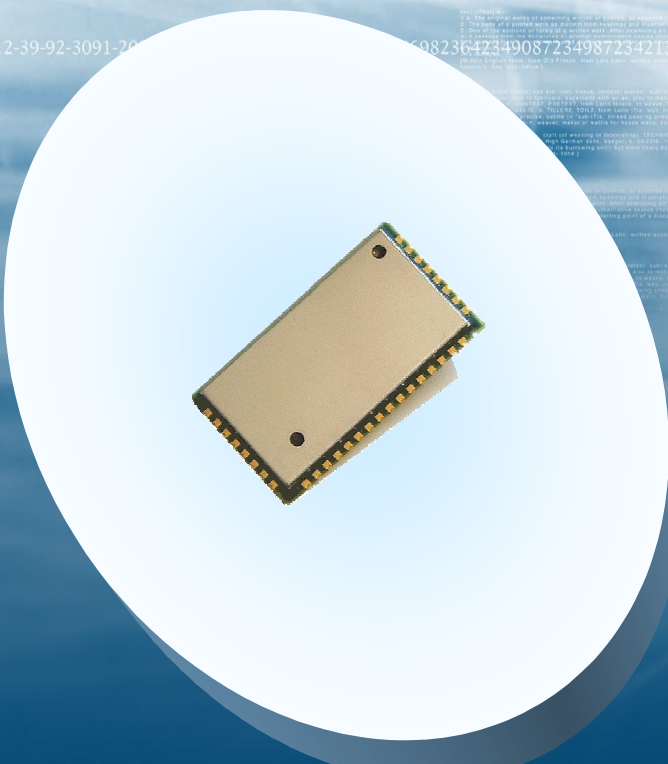


B868-TINYPRO Technical Manual

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CHAPTER I.

INTRODUCTION

I.1. Aim of the Document

The aim of this document is to present the features and the application of the B868-tinyPRO radio module. After the introduction, the characteristics of the B868-tinyPRO radio module will be described within the following distinct chapters:

- Requirements
- General Characteristics of the B868-tinyPRO Module
- Technical description of the B868-tinyPRO Module
- Functional description of the B868-tinyPRO Module
- Process information
- Board Mounting Recommendations
- Antenna Considerations

I.2. Reference documents

- | | |
|--------------------------------|---|
| [1] EN 300 220-1 v1.3.1 | ETSI Standards for SRD , Sept 2000 |
| [2] ERC Rec 70-03 | ERC Recommendation for SRD, March 2001 |
| [3] 2002/95/EC | Directive of the European Parliament and of the Council,
27 January 2003 |
-

I.3. Glossary

ACP	Adjacent Channel Power
BER	Bit Error Rate
Bits/s	Bits per second (1000 bits/s = 1Kbps)
CER	Character Error Rate
dBm	Power level in decibel milliwatt ($10 \log (P/1mW)$)
EMC	Electro Magnetic Compatibility
EPROM	Electrical Programmable Read Only Memory
ETR	ETSI Technical Report
ETSI	European Telecommunication Standard Institute
FM	Frequency Modulation
FSK	Audio Frequency Shift Keying
GFSK	Gaussian Frequency Shift Keying
GMSK	Gaussian Minimum Shift Keying
IF	Intermediary Frequency
ISM	Industrial, Scientific and Medical
kbps	kilobits/s
LBT	Listen Before Talk
LNA	Low Noise Amplifier
MHz	Mega Hertz (1 MHz = 1000 kHz)
PLL	Phase Lock Loop
PROM	Programmable Read Only Memory
NRZ	Non return to Zero
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances
RSSI	Receive Strength Signal Indicator
Rx	Reception
SRD	Short Range Device
Tx	Transmission
SMD	Surface Mounted Device
VCO	Voltage Controlled Oscillator
VCTCXO	Voltage Controlled and Temperature Compensated Crystal Oscillator

CHAPTER II.

REQUIREMENTS

II.1. General Requirements

The B868-tinyPRO module is a single/multi channel radio board, delivering up to 500 mW in the 868 MHz ISM band (unlicensed frequency band).

In order to harmonize our product family, the B868-tinyPRO module has the same mechanical characteristics than the B868-tiny (same PCB format, half-moons connectors, metallic cover, antenna...).

It allows 'point-to-point', 'multipoint' or 'network' functioning modes.

The "ERC recommendation 70-03" describes the different usable sub-bands in the 868 MHz license free band, in terms of bandwidth, maximum power, duty cycle and channel spacing. It gives the following limitations :

<i>Frequency band</i>	<i>Maximum radiated power</i>	<i>Channel spacing</i>	<i>Duty cycle</i>
869.400 – 869.650 MHz	500 mW	25 kHz or wideband	10 %

This band is free to use but the module and the user must respect some limitations. Most of these restrictions are integrated in the conception of the module, except the duty cycle. The 869.400 to 869.650 MHz band is limited to a 10% duty cycle. This means that each module is limited to a total transmit time of 6 minutes per hour. It is the responsibility of the user to respect the duty cycle.

Furthermore, the module complies with the ETSI 300-220-1 v1.3.1 standards (specific for SRD). The main requirements are described in Appendix 1.

Finally, the module complies with the new European Directive 2002/95/EC concerning the Restrictive Usage of Hazardous Substances (RoHS).

II.2. Functional Requirements

The B868-tinyPRO module has a digital part and a RF part. The radio link is a Half Duplex bi-directional link.

The digital part has the following functionalities:

- Communications interface.
- Analog inputs and Logic I/O.
- Micro controller with embedded software

The RF part has the following functionalities:

- Frequency synthesis.
- Front-end.
- Low noise reception

II.3. Temperature Requirements

	<i>Minimum</i>	<i>Typical</i>	<i>Maximum</i>	<i>Unit</i>
<i>Operating</i>				
Temperature	- 20	25	+ 60	°C
Relative humidity	20		75	%
<i>Storage</i>				
Temperature	- 40	25	+ 85	°C
Relative humidity	0		95	%

CHAPTER III.

GENERAL CHARACTERISTICS

III.1. Mechanical Characteristics

Size :	Rectangular 38x 21 mm
Height :	4 mm
Weight :	20 g
PCB :	<ul style="list-style-type: none"> • 6 layers circuit • epoxy FR4 • thickness : 0.8mm
Cover :	<p>Due to high radiated power, the board is protected by a metallic cover mounted on the bottom side of the board.</p> <ul style="list-style-type: none"> • dimensions : 34.5 x 18.5 x 2.2mm • thickness : 200µm
Components :	All SMD components, on both side of the PCB.
Connectors :	The terminals allowing conveying I/O signals are half-moons located around.
Mounting :	<ul style="list-style-type: none"> • SMD • Half moons on 3 external sides
Number of I/O pins :	32

III.2. DC Characteristics

Characteristics	Min.	Typ.	Max.
Power Supply V_{DD} :	+3.0V	+3.6V	+3.7V
Consumption @3.6V :			
Transmission (500mW) :	-	630mA	650mA
Transmission (100mW) :		TBD	TDB
Reception :	-	30mA	35mA
Stand-by :	-	5 μ A	10 μ A
I/O low level :	GND	-	0.2x V_{DD}
I/O high level :	0.8x V_{DD}	-	V_{DD}

CAUTION

In order to get the maximum output power of the module, it is necessary to apply a 3.6V power supply

III.3. Timing Characteristics

Characteristics	Min.	Typ.	Max.
Power Up Sequence :	-	135 ms	150 ms
Stand by :			
Enter in Hard Stand-by :	-	700 μ s	900 μ s
Enter in Serial Stand-by :	-	3.2 ms	-
Wake Up from Hard Stand-by :	-	2.85 ms	3.0 ms
Wake Up from Serial Stand-by :	-	5.5 ms	-
Radio :			
Rx to TX switching time			
(500mW) :	-	-	4ms
(100mW) :			3.5ms
Tx to RX switching time			
(500mW) :	-	-	4ms
(100mW) :			3.5ms

III.4. Functional characteristics

The B868-tinyPRO module allows 2 types of functioning : single or multi channel.

Global		
Frequency band :	869.400 – 869.650 MHz (ERC-Recommendation 70-03)	
Temperature range :	Functioning : -20°C to +60 °C Storage : -40°C to +85 °C	
Relative humidity :	Functioning : 20% to 75% RH Storage : 0% to 95%	
Transmission	<i>Single channel</i>	<i>Multi channel</i>
Channel number :	1 (center frequency 869.525MHz)	10 (first channel at 869.4125MHz)
Channel spacing :	wideband (ERC-Rec 70-03)	25 kHz (ERC-Rec 70-03)
Radio bit rate :	up to 38.4 kbps	4.8 kbps
Output Power @3.6V :	500mW (27dBm ± 1dB)	100mW (20dBm ± 2dB)
Modulation :	GFSK	
ACP :	-	-37dBm max.
Spurious out of the band :	Under the following limits : 	

Reception	<i>Single channel</i>	<i>Multi channel</i>
Sensitivity for CER <math>10^{-3}</math> :	-100dBm \pm 2dB (@ 38.4kbps)	-105dBm \pm 2dB (@ 4.8kbps)
Saturation for CER <math>10^{-3}</math> :	up to -10 dBm under 50 Ohms	
Remaining CER :	1.10^{-6} at -50 dBm	
Selectivity :	-	30 dB protection between channels
Immunity :		
<i>against adjacent channels jammer at -20 dBm :</i>	-	20 dB min.
<i>against other channels jammer at -20 dBm :</i>	-	30 dB min.
<i>against out of the band spurious :</i>	40 dB typ.	
Spurious leakage :		
<i>Below 1 GHz :</i>	-57 dBm max.	
<i>Over 1 GHz :</i>	-47 dBm max.	

III.5. Digital Characteristics

Processor :	Micro-controller RISC 8 bits with Flash memory
Memory :	Flash 16KB, RAM 2KB
Serial link :	<ul style="list-style-type: none"> • Full Duplex, from 1200 to 115200 bauds • 8 bits, with or without parity, 1 or 2 stop bits • Protocol Type : RS-232, TTL level
Flow control :	None, software (Xon/Xoff) or hardware (RTS/CTS)
Specific signals :	<ul style="list-style-type: none"> • <i>Serial</i> : Tx, Rx, RTS, CTS • <i>Outputs</i> : Ack_Tx, Status Tx/Rx, Carrier Detect, Frame Detect • <i>Inputs</i> : Reset, Stand-By • <i>I/O</i> : 7 logic I/O + 2 analog In (with 10 bits resolution)
Flashing :	<ul style="list-style-type: none"> • <i>Through serial</i> : BKGD-MS • <i>Through the air</i> : DOTA (Download Over The Air) functionality

III.6. Absolute Maximum Ratings

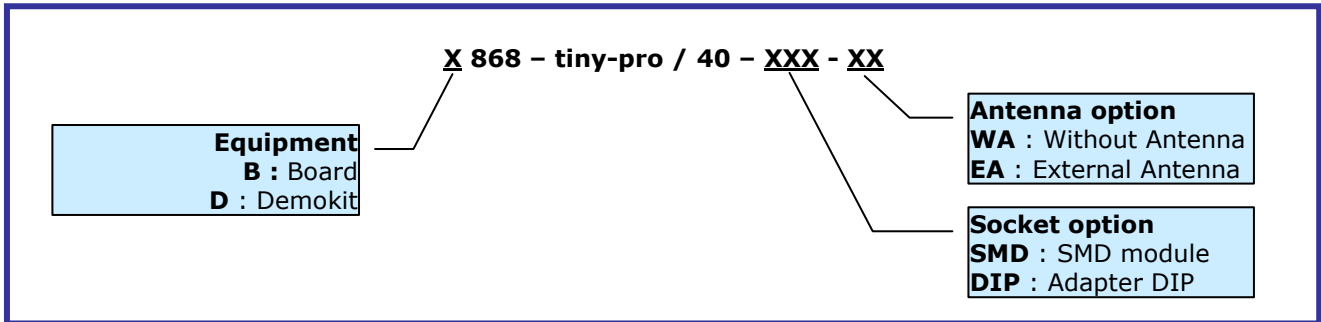
Voltage applied to V_{DD} :	-0.3V to +3.8V
Voltage applied to "TTL" Input :	-0.3V to $V_{DD}+0.3V$

III.7. Ordering information



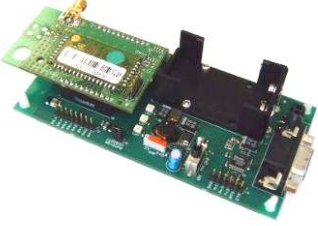
Three different equipments can be ordered :

- The SMD board
- The DIP board
- The Demokit

Select the desired options from the list below to identify the appropriate One RF Technology part number you need.



The versions below are considered standard and should be readily available. For other versions, please contact ONE-RF Technology. Please make sure to give the complete part number when ordering.

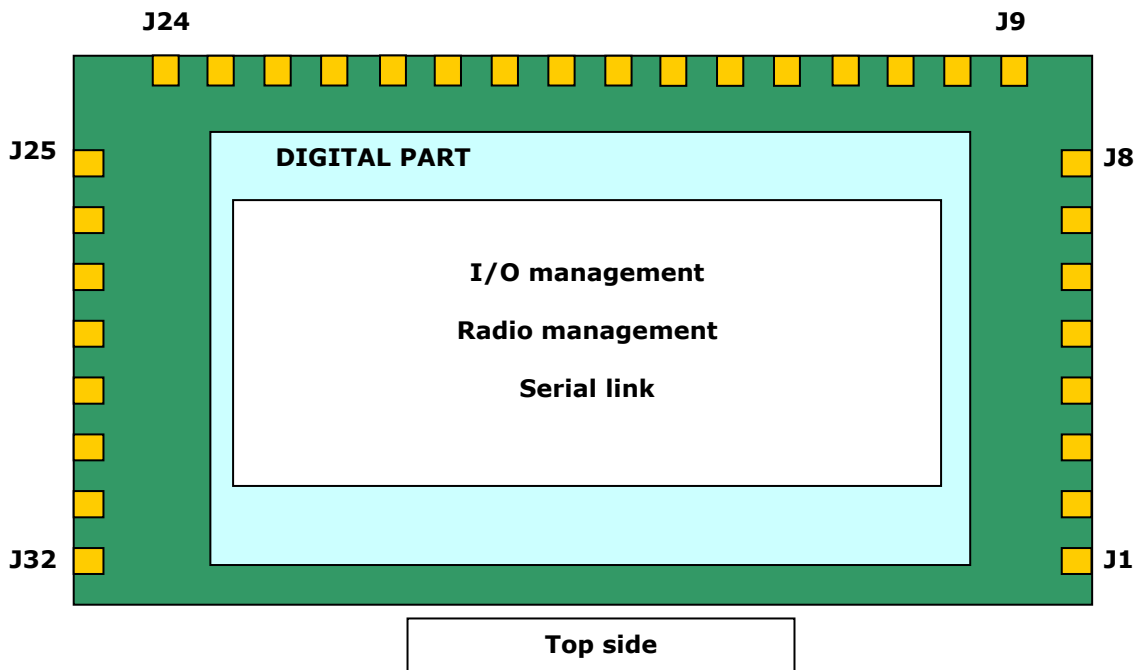
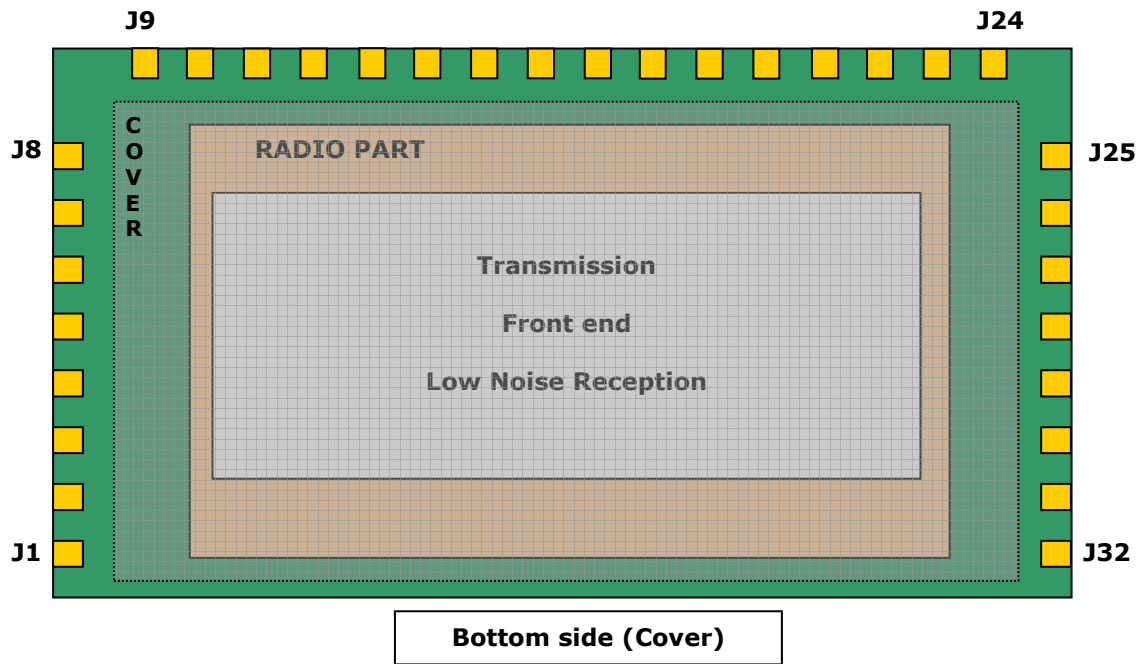
<i>Equipment</i>	<i>Part Number</i>
<p>SMD Version</p> 	B868–tiny-pro/40–SMD-WA
<p>DIP Version</p> 	B868–tiny-pro/40–DIP-WA
<p>Demo Kit</p> 	D868–tiny-pro/40–SMD-EA

CHAPTER IV.

TECHNICAL DESCRIPTION

IV.1. Block diagram





IV.2. Pin out of the module

<i>Pin</i>	<i>Interface function</i>	<i>I/O</i>	<i>Signal level</i>	<i>µC function</i>
J32	ESL5	I/O	TTL	Digital I/O N°5
J31	ESL6	I/O	TTL	Digital I/O N°6
J30	STAND-BY	I	TTL	Stand-by
J29	TXD	O	TTL	TxD UART – Serial Data Transmission
J28	RXD	I	TTL	RxD UART – Serial Data Reception
J27	RESET	I	TTL	µC reset
J26	CTS	I	TTL	Clear To Send
J25	RTS	O	TTL	Request To Send
J24	BKGD-MS / ACK-TX	I/O O	TTL	Single wire background debug interface pin + Flash µC programming or Indicate radio transmission is OK
J23	V _{DD}	-	-	Digital part supply
J22	EA1	I	analog	Analog Input N°1. 10 bits precision.
J21	EA2	I	analog	Analog Input N°2. 10 bits precision.
J20	ESL1-I / STATUS TX-RX	I/O O	TTL	Digital I/O N°1 with interrupt or Indicate if the serial link is on transmission or reception
J19	ESL2-I	I/O	TTL	Digital I/O N°2 with interrupt
J18	ESL3-I Frame Detect	I/O O	TTL	Digital I/O N°3 with interrupt or Indicates if valid Carrier + Synchro word is received
J17	ESL4 Frame Detect	I/O O	TTL	Digital I/O N°4 or Indicates if valid Carrier + Synchro word is received
J16	GND	-	0V	Ground
J15	GND	-	0V	Ground
J14	V _{CC}	-	-	Radio part supply
J13- J12	GND	-	0V	Ground
J11	ESL7 / PrgS	I/O	TTL	Digital I/O N°7 or Signal for serial µC flashing

J10- J02	GND	-	0V	Ground
J01	RF_Antenna	O	-	RF connection to external antenna

IV.3. Description of the Signals

<i>Signals</i>	<i>Description</i>
Reset	External hardware reset of the radio module. Active on low state.
TxD, RxD	Serial link signals, format NRZ/TTL: TxD is for outgoing data. RxD is for incoming data. The '1' is represented by a high state
CTS ⁽¹⁾	Incoming signal. Indicates whether the module can send serial data to user (Active, on low state) or not (inactive, on high state).
RTS ⁽¹⁾	Outgoing signal. Indicates whether the user can transmit serial data (active, on low state) or not (inactive, on high state). The signal switches either when the serial buffer reaches a programmable filling threshold (register S218) or when the user's serial transmission is finished.
ESLx ⁽²⁾	Digital I/O. Available upon request.
EAx	Analogue inputs with a variable voltage, between 0 and V_{DD} . Available upon request.
Stand-By ⁽³⁾	Indicates to the module to switch to low power mode. Active on high state.

⁽¹⁾ : used only if Hardware Flow Control (RTS/CTS) is selected (S216=0).

⁽²⁾ : ESLx-I means interruptible I/O

⁽³⁾ : used only if Hardware Stand-By is selected (S240=1).

CHAPTER V. DESCRIPTION OF THE FUNCTIONALITY

One RF Technology modems and boards are provided with an embedded software which allows to choose between different communication protocols and to play on numerous parameters.

There are 2 different modes :

- The **configuration mode** which allows to parameter the module. It is set through the use of Hayes commands sent on the serial link.
 - The **operating mode** which is the functional use for data transmission.
-

V.1. Configuration Mode

Hayes or 'AT' commands complies with Hayes protocol used in PSTN modem standards. This 'AT' protocol or Hayes mode is used to configure the modem parameters, based on the following principles:

- A data frame always begins with the two ASCII 'AT' characters, standing for 'ATtention'
- Commands are coded over one or several characters and may include additional data
- A given command always ends up with a <CR> Carriage Return

A	T	Command	Additional data	<CR>
---	---	---------	-----------------	------

Note: The delay between 2 characters of the same command must be less than 10 seconds

The only exception to this data-framing rule is the switching command from the operating/communication mode to 'AT Mode'. In this case only, the escape code ('+++') must be started and followed by a silent time at least equal to the serial time out. In this case only <AT> and <CR> shall not be used.

Note : The time between 2 characters of the same command must be under 10 seconds.

Below is the complete list of the 'AT' commands available on the B868-tinyPRO module.

Command	Description
+++	<p>Hayes Mode Activation</p> <p>'+++' command gives an instant access to the modem's parameters configuration mode (Hayes or AT mode), whatever the current operating mode in process might be.</p> <p>'+++' command should be entered as one string, i.e. it should not be preceded by 'AT' and followed by <CR> but two silent times which duration is configurable via S214 register (Serial time-out). The time between two '+' must not exceed the time-out value.</p> <p>Hayes mode inactivates radio functions.</p>
ATO	<p>Communication mode activation</p> <p>'ATO' command gives an instant access to the modem's operating mode, configured in S220 register.</p> <p>'ATO' command is used to get out of Hayes mode.</p> <p>Answer : OK or ERROR if the configuration is not complete</p>
AT/V	<p>Modem's firmware version</p> <p>'AT/V' command displays the modem's firmware version number as follows:</p> <p><i>Version <Product>: vX.YZn</i></p>
AT/S	<p>Modem's registers status</p> <p>'AT/S' command displays status of all relevant registers of the modem</p>

ATSn?	<p>Register interrogation</p> <p>'ATSn?' command displays the content of Hayes register number n (Refer to the register description table). Some registers are standard for every One RF modems while others are specific to some products. Answer : Sn=x<CR></p>
ATSn=m	<p>Register modification</p> <p>'ATSn=m' command configures Hayes register number n with the value m, e.g. AT200=4<CR> enters the value '4' in the register S200. The value is automatically stored in the EEPROM memory. Answer : OK or ERRORxx (Refer to the Error codes table)</p>
ATN	<p>RSSI interrogation</p> <p>'ATN' command runs the received RF level measurement. This RSSI reading is continuously displayed each second until a new character arrives on the serial link. 4 levels are available :</p> <ul style="list-style-type: none"> - '0' : received level < -90dBm - '1' : received level between -90 and -85dBm - '2' : received level between -85 and -80dBm - '3' : received level > -80dBm
ATR	<p>Parameters reset</p> <p>'ATR' command resets all modem's parameters to their default values. Answer : OK</p>
ATP	<p>Stand By Activation</p> <p>When serial stand by is set, the 'ATP' command put the module in stand by mode. To wake up the module, send a NULL (0x00) character.</p>
ATBL	<p>Switch to Bootloader</p> <p>'ATBL' command escape from the main program and run the bootloader. This command is useful to update the firmware by serial or radio link. See the dedicated part for details.</p>

Specific 'AT' commands have been integrated in order to make measurements in continuous mode. These commands are stopped by the sending of a character.

Command	Description
ATT0	Pure carrier transmission at center frequency
ATT1	Pure carrier transmission representing '0'
ATT2	Pure carrier transmission representing '1'
ATT3	Max modulated carrier transmission
ATT6	Min modulated carrier transmission

Note 1 : After an AT command (ended by <CR>), the serial link gives back result code, which is "OK", or "ERROR".

Note 2 : "+++" command gives back OK.

These commands are effective after a maximum delay of 10 mS ; the back code OK indicates the good execution of the command, and another command can be sent right after the back code OK.

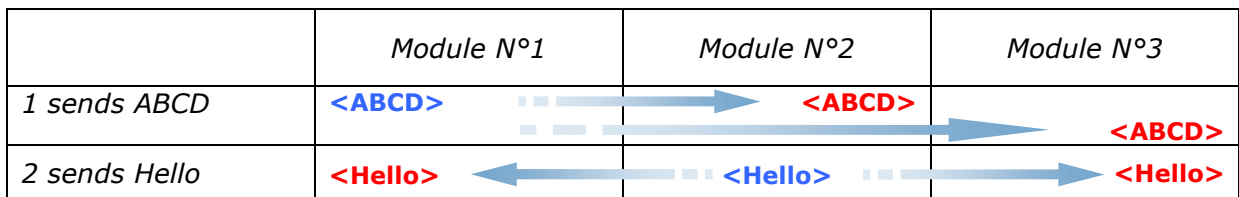
V.2. Operating Mode

There are 4 communication protocols available on the B868-tinyPRO module :

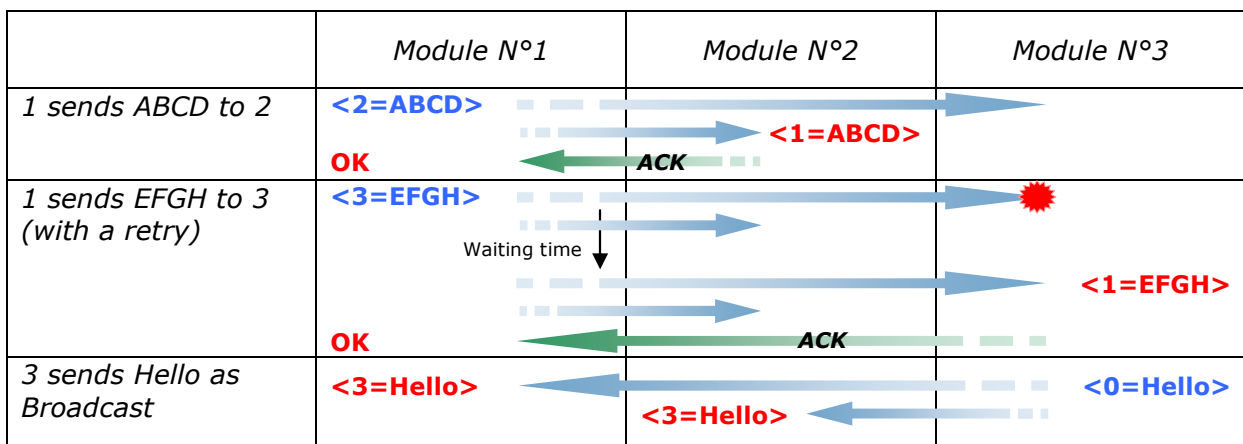
- Transparent mode : this is the default communication protocol of the module. The module transmits the data transparently, without encapsulation or addressing. It acts as a half duplex wired serial link (type RS485).
- Addressed Secured mode : it is a kind of multipoint network protocol. Each module can communicate with every module in the same network. All the frames are addressed, checked through a CRC and acknowledged.
- Downloader over the air : this is a specific communication protocol allowing re-flashing of remote module.
- Auto-repeat mode : this is a specific communication protocol in which the module sends back the frames it has received (radio or serial) without echoing. It allows the user to easily test the module remotely.

For the classical communication protocols (Transparent and Addressed Secured), an additional functionality is available : LBT (Listen Before Talk). It means that the transmitting module will scan the radio link and verify it is free (no radio activity) before sending its data to avoid collision.

▪ **Basic Illustration of Transparent mode**



▪ **Basic Illustration of Addressed Secured mode**

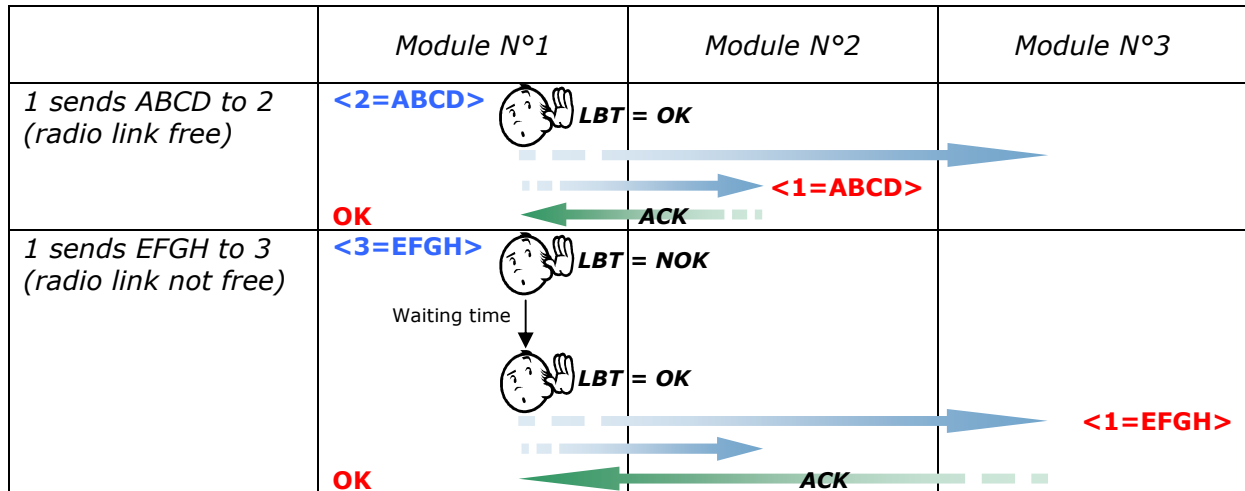


Collision or error

<in blue> : data sent

<in red> : data received

▪ **Basic Illustration of Addressed Secured mode with LBT**



V.3. Registers Detailed Use

The parameters to be configured via Hayes mode are stored in the module permanent memory, called S registers. Those registers are always listed as follow:

- S20x registers correspond to the radio parameters
- S21x registers correspond to the serial parameters
- S22x registers correspond to the operating parameters
- S24x registers correspond to the stand by parameters
- S25x registers correspond to the network parameters

▪ **Radio Configuration**

The Radio configuration is set via the S20x registers. Through them, you can:

- ↔ Change radio channel : S200,
- ↔ Change the radio baud rate : S201,
- ↔ Change the radio Output Power : S202,
- ↔ Modify the carrier length : S204,
- ↔ Change channelization : S206,

The radio parameters are preferably set in the following order :

1. Channelization: S206

This register allows to change the functioning mode : single or multi channel.

S206 value	Functioning mode
0	single channel
1	multi channel

Modules must be on the same Sub-Band to communicate. The default value for this register is **S206=0**

2. Radio baud rate : S201

This register allows changing the radio baud rate.

S201 value	Radio baud rate
0	4.8 kbps
1	9.6 kbps
2	19.2 kbps
3	38.4 kbps

When multi channel functioning is chosen (see register S206), this register is automatically set to '0'. When single channel functioning is chosen, the default value for this register is '3'.

3. **Radio channel : S200**

This register sets the radio channel used for the communication.

S200 value	Frequency
<i>multi channel</i>	
0	869.4125 MHz
1	869.4375 MHz
2	869.4625 MHz
3	869.4875 MHz
4	869.5125 MHz
5	869.5375 MHz
6	869.5625 MHz
7	869.5875 MHz
8	869.6125 MHz
9	869.6375 MHz
<i>single channel</i>	
10	869.525 MHz

When multi channel functioning is chosen (see register S206), S200 value can go from '0' to '9' and the default value is '0'. When single channel functioning is chosen, this register is automatically set to '10'.

4. **Radio Output power : S202**

This register allows to choose the output power of the module, between 25, 100 and 500mW. This parameter allows to optimize power consumption in function of the desired range.

S202 value	Output Power
0	25 mW
1	100 mW
2	500 mW

When multi channel functioning is chosen (see register S206), S202 value can go from '0' to '1' and the default value is '1'. When single channel functioning is chosen, S202 value can go from '0' to '2' and the default value is '2'.

5. **Radio carrier length : S204**

This register sets the duration (in milliseconds) of the radio carrier sent before the data. It serves as synchronization frame for the receiver(s). The default value is 8 milliseconds (S204=8).

Usually, this register isn't modified. However, in some hostile environment (metallic parts, vibrations...) it can be raised to 20ms to have a more reliable synchronization. This will lower the over air throughput as it increase the non-data use of the radio.

▪ **Serial link configuration**

The serial link configuration is set via the S21x registers. Through them, you can:

- ↔ Set the serial baud rate : S210,
- ↔ Set the parity : S212,
- ↔ Set the number of stop bits: S213,
- ↔ Set the serial time-out : S214,
- ↔ Set the flow control type : S216,

After each modification in the serial settings, the B868-tinyPRO will answer 'OK' with the current configuration, and the changes will be effective immediately after.

The Serial parameters are preferably set in the following order :

1. Serial Baud rate : S210

This register selects the serial baud rate value. It is linked to the time-out register S214. They can be set with the following values :

S210 value	Serial baud rate	S214 minimum value
1	1 200 bps	17
2	2 400 bps	9
3	4 800 bps	5
4	9 600 bps	3
5 (default)	19 200 bps	2
6	38 400 bps	2
7	57 600 bps	2
8	115 200 bps	2

2. Serial timeout : S214

The B868-tinyPRO is not able to know when a frame reception is finished on the serial link, but it needs this information to stop radio transmission in transparent mode, or to start sending data in the other modes.

This timeout is the indicator used to decide when the data frame is finished : if no character is received for a time equal to this timeout, the data frame is seen as finished and the modem acts accordingly.

The default value is 5 milliseconds.

The Timeout value is of course in accordance with the serial baud rate : it must be at least equal to the length of 2 characters. See the table in the baud rate (S210) part of this chapter. For example, for a 19200 bps baud rate, the time to send 1 character (1 start bit + 8 data bits + 1 stop bit) is 521 μ s, giving a squared up timeout value of 2 ms.

You can set a higher value to this timeout if you have some gaps in the sending of a frame.

3. Serial data format : S212 and S213

These registers set the format of the characters sent on the serial link :

- ↪ S212 : Parity. It can take three values : '1' for No Parity, '2' for Even Parity, or '3' for Odd Parity. The default value is '1'.
- ↪ S213 : Number of Stop bits: 1 bit or 2 bits. Default value is '1'.

The settings for the available configurations are :

<i>Format type</i>		<i>Parity S212</i>	<i>Stop Bits S213</i>
8/N/1	8 data bits, no parity, 1 stop bit	1	1
8/E/1	8 data bits, even parity, 1 stop bit	2	1
8/O/1	8 data bits, odd parity, 1 stop bit	3	1
8/N/2	8 data bits, no parity, 2 stop bits	1	2
8/E/2	8 data bits, even parity, 2 stop bits	2	2
8/O/2	8 data bits, odd parity, 2 stop bits	3	2
7/N/2	These configurations are only possible in transparent using the same settings as 8/N/1		
7/E/1			
7/O/1			

4. **Flow control management : S216**

In all the modes, the data coming from the serial link are stored in a buffer and then sent. Thus, it is necessary to have a flow control on the serial link to avoid a buffer overflow and the loss of data.

This register works with the buffer size register S218, which sets the limit to activate the flow control.

The B868-tinyPRO manages three types of flow control :

- ↵ Hardware or CTS/RTS (S216=0) : the RTS signal from the B868-tinyPRO will authorize the host to transmit data. The other way will be controlled by the CTS signal entering the modem.
- ↵ Software or Xon/Xoff (S216=1) : the B868-tinyPRO sends a Xoff character on the serial link to interrupt the transmission from the host, and a Xon character to resume. This control will only work from the B868-tinyPRO to the host.
- ↵ None (**S216=2, default**) :the host must manage its outgoing data frames in order not to overflow the buffer.

This flow control is available for our virtual RS232 serial link .

N.B. : in Hayes mode, the flow control is not active so as to be able to modify these registers without locking the serial link.

▪ **Operating Mode configuration**

The Operating mode configuration is set via the S22x registers. Through them, you can:

- ↔ Set the operating mode : S220,
- ↔ Set the number of retries: S223,
- ↔ Set the LBT: S226
- ↔ Set the random waiting time : S227

The Operating Mode parameters are preferably set in the following order :

1. Operating Mode : S220

This is the most significant register : it tells how the B868-tinyPRO must run. The available operating modes are :

<i>Value</i>	<i>Mode</i>
1	Transparent Mode (default)
9	Addressed Secured Mode
10	Demo Mode Master (usable only on demokit)
11	Demo mode Slave (usable only on demokit)
12	Downloader over the air
14	Auto-repeat Mode

2. LBT : S226

This register allows activating and setting up the LBT functionality. The LBT sensitivity refers to the detected RF level over which the RF link is considered as occupied.

<i>S226 value</i>	<i>LBT</i>
0 (default)	OFF
1	ON with high sensitivity
2	ON with medium sensitivity
3	ON with low sensitivity

3. Number of repetitions : S223

This register is used in Addressed Secured mode. It is the number of times the message will be repeated in case of non acknowledgement, or the number of times the module will try to send the message in case of the radio link is not free (when LBT functionality is activated).

This register is set to 2 as default. It is enough in most of the configurations.

4. Random waiting time : S227

This register activates a random waiting time before every radio transmission (except for acknowledge). Particularly when LBT functionality is activated, it will define the time between 2 LBT. The random waiting time is comprised between 0 and 64mS.

<i>S227 value</i>	<i>Random Waiting Time</i>
0 (default)	OFF
1	ON

▪ **Network Configuration**

The configuration to use the B868-tinyPRO in Addressed Secured mode is done with the S25x registers. Through them, you can:

- ↔ Set the Network ID : S250,
- ↔ Set the Client Address : S252,
- ↔ Set the Network options : S255,
- ↔ Set a default address for transmission : S256.

The parameters are preferably set in the following order:

1. Network ID : S250

When in Addressed Secured operation, B868-tinyPRO modules can communicate only if they are parts of the same 'network'.

There can be up to 65535 networks defined, but only one can work in a given area in each radio channel. If you want to place more than one network in the same area, use different radio channels and not different network numbers.

The default value is 0.

2. Network Options : S255

When running in Addressed and Secured mode, this register contains the option flags used to configure the operation.

This register is a group of 4 flag bits :

Bits	7	6	5	4	3	2	1	0
Name	-	ACK	-	Ret	-	-	CR	N°

- ↪ **Header (Bit 0, default 1)** : if set to 1, the frames sent on the serial link will be preceded with a header showing the sender address. This frame will be as follows, for each settings of the bit 2:
 "1=data" if the header is ASCII
 "<0x01>data" if the header is numeric
 If set to 0, the receiver will not know where the frame comes from
- ↪ **Carriage Return (Bit 1, default 0)** : if set to 1, the frame sent on the serial link will be followed by a CR character (<0x0D>).
- ↪ **Status answer (Bit 4, default 0)** : defines if the B868-tinyPRO returns a transmission status after sending a frame. If set to 1 (no answer), the modem will give no information if the frame has been received on the remote side or not.
 If set to 1 (answer), it returns OK if the acknowledge has been received, ERROR45 otherwise, and ERROR41 if the frame is invalid (no header, or wrong format).
- ↪ **ACK (Bit 6, default 0)** : Radio Acknowledge disable: if '1', the radio Ack is disable and any secured radio frame are acknowledged. This is useful when several clients have the same ID in a network.

3. Client Address: S252

The user can set a Client number between 1 and 65535. The client numbers must all be different in a network.

The default value is 0.

4. Default transmission Address: S256

If this register is different from 0, the frames received on the serial link will be sent to this address, without any header detection done.

This register is useful to set a Network-like system with up to 65534 clients and one server, and/or when the clients are not able to manage the frame header.

V.4. Registers List

Numbers in **bold** indicate the default value

Access	Register	Name	Description
Radio			
R/W	S200	Channel	Indicates the channel number, depending on the channelization (S206) Single channel : value 10 Multi-channel : between 0 to 9
R/W	S201	Radio Baud-Rate	Indicates the radio bit rate, depending on the channelization (S206). Single channel : between 0 to 3 Multi-channel : value 0 <ul style="list-style-type: none"> • '0': 4800 bits/s • '1': 9600 bits/s • '2': 19200 bits/s • '3': 38400 bits/s
R/W	S202	Output Power	Radio power output in milliwatts, depend of the channelization (S206). Single channel : between 0 to 2 Multi-channel : between 0 to 1 <ul style="list-style-type: none"> • '0' : 25 mW • '1' : 100mW • '2' : 500mW
R/W	S204	Radio Carrier Length	Indicates the radio carrier length in milliseconds. This carrier is sent before each data frame and is used to synchronize the receiver. Between 5 and 60mS. Default : 8 ms.
R/W	S206	Channelization	Indicates channelization. <ul style="list-style-type: none"> • '0' : single channel (default) • '1' : multi channel

Access	Register	Name	Description												
Serial Link															
R/W	S210	Serial Speed.	<p>Indicates the speed on the Serial Connection</p> <p>'1': 1200 bits/s '5': 19200 bits/s '2': 2400 bits/s '6' : 38400 bits/s '3': 4800 bits/s '7' : 57600 bits/s '4': 9600 bits/s '8' : 115200 bits/s</p> <p>The time out value must be compatible with the serial speed:</p> <table border="1"> <thead> <tr> <th>Min. time-out (S214)</th> <th>Serial Speed (S210)</th> </tr> </thead> <tbody> <tr> <td>17 ms</td> <td>1200 bits/s</td> </tr> <tr> <td>9 ms</td> <td>2400 bits/s</td> </tr> <tr> <td>5 ms</td> <td>4800 bits/s</td> </tr> <tr> <td>3 ms</td> <td>9600 bits/s</td> </tr> <tr> <td>2 ms</td> <td>≥ 19200 bits/s</td> </tr> </tbody> </table>	Min. time-out (S214)	Serial Speed (S210)	17 ms	1200 bits/s	9 ms	2400 bits/s	5 ms	4800 bits/s	3 ms	9600 bits/s	2 ms	≥ 19200 bits/s
Min. time-out (S214)	Serial Speed (S210)														
17 ms	1200 bits/s														
9 ms	2400 bits/s														
5 ms	4800 bits/s														
3 ms	9600 bits/s														
2 ms	≥ 19200 bits/s														
R/W	S212	Parity	<p>Serial Link Parity Type:</p> <ul style="list-style-type: none"> • '1': None (default) , • '2': Even, • '3': Odd. 												
R/W	S213	Number of Stop bits	<p>Serial Link Stop Bits :</p> <ul style="list-style-type: none"> • 1 bit (default), • 2 bits. 												
R/W	S214	Serial Link Time Out	<p>Indicates the value of the time-out on the serial link. The time out value must be compatible with the serial speed: (see S210 register description). Between 2 and 100 milliseconds</p> <p>Default : 5.</p>												
R/W	S216	Flow Control	<p>Indicates flow control type:</p> <ul style="list-style-type: none"> • '0': Hardware: CTS/RTS • '1': Software: Xon/Xoff • '2': None (default) 												

Access	Register	Name	Description
Operation			
R/W	S220	Function Mode	Operating mode of the Modem : '1' : Transparent '9' : Addressed Secured '12' : Downloader over the air '14' : Auto-repeat
R/W	S223	Number of Retries	Number of retries in case of non-Ack response to a message (addressed secured mode) mode, or in case of non free radio link (LBT). Included between 0 and 255 (255 means retry until success). Default value: 2
R/W	S226	LBT	LBT ON / OFF, and sensitivity '0' : OFF '1' : ON with high sensitivity '2' : ON with medium sensitivity '3' : ON with low sensitivity
R/W	S227	Random Waiting Time	Random waiting Time ON / OFF '0' : OFF '1' : ON
Low Power			
R/W	S240	Type of Low-power	Indicates whether the low power control pin is used or not '0': No Low Power (default), '1': Stand-By activated by Hardware pin, '2': Stand-By activated by Serial,

Access	Register	Name	Description																		
Network Control																					
R/W	S250	Network ID	Network Number on 2 Bytes. Default : 0																		
R/W	S252	Client Number	Client Number on 2 Bytes. Between 0 and 65535. Default : 0																		
R/W	S255	Network Options	Indicates the Network options. 4 bits are used : <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Bits</th> <th>7</th> <th>6</th> <th>5</th> <th>4</th> <th>3</th> <th>2</th> <th>1</th> <th>0</th> </tr> </thead> <tbody> <tr> <td></td> <td>-</td> <td>ACK</td> <td>-</td> <td>Ret</td> <td>-</td> <td>-</td> <td>CR</td> <td>N°</td> </tr> </tbody> </table> <p>Default value : 01.</p> <ul style="list-style-type: none"> ➤ Bit 'N°': indicates whether the received frame begins with the Client ID (1) or not (0). ➤ Bit 'CR': indicates whether the received frame ends with the 'Carriage Return' character (0x0D) (1) or not (0). ➤ Bit 'Ret': Indicates if the 'OK' should be returned after each radio transmission (0) or not (1) ➤ Bit '/ACK' : Disable the radio acknowledgement (1) or enable (0). 	Bits	7	6	5	4	3	2	1	0		-	ACK	-	Ret	-	-	CR	N°
Bits	7	6	5	4	3	2	1	0													
	-	ACK	-	Ret	-	-	CR	N°													
R/W	S256	Default Addressee	Indicates the default address to which every radio frame will be sent. Default : 0 (inactive)																		

V.5. Configuration Example

We will describe in this paragraph how to parameter the modules in order to set up 2 different Addressed Secured configurations :

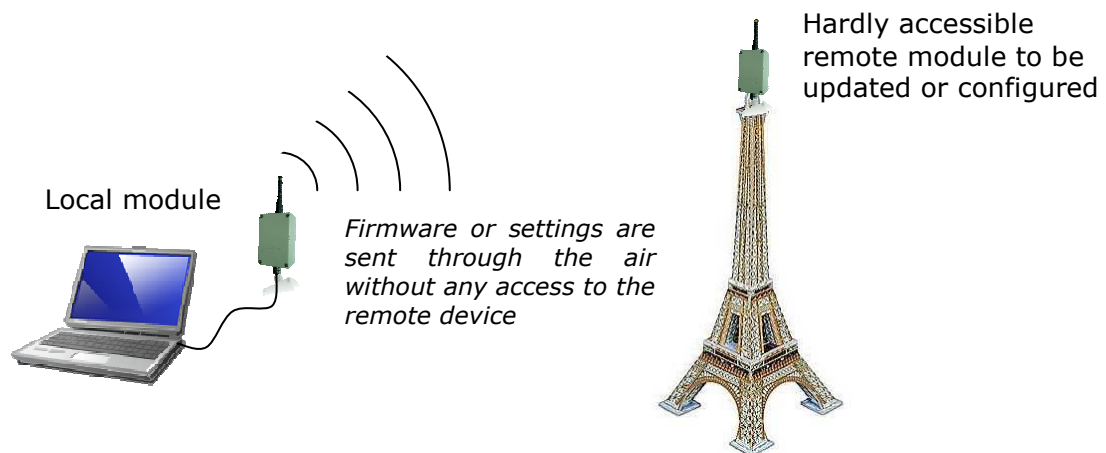
- One classical configuration where all the modules in the network can communicate to each others.
- One specific configuration equivalent to a Client/Server configuration, also called "Star" network, where communications are able only between the Server and the Clients.

<i>CLASSICAL</i>	<i>CLIENT/SERVER</i>	
<i>All</i>	<i>Server</i>	<i>Clients</i>
ATS220=9	ATS220=9	ATS220=9
ATS223=X (up to customer choice)	ATS223=X (up to customer choice)	ATS223=X (up to customer choice)
ATS226=X (up to customer choice)	ATS226=1, 2 or 3 (up to customer choice)	ATS226=1, 2 or 3 (up to customer choice)
ATS227=X (up to customer choice)	ATS227=1	ATS227=1
ATS250≠0	ATS250≠0	ATS250≠0
ATS252=1 to N	ATS252=255 or 65535	ATS252=1 to N except 255 or 65535
ATS255='0X0X00X1' (in binary)	ATS255='000X00X1' (in binary)	ATS255='000X00X1' (in binary)
ATS256=X (up to customer choice)	ATS256=0	ATS256=255 or 65535

V.6. Configuration and Download Over The Air (DOTA)

TinyPRO module includes the new DOTA functionality. This function is able to change or update the firmware of a remote modem, using a local module. In this application, the new firmware is sent through the radio link to another device without the need of any hardware intervention on the remote device. All steps of the process can be done from a local radio module connected to a computer.

A specific programming tool is necessary on the computer. It is available upon request, contact support@one-rf.com.



Completing DOTA, the configuration over the air functionality gives access to the Hayes mode of a remote modem. Thanks to it, you can adjust all the settings of a modem without physical access to it. To use this option, you need:

- A computer with a free Com port and a classic terminal.
- A local TinyPRO module, connected to the computer.
- To know the Serial number of the remote module you want to configure.
- To know the radio configuration of the remote module (at least channel and baud rate).

Here is the method:

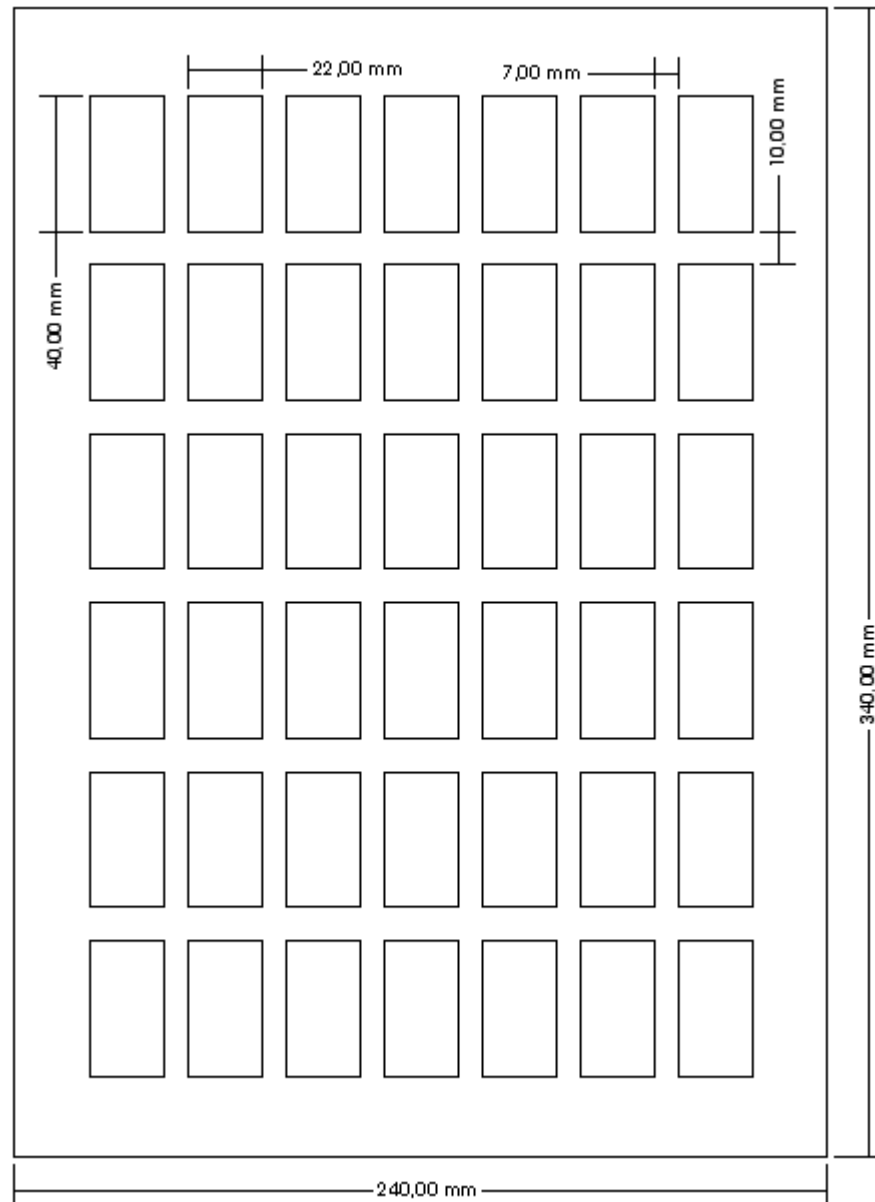
- Reset the local module in transparent mode.
- Adjust the radio settings of the local module to match the remote module configuration.
- Send frame with `+++` immediately followed by the remote module serial number. (11 characters without space nor `+` final character, for example `+++DVBF4900345`).
- If radio configuration is good, the remote module send the radio frame `OK` to confirm that it has entered in Hayes Mode.
- Send all AT commands you need using one frame per order (don't tape the order directly with keyboard but use macro or send file containing the order). For example, `ATS202=2` must be sent in one shot.
- The remote modem respond to each command as it would be directly connected to the PC. Note that `AT/S` order isn't available by air.
- Finally, don't forget to escape the remote module from Hayes mode by sending `ATO`.

CHAPTER VI.

PROCESS INFORMATION

VI.1. Delivery

B868-tinyPRO modules are delivered in plastic tray packaging, each tray including 42 units. The dimensions of the tray are the following: 340 mm x 240 mm x 15 mm. Each unit is placed in a 22 mm x 40 mm location. An empty tray weights 76 g and a loaded tray weights around 250 g.



Trays are delivered in carton boxes, each box including 15 trays. The dimensions of the box are the following: 360 mm x 250 mm x 170 mm. An empty box weights around 430 g.

VI.2. Storage

The optimal storage environment for tiny radio modules should be dust free, dry and the temperature should be included between -40°C and +85°C.

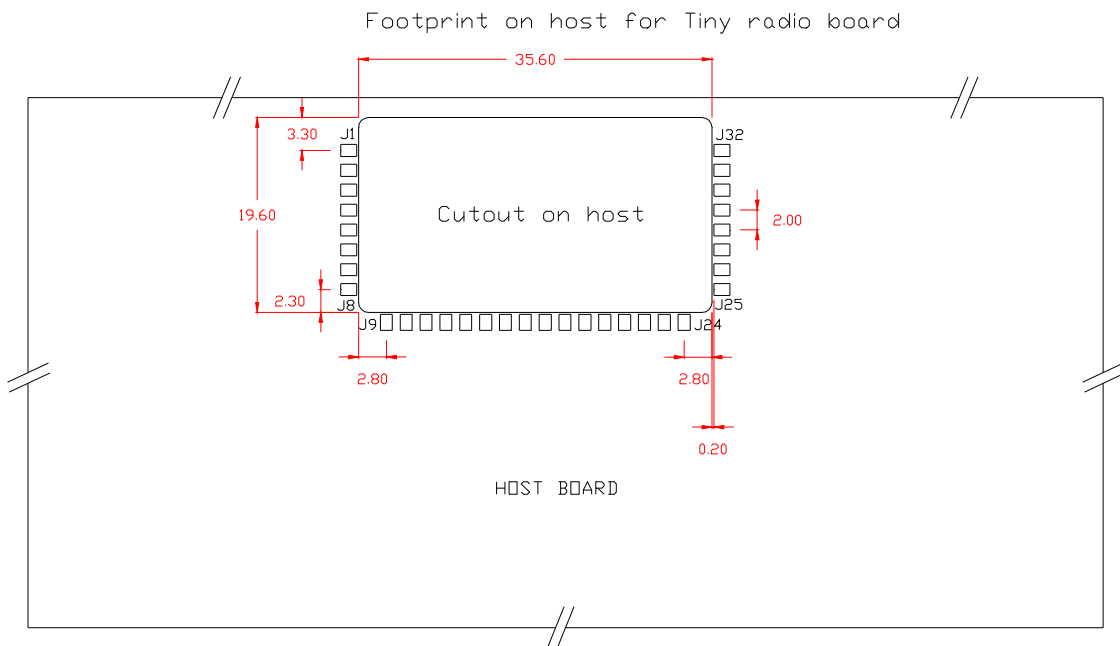
In case of a reflow soldering process, tiny radio modules must be submitted to a drying bake at +60°C during 24 hours. The drying bake must be used prior to the reflow soldering process in order to prevent a popcorn effect. After being submitted to the drying bake, tiny modules must be soldered on host boards within 168 hours.

Also, it must be noted that due to some components, tiny radio modules are ESD sensitive device. Therefore, ESD handling precautions should be carefully observed.

VI.3. Soldering pad pattern

The surface finished on the printed circuit board pads should be made of Nickel/Gold surface. For optimal performances, the host board needs a maximum ground plane so that the integrated antenna becomes less sensitive to the environment.

The recommended soldering pad layout on the host board, as well as the host board cutout for tiny integration are shown in the diagram below:

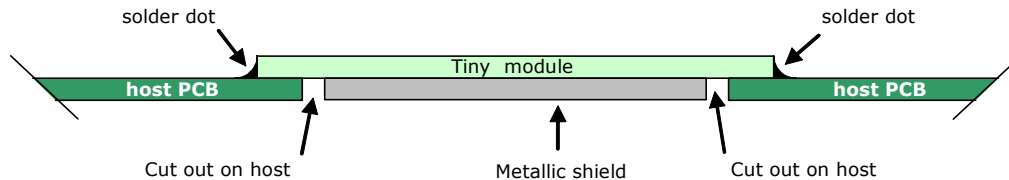


□ Dimension PAD : 1.6mm x 1.2mm

VI.4. Solder paste (RoHS process)

Tiny radio module is designed for surface mounting using half-moon solder joints (see diagram below). For proper module assembly, solder paste must be printed on the target surface of the host board. The solder paste should be eutectic and made of 95.5% of SN, 4% of Ag and 0.5% of Cu. The recommended solder paste height is 200 to 250 μm (8 – 10 mil).

The following diagram shows mounting characteristics for tiny integration on host PCB:



VI.5. Placement

The tiny radio module can be automatically placed on host boards by pick-and-place machines like any integrated circuit with the following recommended parameters:

- Placing accuracy: $\pm 90 \mu\text{m}$ minimum
- Nozzle diameter: 5-6 mm
- Vacuum pressure: 9.10 mm
- Application area: Geometrical center of tiny board

VI.6. Soldering profile (RoHS process)

It must be noted that tiny radio module should not be allowed to be hanging upside down during the reflow operation. This means that the module has to be assembled on the side of the printed circuit board that is soldered last.

The reflow process should be a regular surface mount profile. The ramp up speed should not exceed 3°C/s , reaching a peak temperature of 220 to 250°C during 45 to 60 seconds. The maximum sloping rate should not be higher than 5°C/s .

The barcode label located on the module shield is able to withstand the reflow temperature.

CAUTION

It must also be noted that if the host board is submitted to a wave soldering after the reflow operation, a solder mask must be used in order to protect the tiny radio module's metal shield from being in contact with the solder wave.

CHAPTER VII. BOARD MOUNTING RECOMMENDATION

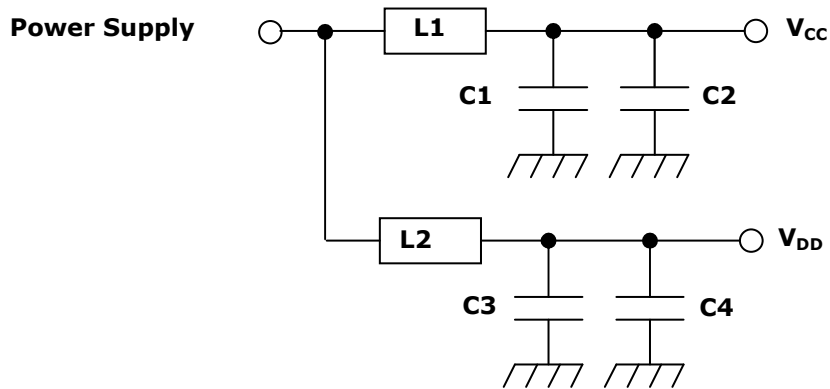
VII.1. Electrical environment

The best performance of the B868-tinyPRO module are obtained in a "clean noise" environment. Some basic recommendations must be followed :

- Noisy electronic components (serial RS232, DC-DC Converter, Display, Ram, bus ,...) must be placed as far as possible from the B868-tinyPRO module.
 - Switching components circuits (especially RS-232/TTL interface circuit power supply) must be decoupled with a 100 μ F tantalum capacitor. And the decoupling capacitor must be as close as possible to the noisy chip.
-

VII.2. Power supply decoupling on B868-tinyPRO module

The power supply of B868-tinyPRO module must be nearby decoupled. A LC filter must be placed as close as possible to the radio module power supplies, V_{CC} (RF power supply) and V_{DD} (digital power supply).



In order to limit voltage drop-out on V_{CC} at transmission, it is important to choose L1 with a very low series resistance ($< 0.10\Omega$).

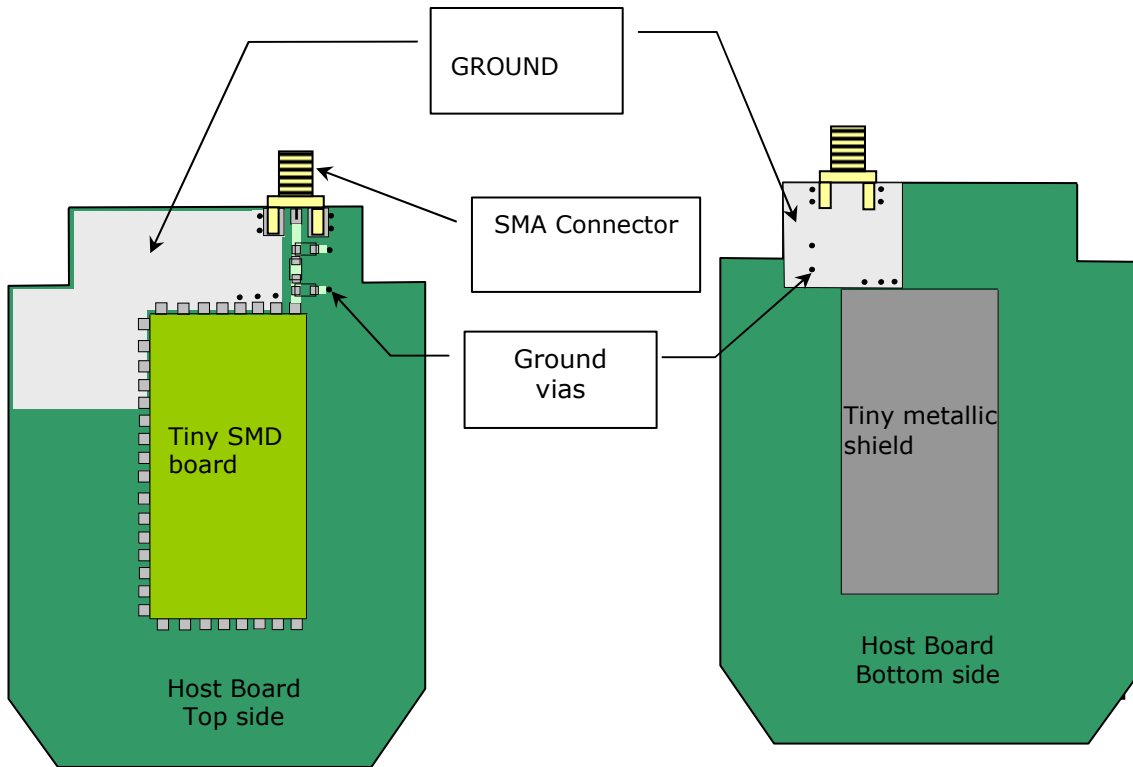
Symbols	Reference	Value	Manufacturer
L1	LQH32CN1R0M33L	1 μ H	Murata
L2	LQH31MN1R0K03	1 μ H	Murata
C1, C3	GRM31CF51A226ZE01	22 μ F	Murata
C2, C4	Ceramic CMS 25V	100nF	Multiple

VII.3. RF layout considerations

Basic recommendations must be followed to achieve a good RF layout :

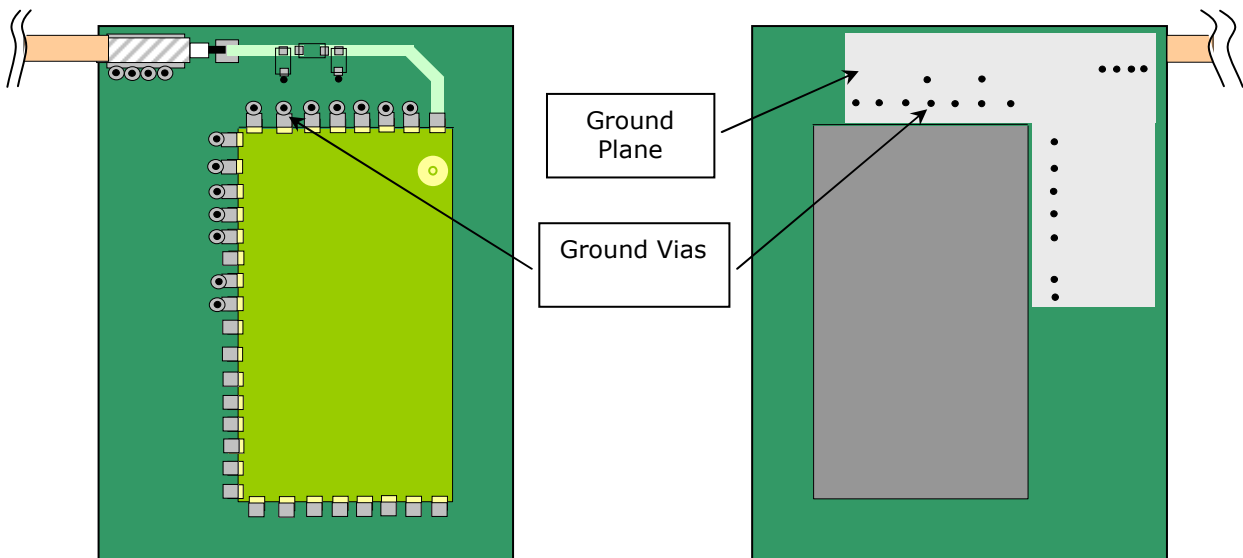
- It is recommended to fill all unused PCB area around the module with ground plane.
- The radio module ground boundaries must be connected to a ground plane (See layout VII.3.a).

Layout VII.3.a : Example of GND layout implantation (top and bottom side)



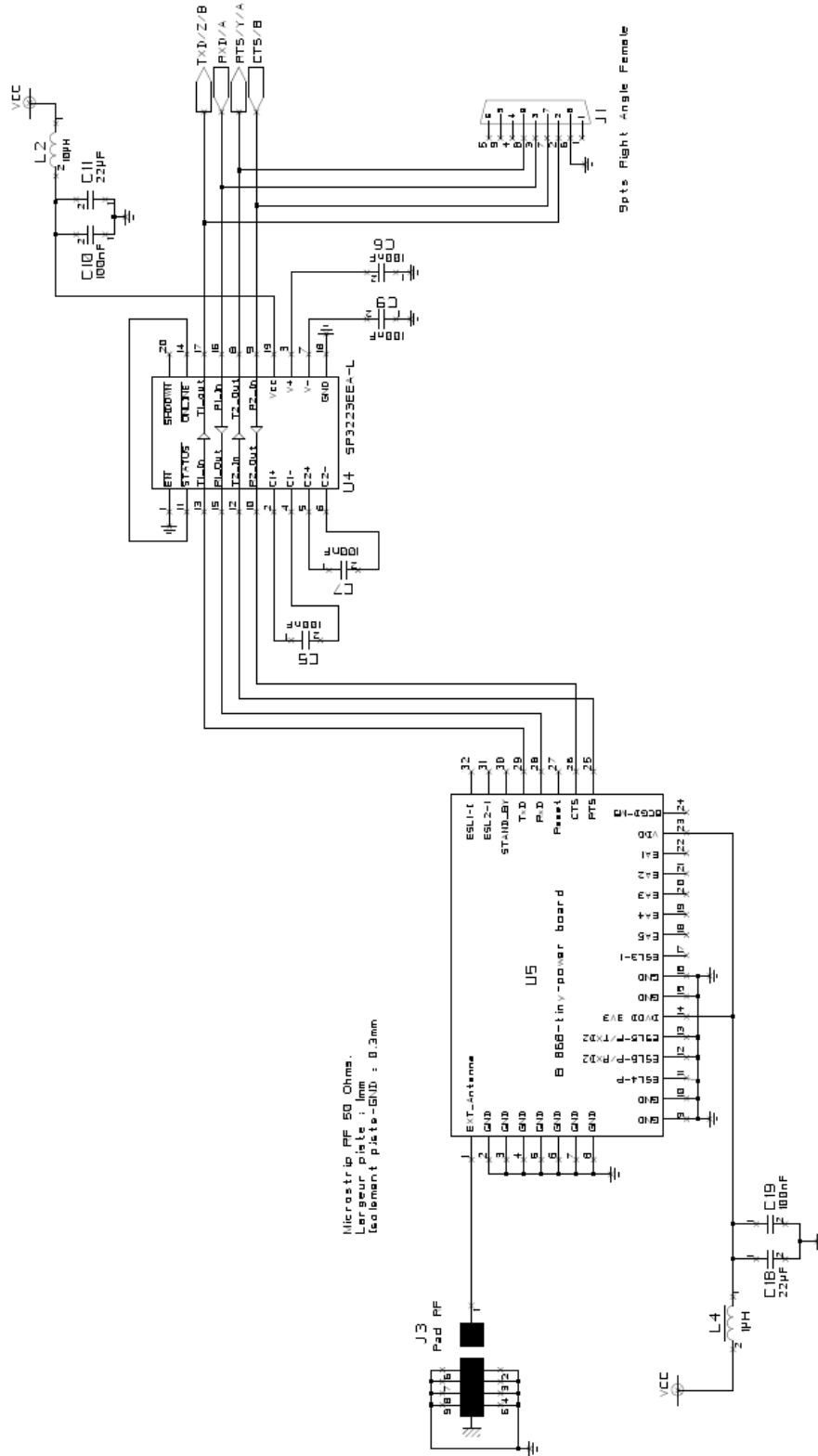
- If the ground plane is on the opposite side, a via must be used in front of each ground boundary (See layout VII.3.b).

Layout VII.3.b : Example of GND layout implantation(top and bottom side)



VII.4. B868-tinyPRO interfacing

Example of a full RS-232 connection with a PC or an Automat.



CHAPTER VIII.

ANTENNA CONSIDERATIONS

VIII.1. Antenna recommendations

B868-tinyPRO performances when used in a product are strongly dependent on the antenna type and its location. Particular cautions are required on the following points:

- Use a good and efficient antenna designed for the 868 MHz band.
- Antenna must be fixed in such a location that electronic noise cannot affect the performances. (outside location is ideal if available).
- Antenna directivity must be low (omni directional antenna is usually the best choice).

WARNING

As the B868-tinyPRO module delivers 500mW, it is very sensitive to the quality of the antenna used. Only choose antennas validated by One RF Technology.

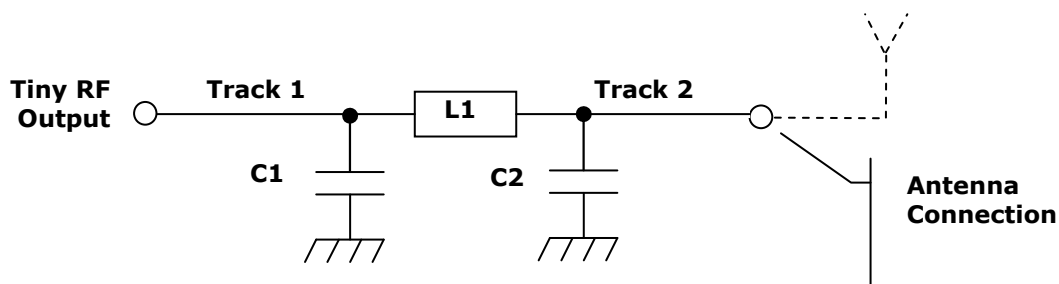
VIII.2. Antenna Specifications

- Frequency Band : 868MHz +/- 25MHz
- Radiation Pattern : Omni directional
- Nominal Impedance: 50 Ω
- VSWR: 1.5:1 max.
- Gain: 0dBi
- Polarization: Vertical

VIII.3. Antenna matching

Impedance matching can be required to deliver the maximum possible power from the module to the antenna and vice versa. This is typically accomplished by inserting a matching network into a circuit between the source and the load.

This matching network must be established as close as possible to the tiny module. Here after an example of matching network between a B868-tinyPRO module and an antenna.



Symbols	Reference	Package	Value	Comments
L1	Coil	0603	tbd	These values must be measured and optimized with a Network Analyzer.
C1, C2	Capacitor	0603	tbd	
Track 1, Track 2	Stripline	<ul style="list-style-type: none"> • Width = 1,2mm (for a 1,6mm PCB thickness and FR4 Epoxy material) • Track 1 length \leq 10mm (as short as possible) • Track 2 length \leq 30mm (as short as possible) • The opposite side requires a ground plane 		
Via	Ideally, ground vias and the RF output Via will have : drill of 0,5 or 0,6mm pad of 1 or 1,2mm			
Antenna connection	Coaxial cable Pad: Hot point: 2*2mm Ground pad:2*4mm Or a specific SMA connector can be used.			

If no impedance matching is necessary, replace L1 by a 00hm resistor, and let C1 & C2 not mounted.

See the layouts paragraph VII.3 to have an idea of the antenna matching implantation :

- Layout VII.3.a: antenna connection via a coaxial solder pad (Top and bottom side)
- Layout VII.3.b: antenna connection via a SMA connector (Top and bottom side)

VIII.4. Antenna types

The following are the antenna examples that may be suitable for tiny applications. We distinguish two types of antenna :

- External antenna (antenna is mounted outside of the device)
- Embeddable antenna (antenna is integrated inside the device)

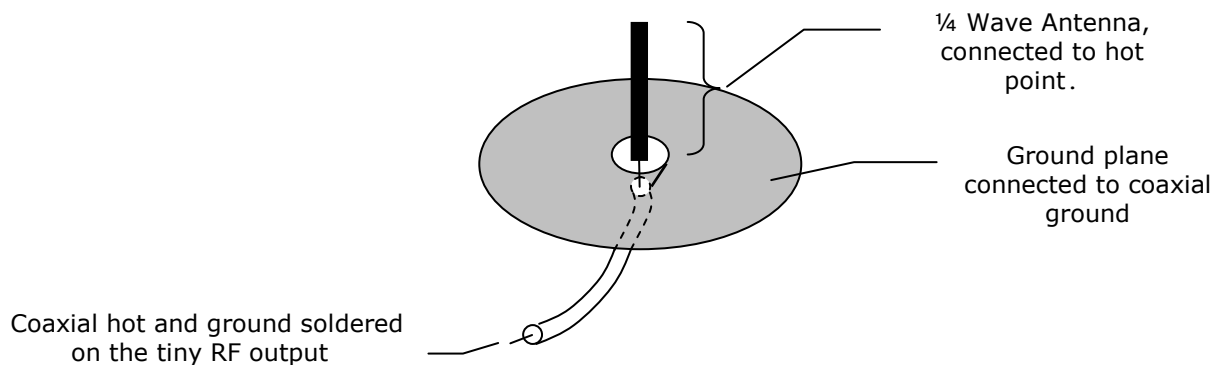
VIII.5. External antenna

External antenna is recommended when the range performance is primordial. For example, for base stations and access points , where a better antenna gain may be required.

▪ **1/4 Wave Monopole antenna:**

The 1/4 Wave antenna is 8 cm long. Shorter compensated antennas could be used as long as they are adapted to 868 MHz frequency.

Best range may be achieved if the 1/4 Wave antenna is placed perpendicular in the middle of a solid ground plane measuring at least 10 cm radius. In this case, the antenna should be connected to the module via some 50 ohm characteristic impedance coaxial cable.



WARNING

The metallic plane must be ideally under the antenna (balanced radiation). Never short-circuit the hot and cold pins!

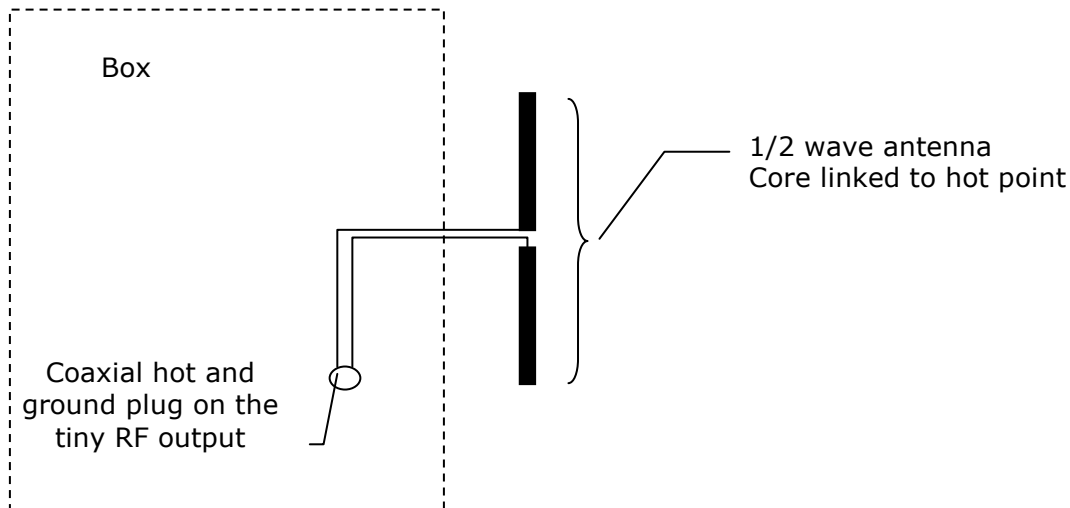
The installation directives are the following:

- Solder the coaxial cable on the hot and ground pad antenna (of the B868-tinyPRO module.)
- Fix the antenna on a metallic plane, or on a metallic box with the metallic screw provided with the antenna.
- If the tiny module is integrated in a plastic box, use a metal tape (copper) glued on the plastic side under the antenna.

▪ ***Half Wave Dipole antenna:***

The $\frac{1}{2}$ Wave Dipole antenna is around 16 cm long. Shorter compensated antennas could be used as long as they are adapted to 868 MHz frequency. In a $\frac{1}{2}$ Wave Dipole antenna the metallic plane is replaced by a second $\frac{1}{4}$ Wave antenna balancing the radiation.

Half wave monopole antenna typically offers a ground-independent design with favorable gain, excellent radiation pattern. It has a high impedance and requires an impedance-matching circuit (See paragraph IX.3)



WARNING

It is recommended to place the $\frac{1}{2}$ wave dipole antenna away from all metallic object, which will detuned it.

Particularity it is not recommended to place this type of antenna directly on a metallic box, but the antenna can be deported away through a 50 Ohm coaxial cable.

VIII.6. Embeddable antennas

In this section you will find antennas designed to be directly attached to B868-tinyPRO module, inside the product casing. These antennas are only used in application where security, cosmetics, size or environmental issues make an external antenna impractical. This type of antenna is used when the integration factor becomes primordial (for mobile and handheld devices) to the range performances.

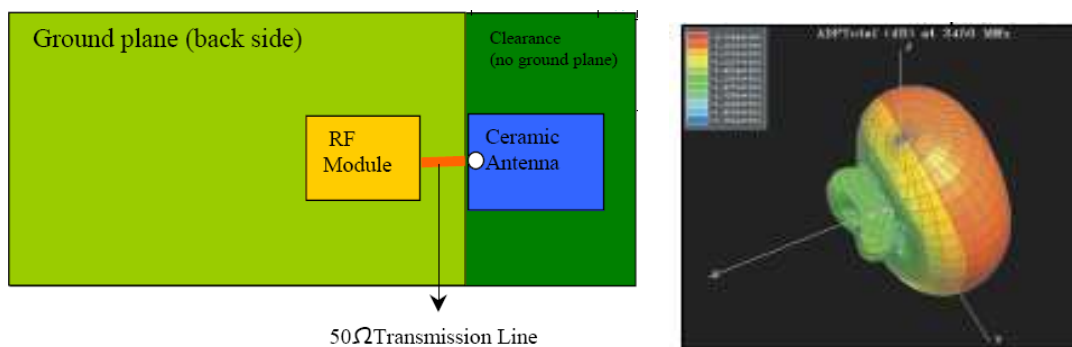
▪ **Basic recommendations:**

- The radio module must not be placed in a metallic casing or close to metallic devices.
- The internal antenna must be far from noisy electronic.

▪ **Ceramic antenna:**

Ceramic antenna is a SMD component to be mounted directly on the PCB. It is designed so that it resonates and be 50 Ohms at the desired frequency. But we recommended to place an impedance-matching circuit (See paragraph IX.3).

The place under and around the ceramic antenna must be free of any track or ground plane. (refer to the antenna constructor requirements). It usually has a hemispherical radiation pattern has described below.



▪ **Miniaturized antenna:**

This type of antenna features a through-hole feedline to directly attach it to the PCB. This antenna acts like a $\frac{1}{4}$ wave antenna so that a minimum ground plane is required.



CHAPTER IX.

ANNEXES

IX.1. ETSI 300-220 standards (summary)

ETSI EN 300 220

The ETSI EN 300 220 specifies in detail the requirements and test methods to be used for type approvals of licence free operated radio equipment. The following is a summary of the most important requirements. The complete document can be downloaded from www.etsi.fr.

Frequency error (section 8.1)

The maximum frequency error depends on type of use; base/mobile or portable, and of the channel separation. The requirement applies only when a channel spacing is specified.

Frequency band	10/12.5kHz channel spacing	20/25 kHz channel spacing	Comment
300-500 MHz	1 / 1.5 / 2.5	2 / 2 / 2.5	Figures is in kHz for base/mobile/portable
500-1000MHz	N.A.	2.5 / 2.5 / 3	

Carrier power, conducted (section 8.2)

This requirement applies for equipment with external antenna connector. The maximum power depends on equipment class. The class is found in the table on page 4

Class	Maximum power mW / dBm
7a	5 / 7
8	10 / 10
9	25 / 14
11	100 / 20
12	500 / 27

Effective radiated power (section 8.3)

This requirement applies for equipment with dedicated or integral antenna. The test method is different from equipment with external antenna connector, but the test limits are the same as above.

TX modulation (section 8.4)

This test apply to analogue speech systems only (FM and AM).

Adjacent channel power (section 8.5)

This test is applicable for equipment operating in bands with specified channel separation and bandwidths.

For 25kHz channel spacing, which is the narrowest channel spacing used in the 868MHz band, the test receiver bandwidth and filter shape for the adjacent channel is specified as follows:

Offset kHz	Attenuation dB
6	-2
8	-6
9.25	-26
13.25	-90

(There is special test instruments made for this kind of measurements, for example the Rhode & Swartz test receiver CMTA 84)

The test should be used using test modulation patterns D-M3 (package) or D-M2 (data stream).

The requirement for 25kHz channel spacing is 200nW = -37dBm for normal test conditions, and 640nW = -32dBm for extreme test conditions.

Modulation bandwidth for wideband equipment (>25kHz) (section 8.6)

This test is applicable when no channel spacing is specified, or channel spacing is larger than 25kHz.

The power envelope shall be measured with a spectrum analyser, RBW=100 Hz, VBW=10kHz, using the maximum hold display function. The bandwidth is defined as the bandwidth of the power envelope where the power is above the required spurious level. The spurious level limit is 250nW = -36dBm.

Spurious emission (section 8.7)

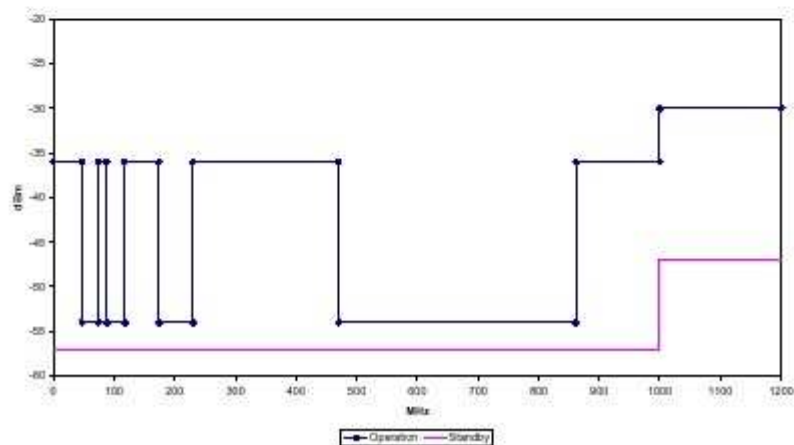
The spurious emission is a measurement of unwanted emitted signals. The device shall be measured without modulation applied.

If the carrier frequency is < 470 MHz the equipment shall be measured for unwanted emissions from 9kHz to 4 GHz. If the carrier frequency is >470 MHz, the upper limit is 12.75 GHz.

All spurs except emission at the intended channel and the adjacent channels shall be measured. The requirement is given in the table, and illustrated in the figure below.

State	47-74 MHz 87.5-118 MHz 174-230 MHz 470-862MHz	Other frequencies below 1000 MHz	Above 1000 MHz
Operating	4nW = -54 dBm	250nW = -36dBm	1µW = -30dBm
Standby	2nW = -57dBm	2nW = -57dBm	20nW = -47dBm

Spurious emission requirement



Frequency stability for low voltage, battery operation (section 8.8)

This requirement applies for battery operated equipment only.

The requirement is that when reducing the operating voltage to zero, the equipment should stay on the desired frequency, or cease to function altogether.

Duty cycle (section 8.9)

This requirement states the transmitter on/off ratio measured during 1 hr period. The duty cycle ratio is found in the table on page 4.

Receiver spurious radiation (section 9.1)

For equipment with integral antenna the radiated emission from the receiver shall be measured. Equipment with external antenna connector shall be measured for both conducted spurious emission and cabinet radiation.

If the carrier frequency is < 470 MHz the equipment shall be measured for unwanted emissions from 9kHz to 4 GHz. If the carrier frequency is >470 MHz, the upper limit is 12.75 GHz.

The radiation limit is given in the table below.

State	Below 1000 MHz	Above 1000 MHz
Receive	2nW = -57dBm	20nW = -47dBm

Receiver spurious response or blocking (section 9.2)

The ETSI standard does not give any mandatory requirements to receiver spurious response or blocking.

IX.2. Examples of propagation attenuation

<i>Factor</i>	<i>433 MHz</i>		<i>868 MHz</i>		<i>2.4 GHz</i>	
	<i>Loss</i>	<i>Attenuation</i>	<i>Loss</i>	<i>Attenuation</i>	<i>Loss</i>	<i>Attenuation</i>
Open office	0 %	0 dB	0 %	0 dB	0 %	0 dB
Window	< 5 %	< 1 dB	15 %	1 – 2 dB	30 %	3 dB
Thin wall (plaster)	25 %	3 dB	35 %	3 – 4 dB	50 %	5 – 8 dB
Medium wall (wood)	40 %	4 – 6 dB	50 %	5 – 8 dB	70 %	10 – 12 dB
Thick wall (concrete)	50 %	5 – 8 dB	60 %	9 – 11 dB	85 %	15 – 20 dB
Armoured wall (reinforced concrete)	70 %	10 – 12 dB	80 %	12 – 15 dB	90 %	20 – 25 dB
Floor or ceiling	50 %	5 – 8 dB	60 %	9 – 11 dB	85 %	15 – 20 dB
Armoured floor or ceiling	70 %	10 – 12 dB	80 %	12 – 15 dB	90 %	20 – 25 dB
Rain and/or Fog	90 %	20 – 25 dB	95 %	25 – 30 dB	?? *	?? *

* = *Attenuations increase along with the frequency. In some cases, it is therefore difficult to determine loss and attenuation value.*

Note = *The table above is only indicative. The real values will depend on the installation environment itself.*

IX.3. Declarations of Compliance

