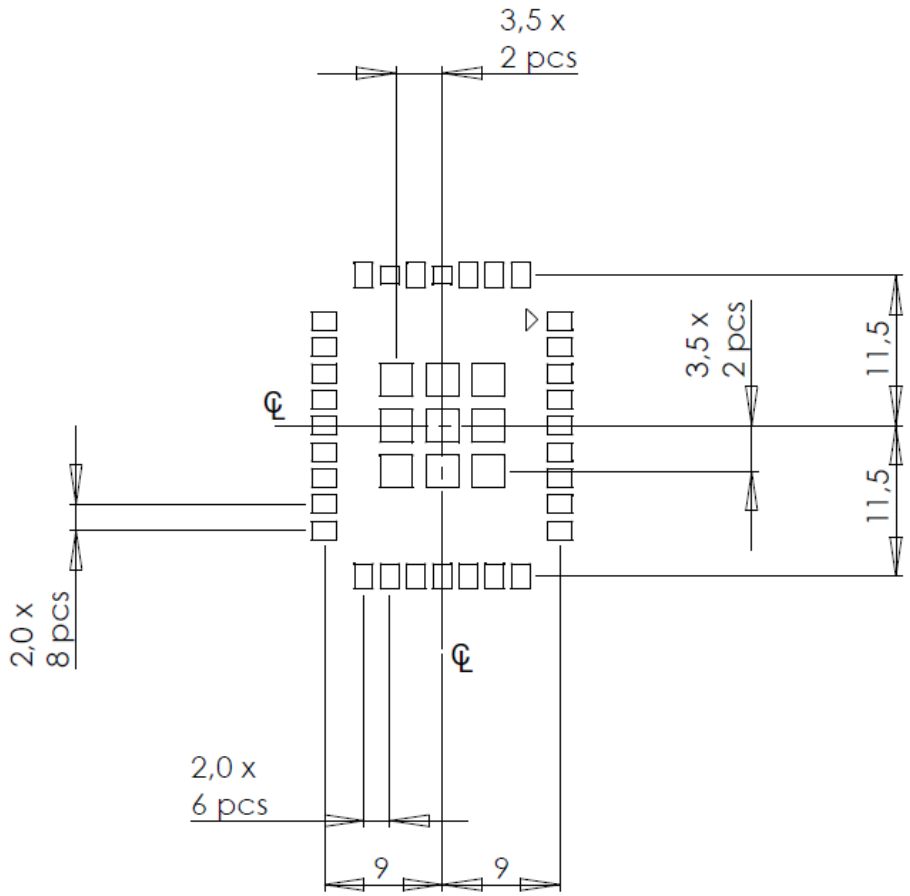
## 9.2 LAND PATTERN

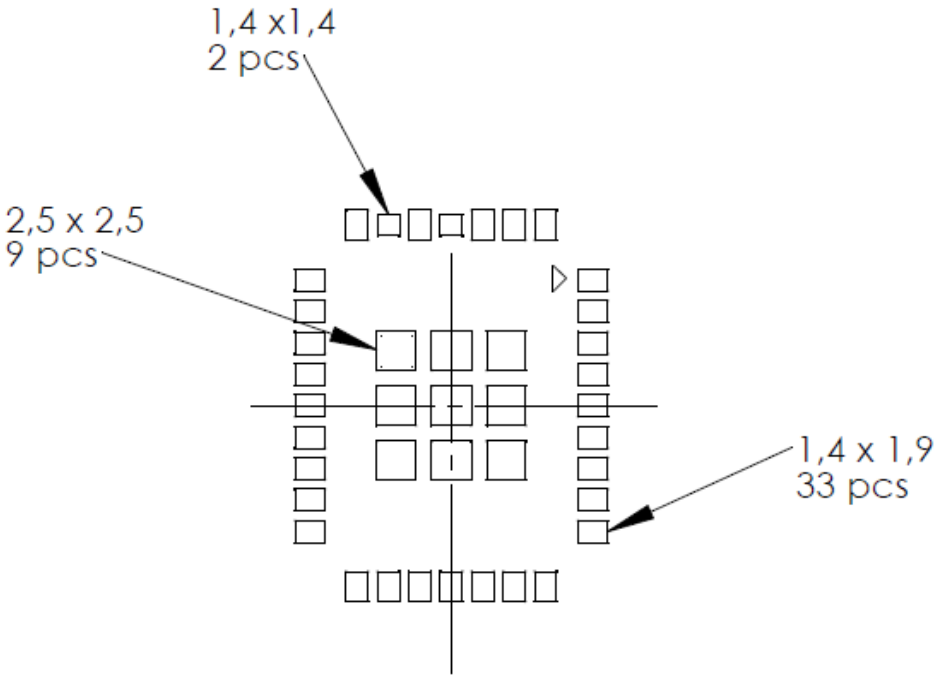


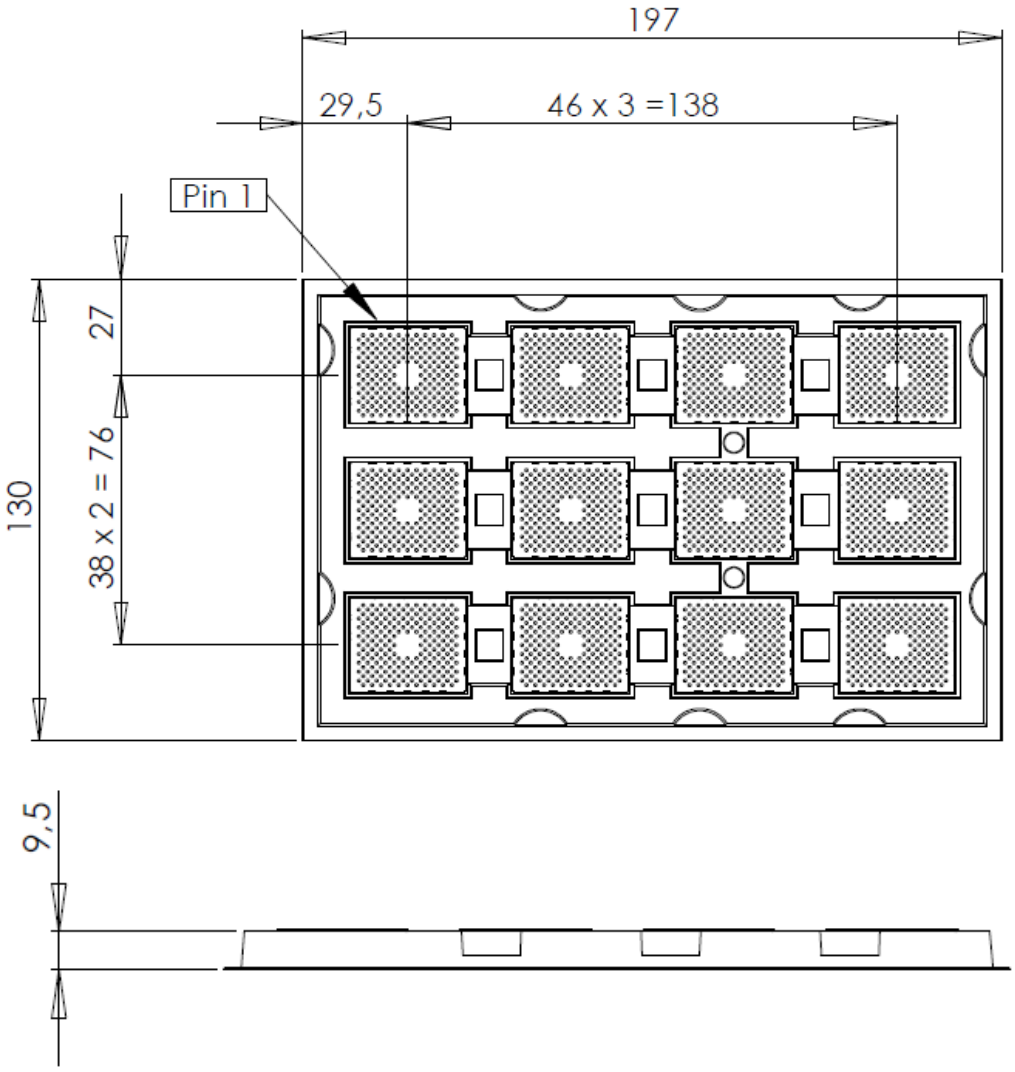


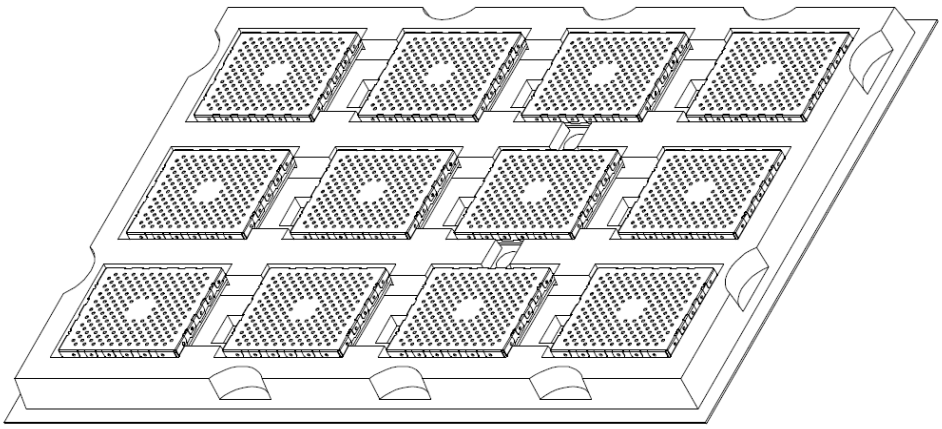

## 9.3 PASTE STENCIL






## 9.4 PACKING TRAY DIMENSIONS





All measures are in mm.

# 10 SMT ASSEMBLY PROCESS AND THERMAL PROCESSING

NUR-05WL2 module contains single sided assembly of SMT components reflow-soldered on multilayer HDI (high density interconnections) glass-fiber re-enforced epoxy printed board. The bottom side terminations are ENIG (NiP/Au) plated. Soldering alloy used for attaching module components is eutectic SnAgCu. Module internal components soldering has been optimized for minimal thermal stress.

NUR-05WL2 modules shall be delivered in a special tray packing to protect modules against mechanical, ESD and moisture related stresses. Due to high density interconnections technology, module total water content have to be below 0.1%-w prior to any thermal processing above water boiling point.

The board assembly process of NUR module on motherboard will introduce re-flow of module components. Thus, to avoid degradation of solder joint interfaces, the module has to be stored and soldered according to the guidelines given below.

## 10.1 STORAGE CONDITIONS

**Long-term storage**

Store modules in unopened vacuum packs in a dry cabinet under following environmental conditions

| | |
|---|---|
| Temperature | +15…+27°C (optimal) |
| Temperature gradient | max. 2°C/hour |
| Relative humidity | <15% within specified temperature range |

Opened and broken packages have to be re-sealed. If open time (floor life out of pack) has been exceeded, or moisture content detected, modules have to be baked prior to re-sealing vacuum pack.

**Short-term storage** (typically same as production environment)

| | |
|---|---|
| Temperature | +20…+27°C |
| Temperature gradient | max. 2°C/hour |
| Relative humidity | <15% within specified temperature range |

Modules may be stored in a dry cabinet without protective packing according to **IPC/JEDEC J-STD-033B.1, table 7-1.**

**MSL level and open time**

| | |
|---|---|
| MSL level | 5 |
| Open time (floor life out of the bag) | 48h |

## 10.2 SOLDERING PROCESS

**Boundary conditions**

| | |
|---|---|
| Acceptable soldering methods | Convection reflow in air or nitrogen atmosphere<br>Condensation reflow soldering (vapor phase) |
| Recommended stencil thickness | 125um ±10um |
| Pad design on motherboard | See recommended pad pattern |
| Stencil openings | See recommended stencil pattern |
| Recommended solder alloy | SnAg3.8±0.2Cu0.7±0.2<br>Note! If using under-eutectic solder alloys, such as SAC305, it may be necessary to increase reflow peak temperature by 5-10°C, due to higher mp. and lower fluidity of non-eutectic SnAgCu alloys. This will increase thermal stress to module and motherboard greatly. |
| Convection reflow oven heater configuration | Double sided heating required in reflow, recommended in preheating zones. |
| Maximum absorbed moisture content prior to thermal processing | 0.1%-w (Test method IPC-TM-650, 2.6.28)<br>Moisture content and/or moisture absorption rate, Printed Board |
| Recommended moisture reduction condition | +60°C/12h vacuum pack removed during drying, re-seal after drying, unless modules will be used within allowed open time after drying |
| Moisture and solvent contamination | No moisture or solvent contamination allowed in solder paste or on solderable surfaces |

**Recommended reflow conditions**

| | |
|---|---|
| Preheating phase | -max. duration 180s<br>-end temperature 190-200°C |

| | |
|---|---|
| | -delta T on assembly max. 10°C at end of preheating |
| Soldering phase | -total duration 190s<br>-max. time above 217°C (mp.) 30s<br>-Tpeak max. 235°C, measured at module bottom<br>-Tpeak max. 225°C, measured at motherboard surface, under module |
| Cooling | Two-stage, double sided cooling recommended<br>1st stage: 2-5°C/s cooling until melting point<br>2nd stage: 1-3°C/s after melting point |

# 11 REGULATORY AGENCIES INFORMATION

When OEM prefers to leverage Nordic ID's grants and certifications of the NUR-05WL2 UHF RFID module, the host device documentation shall include regulatory compliance information on the NUR-05WL2 module. Corresponding to the applicable regulatory agencies the following sections outline regulatory compliance information needed in the user documentation and external labels for the host devices into which the NUR-05WL2 is integrated.

When leveraging Nordic ID's grants and certifications, antenna shall be taken into account in view of the fact that the NUR-05WL2 module has met the essential regulatory requirements with the antennas listed in the context of particular regulatory compliance information (Approved Antennas). Using the antenna that is an approved one, OEM integrator may demonstrate with less effort that the device with the integrated NUR-05WL2 module is in compliance with the requirements.

## 11.1 EUROPEAN UNION AND EFTA COUNTRIES

### USER'S GUIDE REQUIREMENTS

This apparatus is in compliance with the essential requirements of the R&TTE Directive 1999/5/EC. In order to prove presumption of conformity with the essential requirements of the R&TTE Directive 1999/5/EC the following requirements and test methods have been applied to the apparatus:

- article 3.2: ETSI EN 302 208 v1.3.1
  Radio spectrum matters for Radio Frequency Identification (RFID) equipment operating in the band 865 MHz to 868 MHz with power levels up to 2W
- article 3.1b: ETSI EN 301 489-1 v1.9.1
  Common ElectroMagnetic Compatibility (EMC) requirements
- article 3.1b: ETSI EN 301 489-3 v1.4.1
  Specific ElectroMagnetic Compatibility (EMC) conditions for Short-Range Devices (SRD) operating on frequencies between 9 kHz and 40 GHz
- article 3.1a: EN 60950-1:2005
  General requirements for Safety of Information Technology Equipment

This apparatus is in compliance with EU Directive 2003/95/EC, Reduction of Hazardous Substances (RoHS).

**Česky**
**[Czech]**

[name of manufacture] tímto prohlašuje, že tento [type of apparatus] je ve shodě sezákladními požadavky a dalšími příslušnými ustanoveními směrnice1999/5/ES.

**Dansk**
**[Danish]**

Undertegnede [name of manufacture] erklærer herved, at følgende udstyr [type of apparatus] overholder de væsentlige krav og øvrige relevante krav i direktiv 1999/5/EF.

**Deutsch**
**[German]**

Hiermit erklärt [name of manufacture], dass sich das Gerät [type of apparatus] in Übereinstimmung mit den grundlegenden Anforderungen und den übrigen einschlägigen Bestimmungen der Richtlinie 1999/5/EG befindet.

**Eesti**
**[Estonian]**

Käesolevaga kinnitab [name of manufacture] seadme [type of apparatus] vastavust direktiivi 1999/5/EÜ põhinõuetele ja nimetatud direktiivist tulenevatele teistele asjakohastele sätetele.

**English**

Hereby, [name of manufacture], declares that this [type of apparatus] is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC.

**Español**
**[Spanish]**

Por medio de la presente [name of manufacture] declara que el [type of apparatus] cumple con los requisitos esenciales y cualesquiera otras disposiciones aplicables o exigibles de la Directiva 1999/5/CE.

**Ελληνική**
**[Greek]**

ΜΕ ΤΗΝ ΠΑΡΟΥΣΑ [name of manufacture] ΔΗΛΩΝΕΙ ΟΤΙ [type of apparatus] ΣΥΜΜΟΡΦΩΝΕΤΑΙ ΠΡΟΣ ΤΙΣ ΟΥΣΙΩΔΕΙΣ ΑΠΑΙΤΗΣΕΙΣ ΚΑΙ ΤΙΣ ΛΟΙΠΕΣ ΣΧΕΤΙΚΕΣ ΔΙΑΤΑΞΕΙΣ ΤΗΣ ΟΔΗΓΙΑΣ 1999/5/ΕΚ.

**Français**
**[French]**

Par la présente [name of manufacture] déclare que l'appareil [type of apparatus] est conforme aux exigences essentielles et aux autres dispositions pertinentes de la directive 1999/5/CE.

**Italiano**

**[Italian]**

Con la presente [name of manufacture] dichiara che questo [type of apparatus] è conforme ai requisiti essenziali ed alle altre disposizioni pertinenti stabilite dalla direttiva 1999/5/CE.

**Latviski**

**[Latvian]**

Ar šo [name of manufacture] deklarē, ka [type of apparatus] atbilst Direktīvas 1999/5/EK būtiskajām prasībām un citiem ar to saistītajiem noteikumiem.

**Lietuvių**

**[Lithuanian]**

Šiuo [name of manufacture] deklaruoja, kad šis [type of apparatus] atitinka esminius reikalavimus ir kitas 1999/5/EB Direktyvos nuostatas.

**Nederlands**

**[Dutch]**

Hierbij verklaart [name of manufacture] dat het toestel [type of apparatus] in overeenstemming is met de essentiële eisen en de andere relevante bepalingen van richtlijn 1999/5/EG.

**Malti**

**[Maltese]**

Hawnhekk, [name of manufacture], jiddikjara li dan [type of apparatus] jikkonforma mal-ħtiġijiet essenzjali u ma provvedimenti oħrajn relevanti li hemm fid-Dirrettiva 1999/5/EC.

**Magyar**

**[Hungarian]**

Alulírott, [name of manufacture] nyilatkozom, hogy a [type of apparatus] megfelel a vonatkozó alapvetõ követelményeknek és az 1999/5/EC irányelv egyéb elõírásainak.

**Polski**

**[Polish]**

Niniejszym [name of manufacture] oświadcza, że [type of apparatus] jest zgodny z zasadniczymi wymogami oraz pozostałymi stosownymi postanowieniami Dyrektywy 1999/5/EC.

**Português**

**[Portuguese]**

[name of manufacture] declara que este [type of apparatus] está conforme com os requisitos essenciais e outras disposições da Directiva 1999/5/CE.

**Slovensko**
**[Slovenian]**

[name of manufacture] izjavlja, da je ta [type of apparatus] v skladu z bistvenimi zahtevami in ostalimi relevantnimi določili direktive 1999/5/ES.

**Slovensky**
**[Slovak]**

[name of manufacture] týmto vyhlasuje, že [type of apparatus] spĺňa základné požiadavky a všetky príslušné ustanovenia Smernice 1999/5/ES.

**Suomi**
**[Finnish]**

[name of manufacture] vakuuttaa täten että [type of apparatus] tyyppinen laite on direktiivin 1999/5/EY oleellisten vaatimusten ja sitä koskevien direktiivin muiden ehtojen mukainen.

**Svenska**
**[Swedish]**

Härmed intygar [name of manufacture] att denna [type of apparatus] står i överensstämmelse med de väsentliga egenskapskrav och övriga relevanta bestämmelser som framgår av direktiv 1999/5/EG.

## LABELING REQUIREMENTS

The '**CE**' marking must be in a visible area on the OEM product.

## APPROVED ANTENNAS

Maximum allowed ERP power is 33dBm. NUR-05WL2 has output power of 27dBm. Meaning that 8dBi is the maximum allowed antenna gain.

Formula how to calculate maximum allowed antenna gain:

**27 dBm – 2.15 (dipole gain) + [antenna gain dBi] – [cable attenuation dB] < 33dBm**

Beamwidth restrictions:

For transmissions ≤ 500 mW e.r.p. there shall be no restriction on beamwidth.

For transmissions of > 500 mW e.r.p. to ≤ 1 000 mW e.r.p. beamwidths shall be ≤ 180º

For transmissions of > 1 000 mW e.r.p. to 2 000 mW e.r.p. beamwidths shall be ≤ 90º

## 11.2 FCC

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

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.

**FCC Caution:** Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

This NUR-05WL2 transmitter module is authorized to be used in other devices only by OEM Integrators under the following conditions:

1. The antenna(s) must be installed such that a minimum separation distance of 20cm is maintained between the radiator (antenna) & user's/nearby people's body at all times.
2. The transmitter module must not be co-located with any other transmitter, except with those that are within the limits shown in the NUR-05WL2 filing.
3. The transmitter module can only be used with a host antenna circuit trace layout design in strict compliance with the OEM instructions provided.

When the conditions above are met, typically no further transmitter testing is required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

The antenna used with the NUR-05WL2 transmitter module can have a gain of 8 dBi at the maximum. Higher gain antennas may be used if cable loss compensates the exceeded antenna gain. For example 2dB antenna cable loss reduces EIRP so that 10dBi antenna may be used.

**Note**

In the event that these conditions can't be met (for certain configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID can't be used on the final product. In these circumstances, the OEM integrator will be responsible for reevaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user manual of the end product.

For the User's Guide the required FCC statements outlined in the User's Guide Requirements section must be in a prominent location.

## USER'S GUIDE REQUIREMENTS

"To comply with FCC's RF radiation exposure requirements, the antenna(s) used for this transmitter must be installed such that a minimum separation distance of 20cm is maintained between the radiator (antenna) & user's/nearby people's body at all times and must not be co-located or operating in conjunction with any other antenna or transmitter."

"This device complies with Part 15 of the FCC Rules"

"Any changes or modifications to the transmitting module not expressly approved by
Nordic ID Oy could void the user's authority to operate this equipment"

## LABELING REQUIREMENTS

The end product must be labeled with the following identification information in a visible area:

**"Contains Transmitter Module FCC ID: SCCNUR05WL2"**

or

**"Contains FCC ID: SCCNUR05WL2"**

### APPROVED ANTENNAS

**Option 1:**

| | |
|---|---|
| Manufacturer: | Nordic ID |
| Antenna Description: | Circular polarized patch antenna |
| Frequency range: | 902 – 928 MHz |
| Manufacturer Part Number: | Sampo S0 |
| Gain: | 7dBi |

**Option 2:**

| | |
|---|---|
| Manufacturer: | TBD |
| Antenna Description: | TBD |
| Frequency range: | TBD |
| Manufacturer Product Name: | TBD |
| Gain: | TBD |

**Option 3:**

| | |
|---|---|
| Manufacturer: | TBD |
| Antenna Description: | TBD |
| Frequency range: | TBD |
| Manufacturer Product Name: | TBD |
| Gain: | TBD |

## 11.3 INDUSTRY CANADA

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

To leverage the Nordic ID's IC grant, the device with the integrated NUR-05WL2 module shall be met the following conditions:

1. The antenna used with the NUR-05WL2 module must be installed so that the distance of the antenna from all persons can be maintained at least 20 cm in every situation.
2. The antenna(s) used with the NUR-05WL2 module must not be collocated in conjunction with any other transmitter or its antenna that is capable of transmitting at the same time, except the transmitter-antenna configurations that are within the limits of the NUR-05WL2's IC grant.
3. The design of an antenna circuit trace layout in a host shall comply with the OEM design instructions provided.

When the conditions above are met, typically no transmitter testing is required, although the OEM integrator shall demonstrate that the end-product is in compliance with the other regulatory requirements.

There is no user's documentation requirements other than that the required FCC statements outlined in the FCC section are in a prominent place in the user's guide.

## LABELLING REQUIREMENTS FOR THE HOST DEVICE

The end product must be labeled with the following identification information in a visible area:

**"Contains IC: 5137A-NUR05WL2"**

## CERTIFIED ANTENNAS

This radio transmitter 5137A-NUR05WL2 has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

**Option 1:**

| | |
|---|---|
| Manufacturer: | Nordic ID |
| Antenna Description: | Circular polarized patch antenna |
| Frequency range: | 902 – 928 MHz |
| Manufacturer Part Number: | Sampo S0 |
| Gain: | 7dBi |

## 11.4 INDUSTRIE CANADA

Le présent appareil est conforme aux CNR d'Industrie 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, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante..

Le module transmetteur NUR-05WL2 est autorisé à être utilisé avec d´autres appareils uniquement par des intégrateurs OEM sous les conditions suivantes:

1. La ou les antenne(s) doivent être installées à une distance de separation minimum de 20cm, celle-ci doit être maintenue entre le radiateur (antenne) et le(s) utilisateur(s)/ ou toute(s) autre(s) personne(s) a tout moment.
2. Le module transmetteur ne doit pas être colocalisé avec d´autre(s) transmetteur(s), sauf si ce(s) dernier(s) répond(ent) avec ceux qui sont dans les limites indiquées dans l´application de NUR-05WL2
3. Le module transmetteur peut être uniquement utilisé avec un schema du design de configuration de la piste du circuit de l´antenne hôte en respectant strictement les instructions OEM fournies.

### EXIGENCES APPLICABLES AUX APPAREILS HÔTES

Le produit fini doit disposer d´étiquette mentionnant les information suivantes d´identification sur une surface visible:

**“Contains IC: 5137A-NUR05WL2”**

### TYPES D'ANTENNES ACCEPTABLES

Le présent émetteur radio (IC: 5137A-NUR05WL2) a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

**Option 1:**

| | |
|---|---|
| Fabricant: | Nordic ID |
| Déscription de l´antenne: | Circular polarized patch antenna |
| Portée de la fréquence: | 902 – 928 MHz |
| Numéro de la pièce du fabricant: | Sampo S0 |
| Gain: | 7dBi |