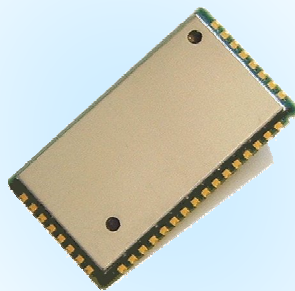


B868-TINYPRO

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
- Technical description
- Functional description (standard and telemetry)
- Process information
- Board Mounting Recommendations
- Antenna Considerations

I.2. Reference documents

[1] EN 300 220-2 v2.1.1	ETSI Standards for SRD , April 2006
[2] ERC Rec 70-03	ERC Recommendation for SRD, May 2007
[3] 2002/95/EC	Directive of the European Parliament and of the Council, 27 January 2003
[4] TinyTools : User Manual	
[5] Mesh Lite : Technical Manual	

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
kbits/s	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 (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

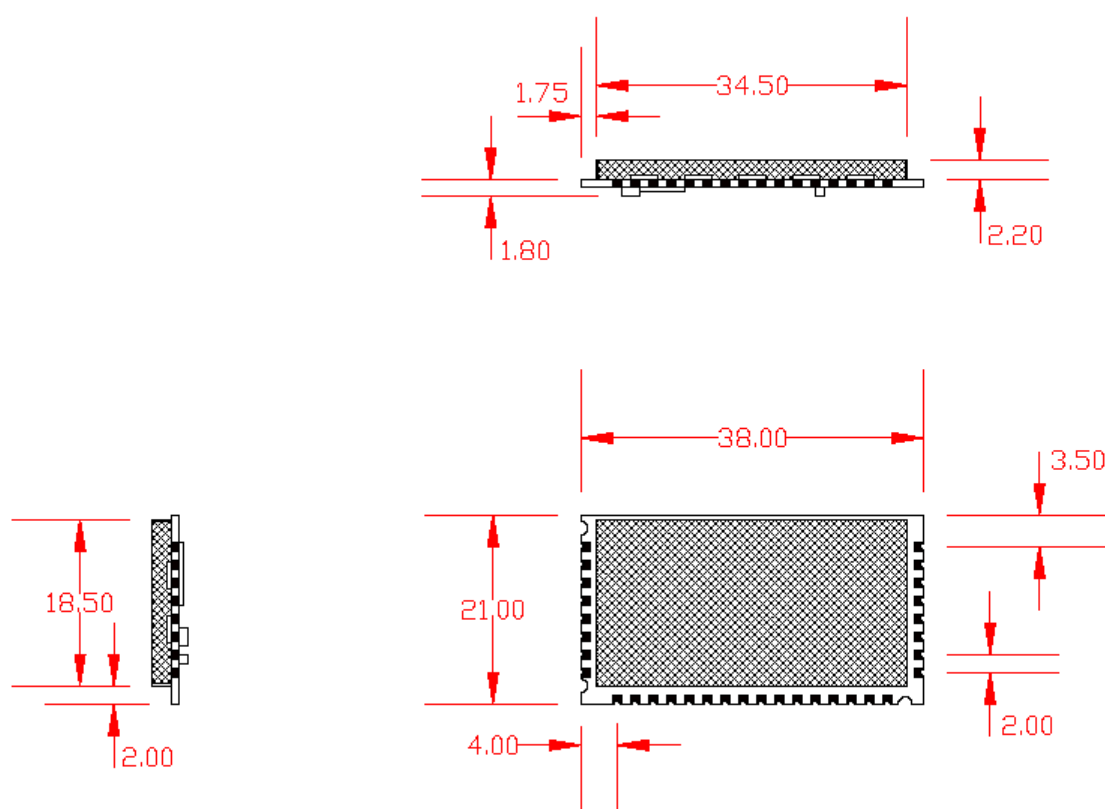
	<i>Minimum</i>	<i>Typical</i>	<i>Maximum</i>	<i>Unit</i>
<i>Operating</i>				
Temperature	- 40	25	+ 85	°C
Relative humidity	20		75	%
<i>Storage</i>				
Temperature	- 40	25	+ 85	°C
Relative humidity	0		95	%

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_{CC} , V_{DD}) :	+3.0V	+3.6V	+3.7V
Consumption @3.6V :			
Transmission (500mW) :	-	630mA	650mA
Transmission (100mW) :		300mA	350mA
Reception :	-	30mA	35mA
Stand-by :	-	5 μ A	10 μ A
I/O low level :	GND	-	0.2xV _{DD}
I/O high level :	0.8xV _{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) : (100mW) :	-	- -	4ms 3.5ms
Tx to RX switching time (500mW) : (100mW) :	-	- -	4ms 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)	
Transmission	Single channel	Multi channel
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 \pm 1dB)	100mW (20dBm \pm 2dB)
Modulation :	GFSK	
ACP :	-	-37dBm max.
Spurious out of the band :	<p>Under the following limits :</p>	

Reception	<i>Single channel</i>	<i>Multi channel</i>
Sensitivity for $CER < 10^{-3}$:	-100dBm \pm 2dB (@ 38.4kbps)	-105dBm \pm 2dB (@ 4.8kbps)
Saturation for $CER < 10^{-3}$:	up to -5 dBm under 50 Ohms	
Remaining CER :	< 1.10^{-6} at -50 dBm	
Selectivity :	-	30 dB protection between channels
Immunity :		
against adjacent channels jammer at -20 dBm :	-	20 dB min.
against other channels jammer at -20 dBm :	-	30 dB min.
against out of the band spurious :	40 dB typ.	
Spurious leakage :		
Below 1 GHz :	-57 dBm max.	
Over 1 GHz :	-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, Frame Detect • <i>Inputs</i> : Reset, Stand-By, ProgS • <i>I/O</i> : 8 I/O (among those 3 analog inputs with 10 bits resolution)
Flashing :	<ul style="list-style-type: none"> • <i>Through serial</i> • <i>Through the air</i> : DOTA (Download Over The Air) functionality

III.6. Absolute Maximum Ratings

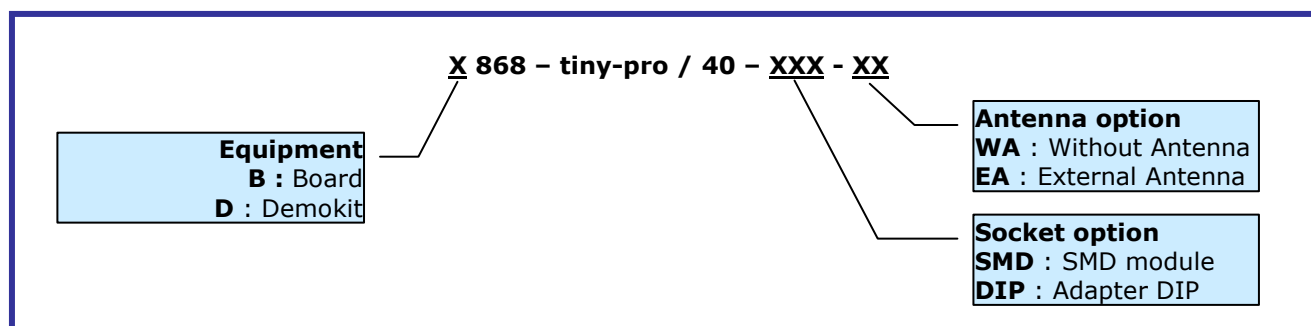
Voltage applied to V_{CC}, V_{DD} :	-0.3V to +3.8V
Voltage applied to "TTL" Input :	-0.3V to $V_{DD}+0.3V$

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 Telit part number you need.



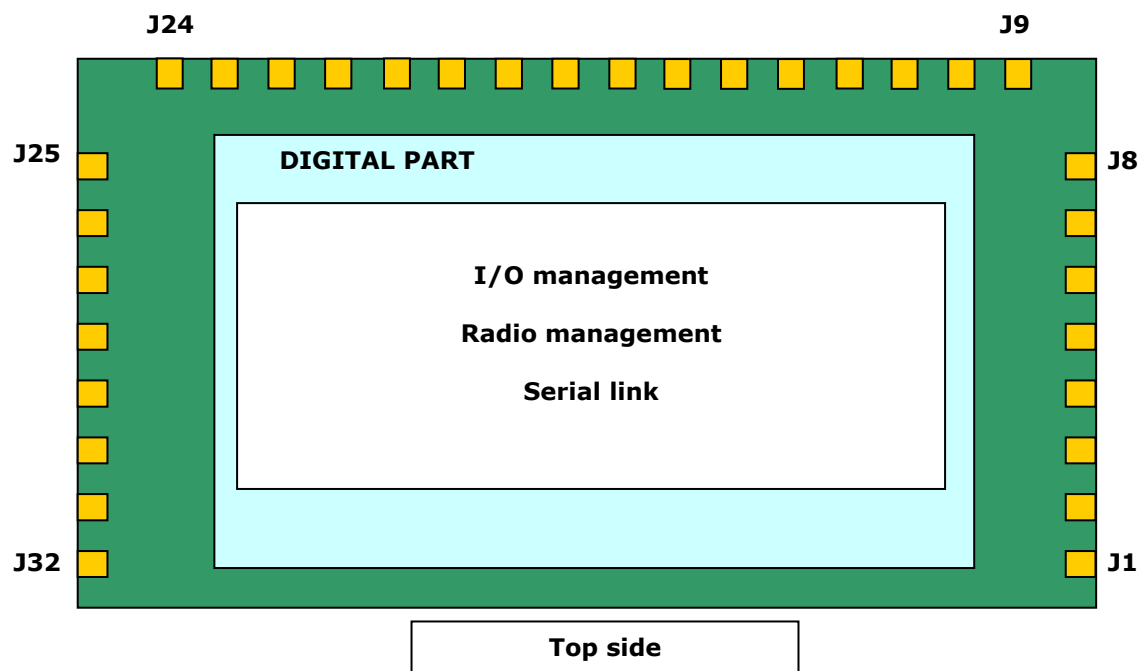
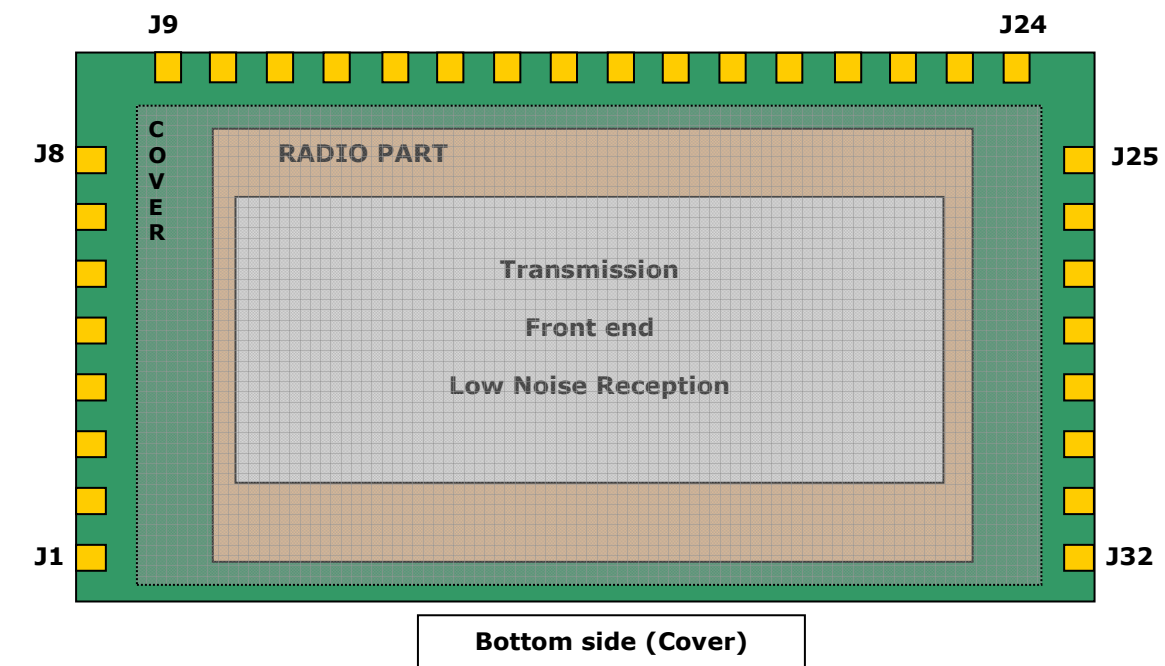
The versions below are considered standard and should be readily available. For other versions, please contact Telit. Please make sure to give the complete part number when ordering.

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

CHAPTER IV.

TECHNICAL DESCRIPTION

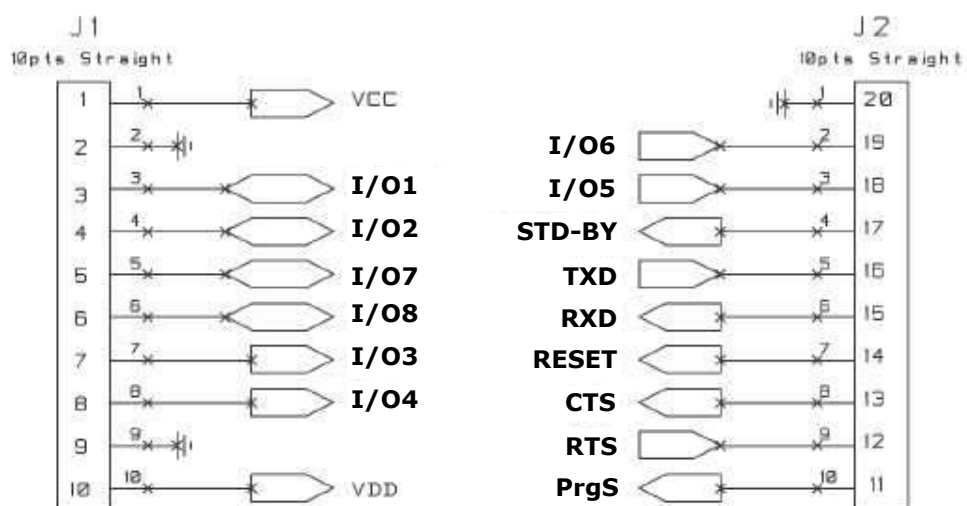
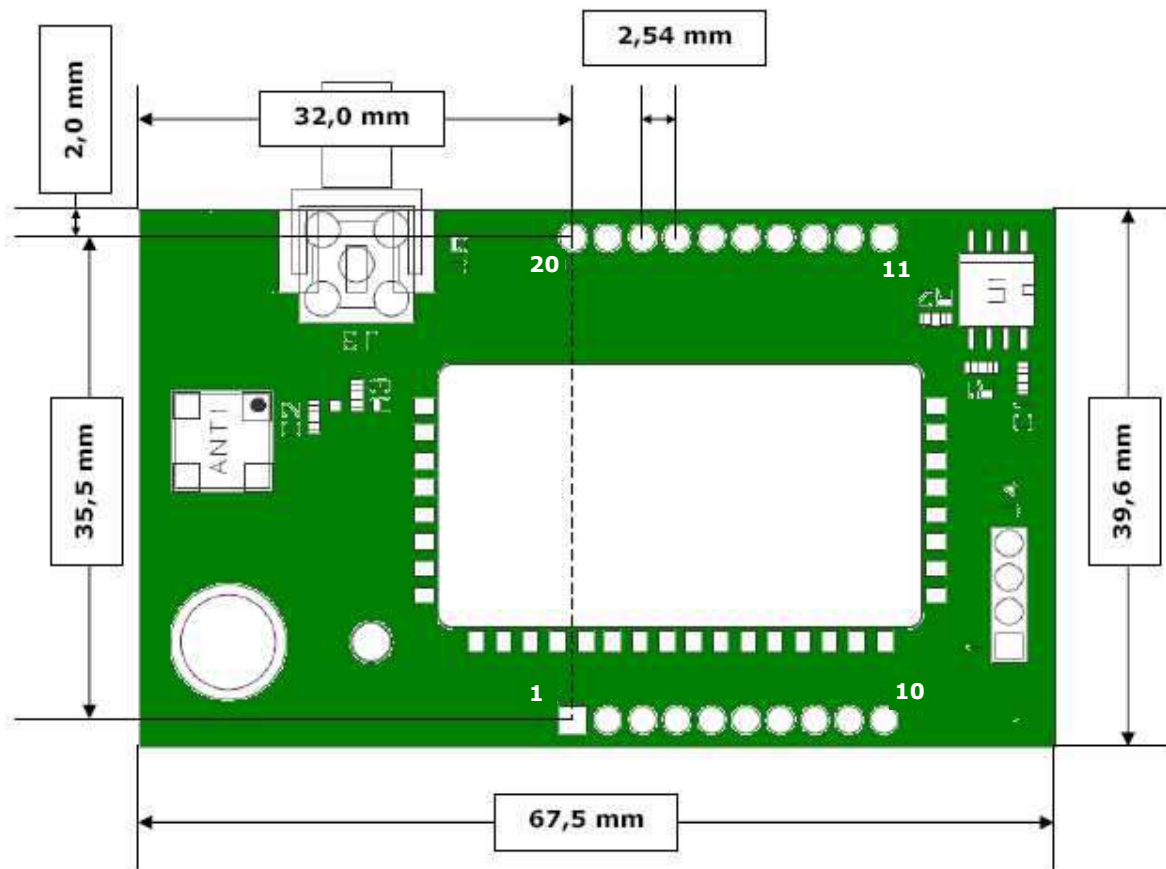
IV.1. Block diagram and Pin-out of the SMD Module



<i>Pin</i>	<i>Interface function</i>	<i>I/O</i>	<i>Signal level</i>	<i>Function</i>
J32	I/O6	I/O	TTL	Digital I/O, interrupt Input capable
J31	I/O5	I/O	TTL	Digital I/O, interrupt Input capable
J30	STAND-BY	I	TTL	Signal for stand-by
J29	TXD	O	TTL	TxD UART – Serial Data Transmission
J28	RXD	I	TTL	RxD UART – Serial Data Reception
J27	RESET	I	TTL	Signal for reset
J26	CTS	I	TTL	Clear To Send
J25	RTS	O	TTL	Request To Send
J24	BKGD-MS	I/O	TTL	Single wire background debug interface pin + Flash μ C programming
	ACK-TX	O	TTL	Indicate radio transmission is OK
J23	V _{DD}	-	-	Digital part supply
J22	I/O4	I/O	analog	Digital I/O, analog Input (10 bits) capable
J21	I/O3	I/O	analog	Digital I/O, analog Input (10 bits) capable
J20	I/O8	I/O	TTL	Digital I/O
	STATUS TX-RX	O	TTL	Indicate if the serial link is on transmission or reception
J19	I/O7	I/O	TTL	Digital I/O
J18	I/O2	I/O	TTL	Digital I/O, interrupt Input capable
	Frame Detect	O	TTL	Indicates if valid Carrier + Synchro word is received
J17	I/O1	I/O	analog	Digital I/O, analog Input (10 bits) capable
	Frame Detect	O	TTL	Indicates if valid Carrier + Synchro word is received
J16	GND	-	-	Ground
J15	GND	-	-	Ground
J14	V _{CC}	-	-	Radio part supply

J13- J12	GND	-	-	Ground
J11	PrgS	I	TTL	Signal for serial μ C flashing
J10- J02	GND	-	-	Ground
J01	RF_Antenna	O	-	RF connection to external antenna

IV.2. Block Diagram and Pin-out of the DIP Module



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 is full or when the user's serial transmission is finished.
ACK-TX	Indicates that the buffer transmission was done correctly. The signal is activated at the end of a message transmission on the radio (active RTS) and stays active until RTS switches to inactive state. Active (transmitted buffer) on low state.
I/Ox	Input/Output, available with telemetry firmware.
Stand-By ⁽²⁾	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⁾ : used only if Hardware Stand-By is selected (S240=1).

CHAPTER V.

STANDARD FIRMWARE : DESCRIPTION OF THE FUNCTIONALITY

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

For B868-tinyPRO module, there are 3 different firmwares :

- **Standard firmware.**
- **Telemetry firmware**, allowing a functional use of I/Os of the module : refer to Chapter VI for detailed explanation.
- **Mesh Lite firmware**, allowing mesh networking : refer to dedicated manual ([5]) for detailed explanation.

This Chapter is dedicated to the standard firmware functionalities.

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.

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

Command	Description
+++	Hayes Mode Activation '+++' 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. '+++' 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. Hayes mode inactivates radio functions.
ATO	Communication mode activation 'ATO' command gives an instant access to the modem's operating mode, configured in S220 register. 'ATO' command is used to get out of Hayes mode. Answer : OK or ERROR if the configuration is not complete
AT/V	Modem's firmware version 'AT/V' command displays the modem's firmware version number as follows: <i>Version <Product>: vX.YZn</i>
AT/S	Modem's registers status 'AT/S' command displays status of all relevant registers of the modem

ATSn?	Register interrogation 'ATSn?' command displays the content of Hayes register number n (Refer to the register description table). Some registers are standard for every Telit modems while others are specific to some products. Answer : Sn=x<CR>
ATSn=m	Register modification 'ATSn=m' command configures Hayes register number n with the value m, e.g. ATS200=4<CR> enters the value '4' in the register S200. The value is automatically stored in the EEPROM memory. Answer : OK or ERROR
ATN	RSSI interrogation '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 : <ul style="list-style-type: none"> - '0' : received level < -87dBm - '1' : received level between -87 and -82dBm - '2' : received level between -82 and -77dBm - '3' : received level > -77dBm
ATR	Parameters reset 'ATR' command resets all modem's parameters to their default values. Answer : OK
ATP	Stand By Activation 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.
ATBL	Switch to Bootloader '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.

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.

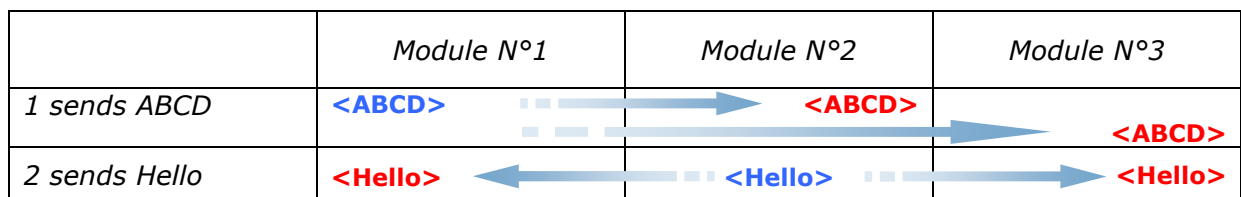
V.2. Operating Mode

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

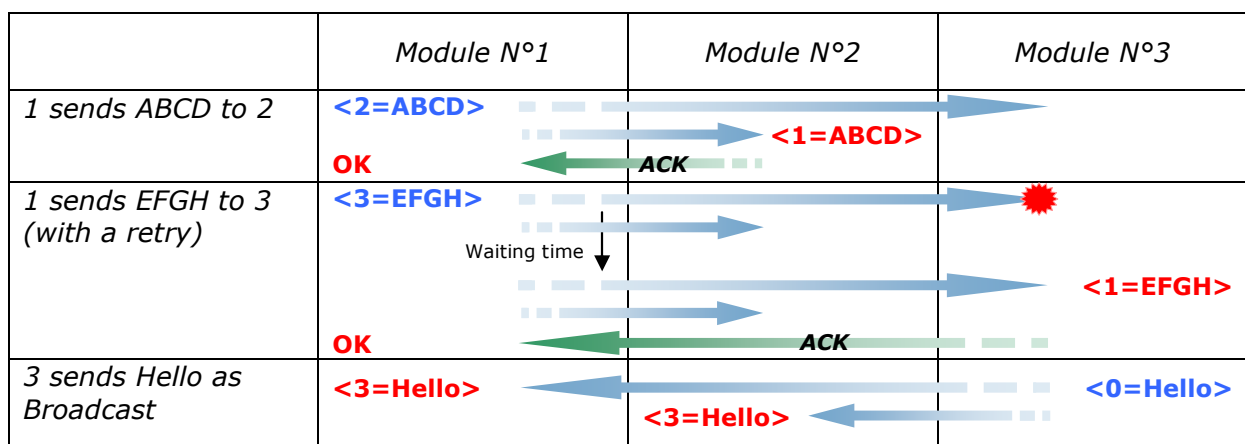
- Transparent mode : this is the default communication protocol of the module. The module transmits the data transparently, without encapsulation or addressing. It acts as a half duplex wired serial link (type RS485).
- Addressed Secured mode : it is a kind of multipoint network protocol. Each module 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**

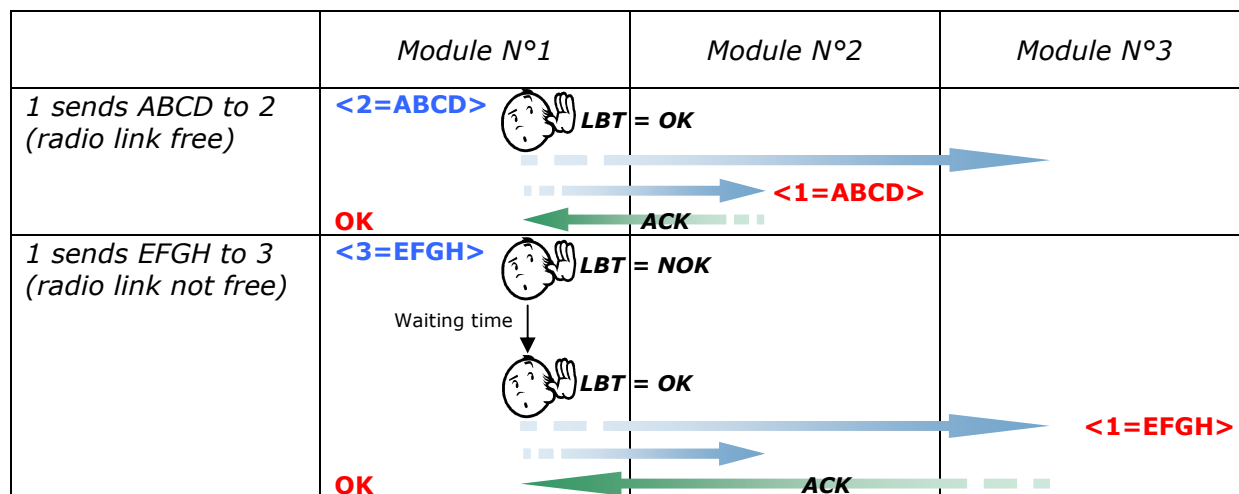


☀ Collision or error

<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.

<i>S206 value</i>	<i>Functioning mode</i>
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.

<i>S201 value</i>	<i>Radio baud rate</i>
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.

6. Radio Whitening Character : S209

This register sets the value XOR with each character of the radio frame in order to avoid long sequences of 0s or 1s. If the user application sends frames containing series of 0x00 or 0xFF, the receiver can unsynchronized itself, thus the need for this whitening.

To mix a frame of these types, use a value of 170 (Hex : 0xAA , Bin : 10101010)

▪ 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.

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 .

Note 1 : in Hayes mode, the flow control is not active so as to be able to modify these registers without locking the serial link.

Note 2 : in Addressed Secured mode, the flow control works only by activating the default transmission address (S256 ≠ 0).

▪ **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
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>Value</i>	<i>LBT</i>	<i>Comment</i>
0	OFF (default)	no LBT
1	ON with high sensitivity	LBT with detection for RF >-87dBm
2	ON with medium sensitivity	LBT with detection for RF >-82dBm
3	ON with low sensitivity	LBT with detection for RF >-77dBm

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). When LBT functionality is ON, it is automatically activated. 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	2B	Ret	-	NH	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>).
- ↳ **Numeric Header (Bit 2, default 0)** : Used when bit 0 is set to 1, it selects the type of header for transmission or reception to ASCII (0) or numeric (1).
- ↳ **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, ERROR otherwise.
- ↳ **2 bytes Numeric Header (Bit 5, default 0)** : Used when bit 2 is set to 1, it defines if the numeric header is on 1 byte (0) for less than 255 modems, or 2 bytes (1) for up to 65535 modems. This bit has no effect if the header is ASCII (Bit 2 = 0). The frames sent and received will be as follows :
 "<0x01>Data" if this bit is set to 0
 "<0x00><0x01>Data" if this bit 5 is set to 1
- ↳ **ACK (Bit 6, default 0)** : Radio Acknowledge disable: if '1', the radio Ack is disable and any secured radio frames are not 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
General			
R	S192	Serial Number	Serial number of the module, the one present on the sticker. Read-only register.
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.	<div>Indicates the speed on the Serial Connection</div> <div>'1': 1200 bits/s '5': 19200 bits/s</div> <div>'2': 2400 bits/s '6' : 38400 bits/s</div> <div>'3': 4800 bits/s '7' : 57600 bits/s</div> <div>'4': 9600 bits/s '8' : 115200 bits/s</div> <div>The time out value must be compatible with the serial speed:</div> <table><tr><th>Min. time-out (S214)</th><th>Serial Speed (S210)</th></tr><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></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	<div>Serial Link Parity Type:</div> <div><ul style="list-style-type: none">'1': None (default) ,'2': Even,'3': Odd.</div>												
R/W	S213	Number of Stop bits	<div>Serial Link Stop Bits :</div> <div><ul style="list-style-type: none">1 bit (default),2 bits.</div>												
R/W	S214	Serial Link Time Out	<div>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).</div> <div>Between 2 and 100 milliseconds</div> <div>Default : 5.</div>												
R/W	S216	Flow Control	<div>Indicates flow control type:</div> <div><ul style="list-style-type: none">'0': Hardware: CTS/RTS'1': Software: Xon/Xoff'2': None (default)</div>												

Access	Register	Name	Description
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Operation			
R/W	S220	Function Mode	Operating mode of the Modem : <ul style="list-style-type: none"> • '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 <ul style="list-style-type: none"> • '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 <ul style="list-style-type: none"> • '0' : OFF • '1' : ON

Low Power			
R/W	S240	Type of Low-power	Indicates whether the low power control pin is used or not <ul style="list-style-type: none"> • '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	<div>Indicates the Network options. 4 bits are used :</div> <table><tr><td>Bits</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr><tr><td></td><td>-</td><td>ACK</td><td>2B</td><td>Ret</td><td>-</td><td>NH</td><td>CR</td><td>N°</td></tr></table> <div>Default value : 01.</div> <div><div>➤ Bit 'N°': indicates whether the received frame begins with the Client ID (1) or not (0).</div><div>➤ Bit 'CR': indicates whether the received frame ends with the 'Carriage Return' character (0x0D) (1) or not (0).</div><div>➤ Bit 'NH': indicates whether the format in Transmission (and in reception, if the Bit 'N°' is activated) is ASCII (1=Data) (0) or Numeric (<0x01>Data) (1).</div><div>➤ Bit 'Ret': Indicates if the 'OK' should be returned after each radio transmission (0) or not (1).</div><div>➤ Bit '2B': In case of a Numeric Header (bit 'NH'=1) indicates if the header is on 1 bytes (0) or 2 bytes (1). Used if you have more than 255 modems in your system.</div><div>➤ Bit '/ACK' : Disable the radio acknowledgement (1) or enable (0).</div></div>	Bits	7	6	5	4	3	2	1	0		-	ACK	2B	Ret	-	NH	CR	N°
Bits	7	6	5	4	3	2	1	0													
	-	ACK	2B	Ret	-	NH	CR	N°													
R/W	S256	Default Address	Indicates the default address to which every radio frame will be sent. Default : 0 (inactive)																		

V.5. Configuration Example

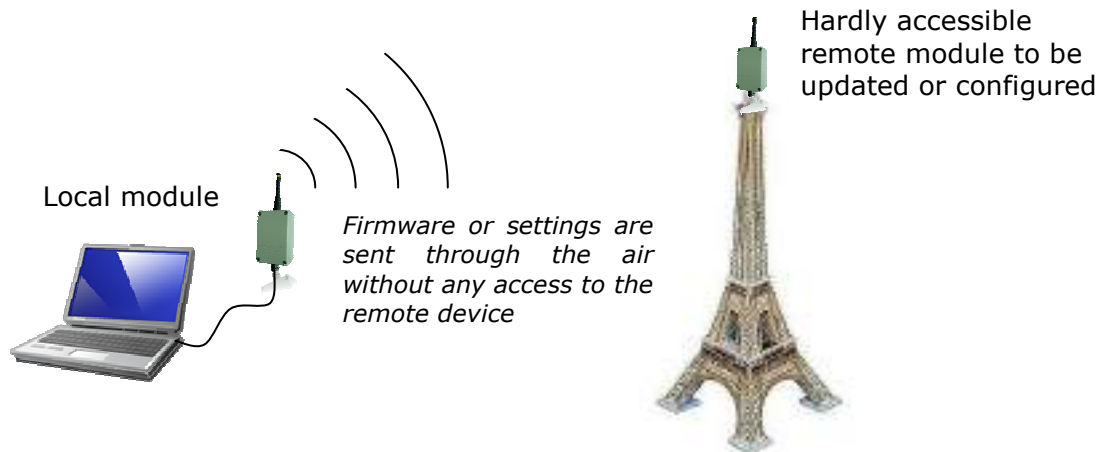
We will describe in this paragraph how to parameter the modules in order to set up 2 different Addressed Secured configurations :

- 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.

CLASSICAL	CLIENT/SERVER	
All	Server	Clients
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.



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.

Both functionalities are available through a specific software tool "TinyTools". Refer to its user manual ([4]) for detailed explanation.

CHAPTER VI.

TELEMETRY FIRMWARE : DESCRIPTION OF THE FUNCTIONALITY

This Chapter is dedicated to the functionalities of the telemetry firmware allowing functional use of I/Os of the module.

VI.1. General Features

- Telemetry protocol is based on the addressed secured operating mode. Each module is able to execute telemetry orders while exchanging serial data.
- 8 pins of the module are dedicated for I/O use, with different capability :
 - ✎ 10 bits analog inputs capable, readable either locally or remotely,
 - ✎ PWM input capable, readable either locally or remotely,
 - ✎ interruptible input to wake up and send frame on edge event,
 - ✎ 10 KHz PWM output with 8 bits resolution duty cycle writable either locally or remotely.
- I/O copy between 2 modules or more in star architecture to update digital output according to digital input from another module.
- Independent I/O and data binding to route data and I/O frame to different target.
- 8 pins are reserved for user telemetry application. All pins are digital I/O capable and some pin has specific functionalities shown in the following table.

<i>Pin</i>	<i>Name</i>	<i>Digital IO</i>	<i>Analog input</i>	<i>IRQ input</i>	<i>PWM input</i>	<i>PWM output</i>
J17	I/O1	✓	✓			
J18	I/O2	✓		✓ (1)		
J19	I/O7	✓				
J20	I/O8	✓				✓
J21	I/O3	✓	✓			
J22	I/O4	✓	✓			
J31	I/O5	✓		✓ (2)	✓	
J32	I/O6	✓		✓ (2)		

(1) Interrupt event on rising edge

(2) Interrupt event on falling edge

VI.2. Registers Description

Most of registers described in previous chapter are available in telemetry firmware. Below are listed registers specific to this protocol.

Access	Register	Name	Description
<u>Serial Link</u>			
R/W	S216	Flow Control	Indicates flow control type: <ul style="list-style-type: none"> • '0': Hardware: CTS/RTS (default) • '1': Software: Xon/Xoff • '2': None
<u>Operation</u>			
R/W	S220	Function Mode	Operating mode of the Modem : <ul style="list-style-type: none"> • '6' : Telemetry Master • '7' : Telemetry Client (default)
<u>Low power and timing</u>			
R/W	S240	Type of Low-power	Only available on Telemetry client. <ul style="list-style-type: none"> • '0': Low Power disable (default) • '1': Low Power Hard : activated by Std-By pin • '2': Low Power Soft : module is periodically waked up by an internal timer to send IO frame, see S241 and S243 registers for timing settings • '3': Low Power Hard & Soft : module is waked up by timer but you can also quit stand by at any time by a falling edge on std-by pin
R/W	S241	Wake up Period	Only available on Telemetry client. Time in seconds between 2 telemetry frames sending. This timer is useful to periodically wake up the module and send its IO state. This timer is usable even if the module isn't low power (S240=0), in this case, this timer is useful to periodically check the radio link. <ul style="list-style-type: none"> • '0': disable (default) • '1' to '250': wake up period in seconds
R/W	S243	Wake up duration	Duration of wake up in ms. Between 0 and 255. Default value : 125
<u>Network Control</u>			
R/W	S258	Default I/O Recipient	When periodic wake up is enable (register 241), the module will send periodically its I/O state to the specified default IO recipient. When interrupt capable input is set (register 262), an edge on the specified input trigs a telemetry frame sending to the default IO recipient.

<i>I/O control</i>			
R/W	S260	I/O Direction	<p>I/O pins can be set either in input (digital or analog) or output (digital only). Each bit of this register indicates if a pin should be an input ('0', default) or output ('1').</p> <ul style="list-style-type: none"> • Bit 0: I/O1 • Bit 1: I/O2 • Bit 2: I/O7 • Bit 3: I/O8 • Bit 4: I/O3 • Bit 5: I/O4 • Bit 6: I/O5 • Bit 7: I/O6
R/W	S261	Dedicate I/O	<p>A few pins are shared between telemetry and status indicators like 'Status TX-RX or 'Frame Detect'. By default, all this pins have been affected for telemetry use but if necessary, the original pin function can be recovered by setting to '1' the corresponding bit.</p> <ul style="list-style-type: none"> • Bit 0: I/O1 or Frame Detect • Bit 1: I/O2 or Frame Detect • Bit 2: I/O7 • Bit 3: I/O8 or Status TX-RX • Bit 4: I/O3 • Bit 5: I/O4 • Bit 6: I/O5 • Bit 7: I/O6
R/W	S262	Interrupt inputs	<p>Some inputs are IRQ capable, i.e. an edge occurring on an IRQ pin automatically wakes up the module and sends its IO state to the default recipient specified in S258 register. As S260 register, each bit is dedicated to a pin.</p> <ul style="list-style-type: none"> • Bit 0 (I/O1): IRQ not available • Bit 1 (I/O2): '0' IRQ disable, '1' IRQ enable on rising edge • Bit 2 (I/O7): IRQ not available • Bit 3 (I/O8): IRQ not available • Bit 4 (I/O3): IRQ not available • Bit 5 (I/O4): IRQ not available • Bit 6 (I/O5): '0' IRQ disable, '1' IRQ enable on falling edge • Bit 7 (I/O6): '0' IRQ disable, '1' IRQ enable on falling edge
R/W	S263	PWM output	<p>A 10kHz PWM output is available on I/O8. Set this register to '8' to activate the PWM output. Reset to '0' (default) to disable the PWM output. All other values are reserved.</p>
R/W	S264	I/O copy	<p>Enables the I/O copy mode.</p> <ul style="list-style-type: none"> • '0': disable (default) • '1': enable
R/W	S265	Digital Output Start-up value	<p>Specifies the value taken by outputs immediately after module power on. Each bit is dedicated to a pin as specified in S260 register.</p>
R/W	S266	PWM Start-up Value	<p>Specifies the duty cycle applied to the 10kHz PWM Output immediately after the module power on. Between 0 and 255.</p> <ul style="list-style-type: none"> • '0': PWM output always to 0 (default) • '128': 50% duty cycle • '255': PWM output always to 1.



VI.3. Detailed Features

▪ ***Frame syntax for mixed telemetry and data exchanges***

Telemetry protocol is able to execute telemetry orders while exchanging serial data. It uses an addressed secured mode to insure reliability and network capabilities. Data and Telemetry commands are differenced using '=' and 'T' characters respectively.

⇒ A data frame is sent as following:

[Address]["="][Data]
 (example: "2=hello" sends "hello" on the serial link of module N°2.)

⇒ While telemetry orders are sent as following:

[Address]["T"][Telemetry_order]
 (example: "3T[0x02]<CR>" request the input values of module N°3)

The telemetry frames are described in the following tables :

↳ General syntax

Field	Size (byte)	Description
Address	1 to 5	ASCII ID of the addressed module
T	1	Separator indicating the end of address field and the telemetry frame type
Telemetry command	1	Specifies the telemetry action wanted to be performed: Read inputs, Write Digital, Write PWM...
Specific fields (depending on the command)	0 to 14	According to the command, a few information is needed in this field
<CR>	1	All telemetry frames ends by carriage return

↳ Read request :

Field	Size (byte)	Description	Example
Address	1 to 5	ASCII ID of the addressed module	"3" (0x33)
T	1	Separator indicating the end of address field and the telemetry frame type	"T" (0x54)
0x02	1	0x02 is the order to request a read of the inputs of a module. No more information is needed for this command.	0x02
<CR>	1	All telemetry frames ends by carriage return	<CR> (0x0D)

Ask all values to module N°3 ←

✎ Write Digital Outputs:

Field	Size (byte)	Description	Example																
Address	1 to 5	ASCII ID of the addressed module	"28" (0x32, 0x38)																
T	1	Separator indicating the end of address field and the telemetry frame type	"T" (0x54)																
0x03	1	0x03 is the order to perform a digital write on the outputs of the addressed module	0x03																
Mask	1	Specifies the outputs to be updated. Each bit corresponds to one pin, only the set bits will be written <table><tr><td>I/O 6</td><td>I/O 5</td><td>I/O 4</td><td>I/O 3</td><td>I/O 8</td><td>I/O 7</td><td>I/O 2</td><td>I/O 1</td></tr><tr><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td></tr></table>	I/O 6	I/O 5	I/O 4	I/O 3	I/O 8	I/O 7	I/O 2	I/O 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0xC0
I/O 6	I/O 5	I/O 4	I/O 3	I/O 8	I/O 7	I/O 2	I/O 1												
0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1												
Value	1	Value to write on the outputs, 1 bit per pin. <table><tr><td>I/O 6</td><td>I/O 5</td><td>I/O 4</td><td>I/O 3</td><td>I/O 8</td><td>I/O 7</td><td>I/O 2</td><td>I/O 1</td></tr><tr><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td></tr></table>	I/O 6	I/O 5	I/O 4	I/O 3	I/O 8	I/O 7	I/O 2	I/O 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0x80
I/O 6	I/O 5	I/O 4	I/O 3	I/O 8	I/O 7	I/O 2	I/O 1												
0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1												
<CR>	1	All telemetry frames ends by carriage return	<CR> (0x0D]																

Set pin J32 to 1, J31 to 0 and let current value on the other pins of module N°28 ←

✎ Write PWM Output:

Field	Size (byte)	Description	Example
Address	1 to 5	ASCII ID of the addressed module	"2" (0x32)
T	1	Separator indicating the end of address field and the telemetry frame type	"T" (0x54)
0x04	1	0x04 is the order to change the duty cycle of the PWM output	0x04
Value	1	New value to be affected to the duty cycle of PWM output	0x40
<CR>	1	All telemetry frames ends by carriage return	<CR> (0x0D]

Set PWM output duty cycle to 25% on module N°2 ←

↩ Returned value :

Field	Size (byte)	Description	Example																
Address	1 to 5	ASCII ID of the module returning the frame																	
T	1	Separator indicating the end of address field and the telemetry frame type																	
0x01	1	0x01 indicates that the module return all value following a read request																	
Digital value	1	Digital value read on the module with one bit by pin <table><tr><td>I/O 6</td><td>I/O 5</td><td>I/O 4</td><td>I/O 3</td><td>I/O 8</td><td>I/O 7</td><td>I/O 2</td><td>I/O 1</td></tr><tr><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td></tr></table>	I/O 6	I/O 5	I/O 4	I/O 3	I/O 8	I/O 7	I/O 2	I/O 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	
I/O 6	I/O 5	I/O 4	I/O 3	I/O 8	I/O 7	I/O 2	I/O 1												
0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1												
IO direction	1	Indicate the direction In/Out of each pin. One bit per pin with '0' for input and '1' for output <table><tr><td>I/O 6</td><td>I/O 5</td><td>I/O 4</td><td>I/O 3</td><td>I/O 8</td><td>I/O 7</td><td>I/O 2</td><td>I/O 1</td></tr><tr><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td><td>0 or 1</td></tr></table>	I/O 6	I/O 5	I/O 4	I/O 3	I/O 8	I/O 7	I/O 2	I/O 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	
I/O 6	I/O 5	I/O 4	I/O 3	I/O 8	I/O 7	I/O 2	I/O 1												
0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1												
PWM input value	4	Timing values read on the PWM input: the 2 first bytes (LSB first) are the up signal duration while the 2 last bytes are the down level duration. TBD																	
Analog input values	6	10 bits ADC value sampled from each of the 3 analog inputs. The first value is for J17 then J21 and the last one is for J22. All 10 bits values are written with 2 bytes LSB first <table><tr><td>I/O 1</td><td>I/O 3</td><td>I/O 4</td></tr><tr><td>value (2 Bytes)</td><td>value (2 Bytes)</td><td>value (2 Bytes)</td></tr></table>	I/O 1	I/O 3	I/O 4	value (2 Bytes)	value (2 Bytes)	value (2 Bytes)											
I/O 1	I/O 3	I/O 4																	
value (2 Bytes)	value (2 Bytes)	value (2 Bytes)																	
Timer	1	When enable (see S241 register) this is the period of IO send given in second.																	
Option	1	This byte is reserved and should be ignored.																	
<CR>	1	All telemetry frames ends by carriage return																	

▪ **Analog inputs**

3 analog inputs are available on J17, J21 and J22. The ADC use a successive approximation register (SAR) architecture with 15 μ s sample & hold and 10 bits resolution. To use the analog inputs, the corresponding pin should set as input by S260 register. A read request (command 0x02) return all telemetry values of a module including the ADC values. When a pin is set as output, the returned value is zero. For the inputs, the range is from 0x0000 to 0x03FF corresponding to 0V up to V_{CC} .

▪ **PWM input**

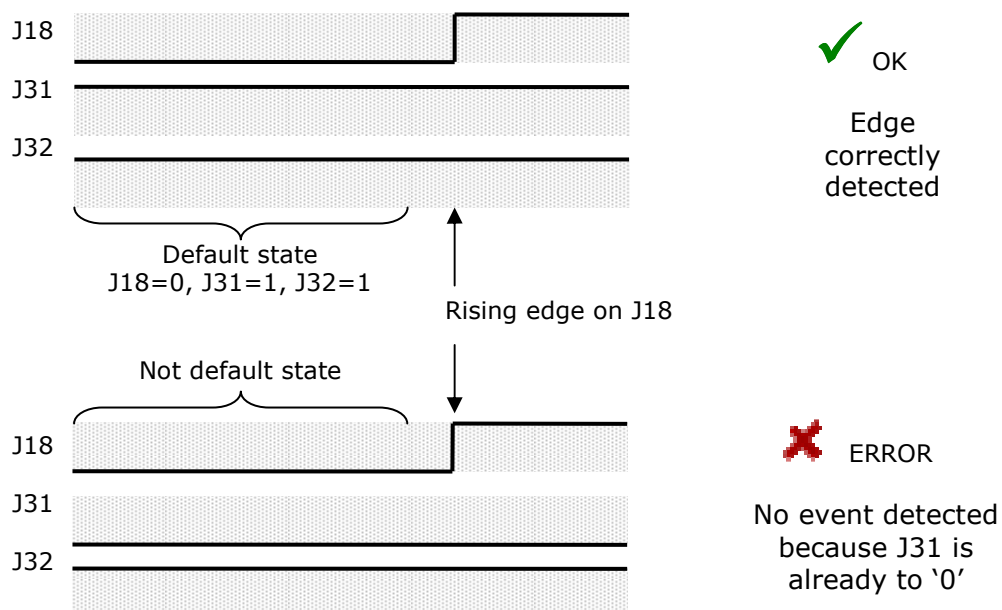
J31 is PWM input capable. To use it, the direction should be set as input using S260 register. A reading is performed by requesting a read command (0x02) to the desired module (local or remote). The returned values are the up level and down level duration. **TBD**

▪ **Interruptible inputs**

3 pins (J18, J31 and J32) are interruptible. To use it, the desired pins should be declared as input via S260 register and the interrupt should be activated via S262 register.

When enabled, an edge event on those pins automatically sends a telemetry frame to the default client chosen in S258 register. The frame sent is the same as the one returned after a reading request. If the module is in stand-by mode when the edge occurs, the module first wakes up and then sends the telemetry frame.

NB: J18 is sensitive to rising edge only while J31 and J32 are waiting for falling edge. If more than one interrupt pin is activated, an edge event is detected only if the default state is broken as shown below. Assuming the 3 interrupt pins are activated (S262=0xC2):



▪ **PWM output**

J20 can be set as a PWM output configuring S263=8. The PWM frequency is 10 KHz with 8 bits resolution for duty cycle. The duty cycle is change by sending a PWM write order (command 0x04) to the desired module with the new value to reach. Value is from 0x00 to 0xFF corresponding to constant '0' to permanent '1' respectively.

A start value for PWM output can be saved in S266 register. This value is affected to the PWM output immediately after startup.

▪ **IO Copy**

"Telemetry" is the action to read or set I/O of a remote module by sending orders from an intelligent part like PC or automate.

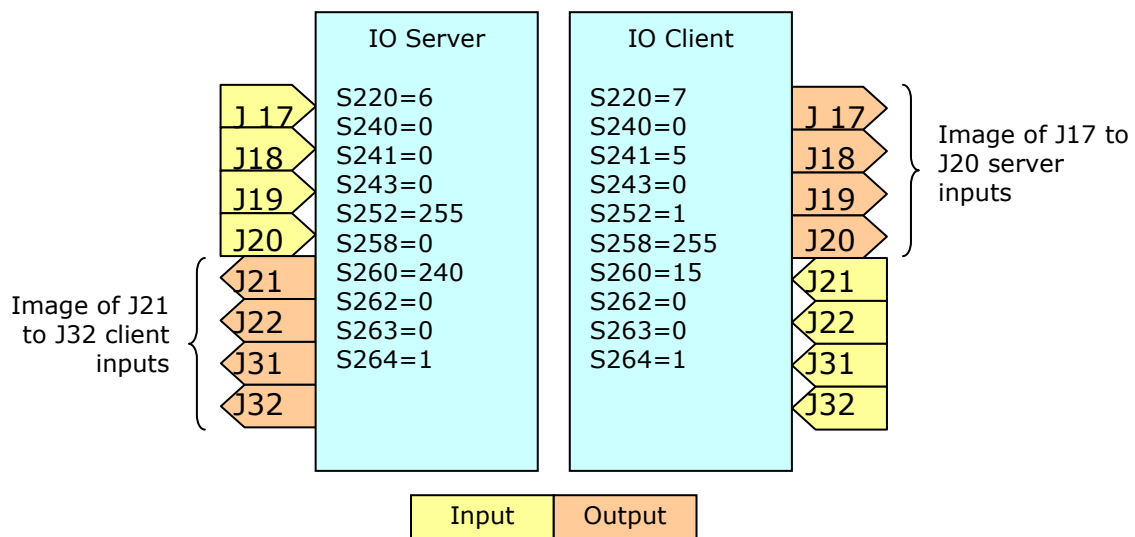
"IO Copy" is the capacity to automatically set the outputs of a module according to the inputs of a remote module and vice versa. In this case, the modules are autonomous without the need of a controller.

The IO Copy can be used either in point to point architecture or in a star network. In all cases, IO copy requires the use of one IO server (S220=6) and one or more IO client (S220=7).

Each client sends periodically its input values to the server (specified in S258 register) and wait for server input values coming back to update its local outputs.

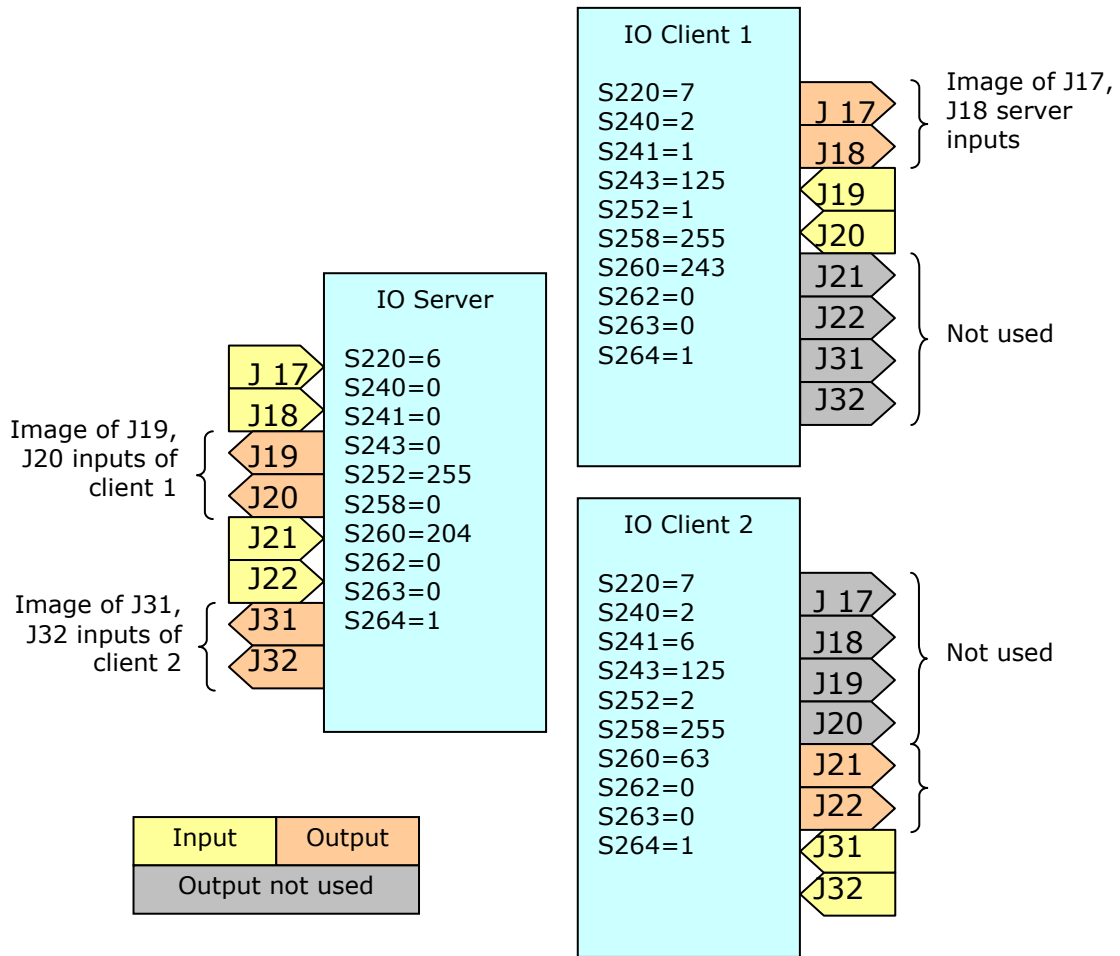
The update period is chosen by S241 register from 1 to 250 seconds and can be different for each client. Between 2 updates, a client can go in stand-by mode to save power.

All communications are performed by client, the server only answers to client requests. This operating mode allows clients to be very low power while only the master needs to be permanently powered. If a lot of clients are used with short update period, it is strongly recommended to use LBT to avoid radio collision (see S226 register).

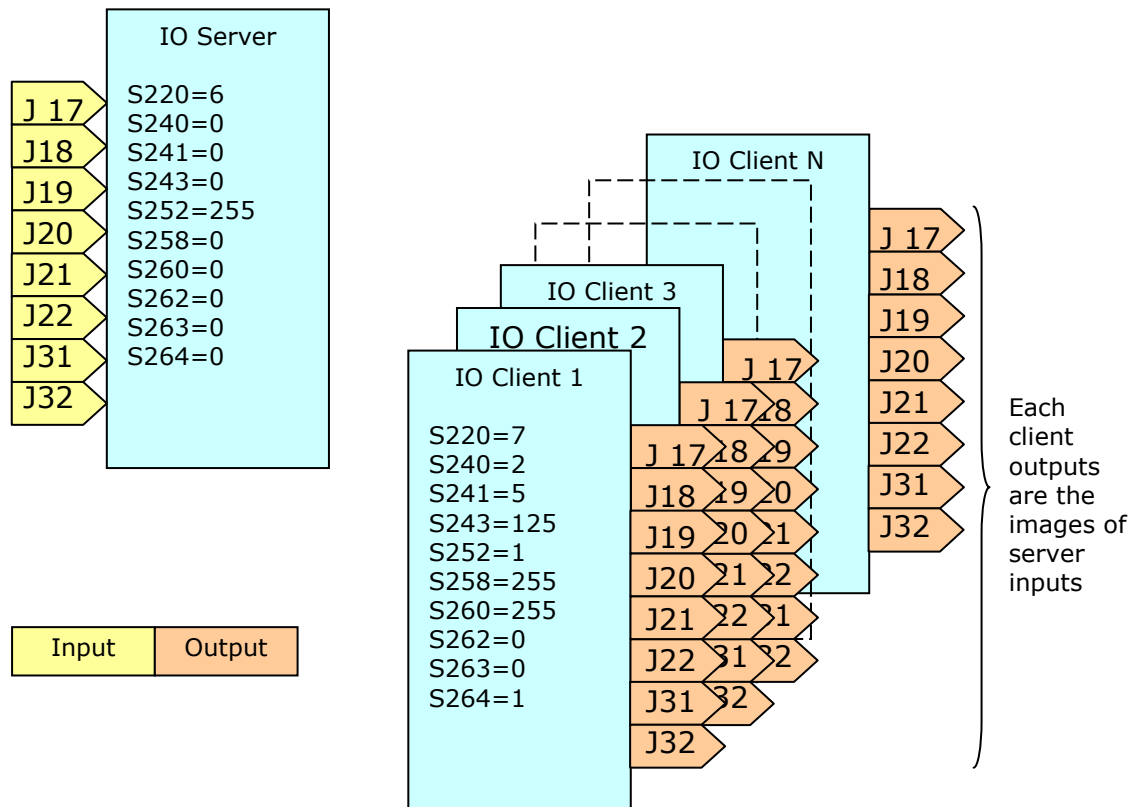


Example 1:

IO copy in point to point architecture with 4 ports copied from server to client and 4 ports copied from client to server with one refresh every 5 seconds.

**Example 2:**

IO copy with Star architecture with 2 ports copied from server to each client and 2 ports copied from each client to server. Low power is activated on both clients with one refresh each second on Client 1 and every 6 seconds on Client 2.



Example 3:

IO copy with Star architecture with server inputs copied to N clients outputs.

If refresh time is critical to update outputs of the server according to the inputs of a client, it is possible to use the interrupt functionality. In this case, an edged occurring on the client input will immediately trigs the send of an update frame to the server without waiting the next refresh period.

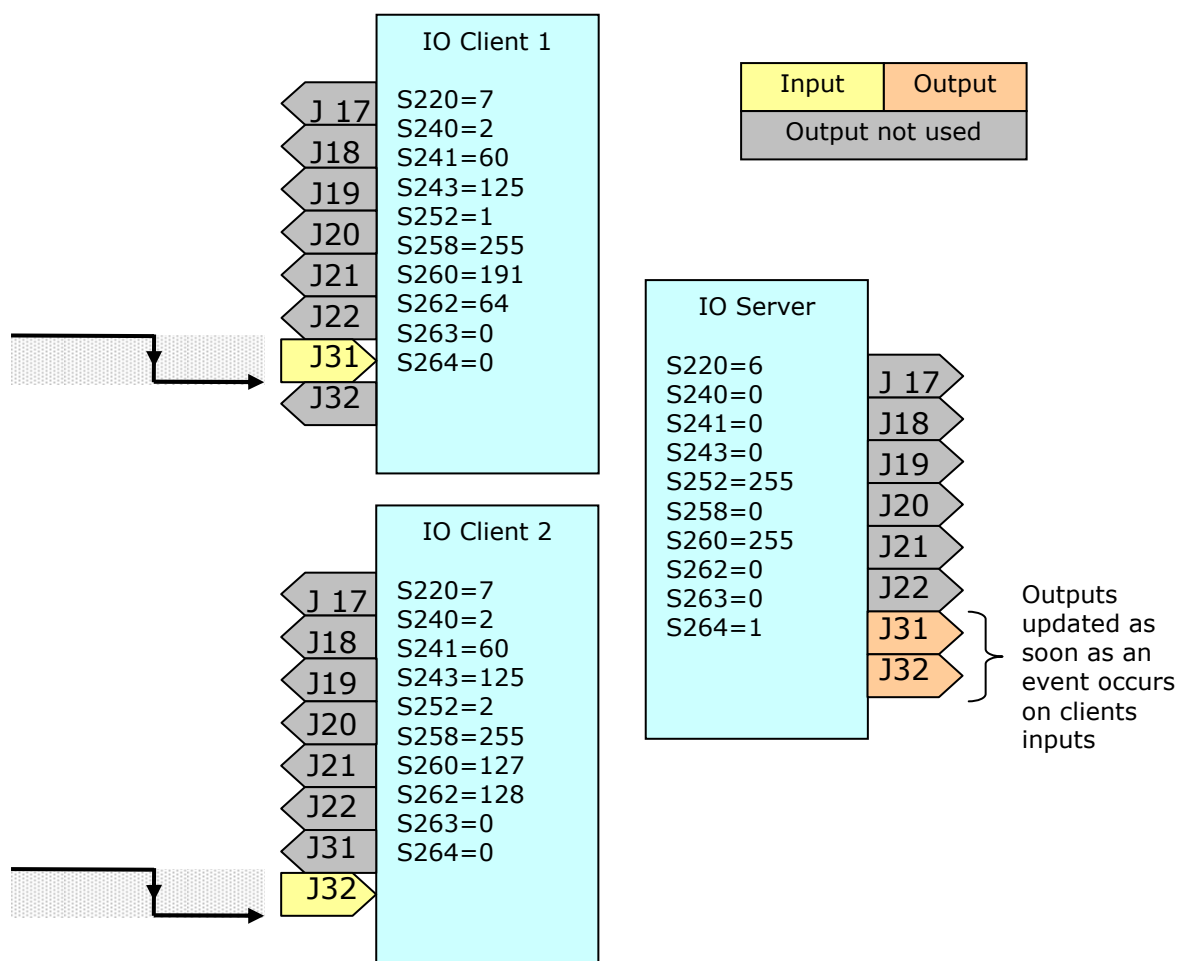
Finally, it is possible to detect a link failure in small network up to 8 clients. Clients should be numbered from 1 to 8. When a client sends its inputs values, the frame also contain the timer period in second. The server records this period for each of the first 8 clients. When message is no more received from a client during the specified period + 2 seconds, the master indicates the failure writing 'ERROR<CR>' on its serial link and rising edge on ACK_TX signal (pin J24).

Combining the two previous functionalities:

- The consumption is very low,
- The server outputs are refreshed immediately in case of an edge occurring on a client,
- The radio link and client operation are checked periodically.

This configuration is ideal for wireless alarm sensor as exposed in example 4.

More over, if it is not necessary to know on which client the edge occurred, it is possible to install up to 8 clients, all with J32 as interrupt input activated. In this case, the J32 server output will fall down as soon as an event occurs on one of the 8 clients.

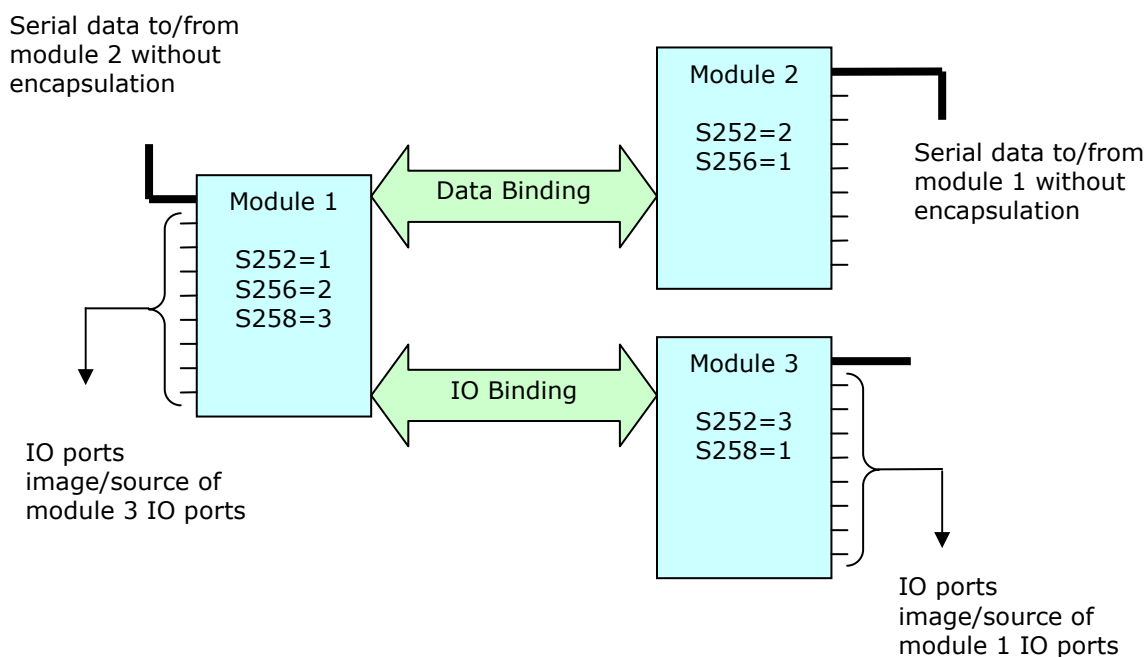
**Example 4:*****Low power and fast response time.******Two very low power clients sends their values only once every minute but can send immediately a frame in case of falling edge.***

▪ **Bindings**

A binding is a virtual link between two modules to simulate a point to point communication even if these modules are included in a bigger network. The advantage is that no more encapsulation is needed to send data between the two modules.

In telemetry protocol, it is possible to set two different bindings for data and telemetry frames. The default data client is chosen in S256 register while the default telemetry client is chosen in S258. In this case all telemetry actions such as IO copy are routed to a client while all data frames are routed to another client without any ID nor encapsulation consideration during use.

Note: if a data binding is set (S256≠0) no more telemetry order can be sent via the serial link; a data binded module consider all serial frames as data to be sent to the default recipient.



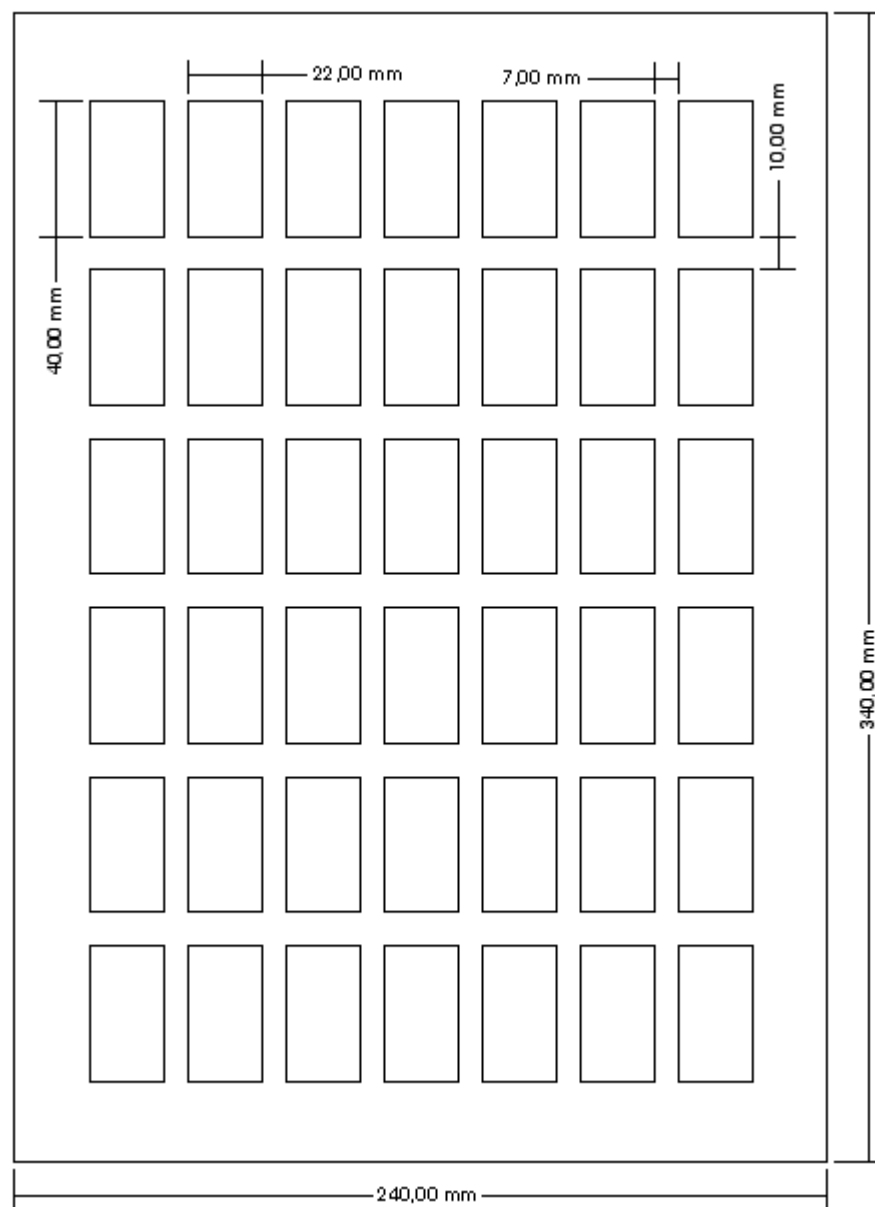
Independent data and telemetry bindings

CHAPTER VII.

PROCESS INFORMATION

VII.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.

VII.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.

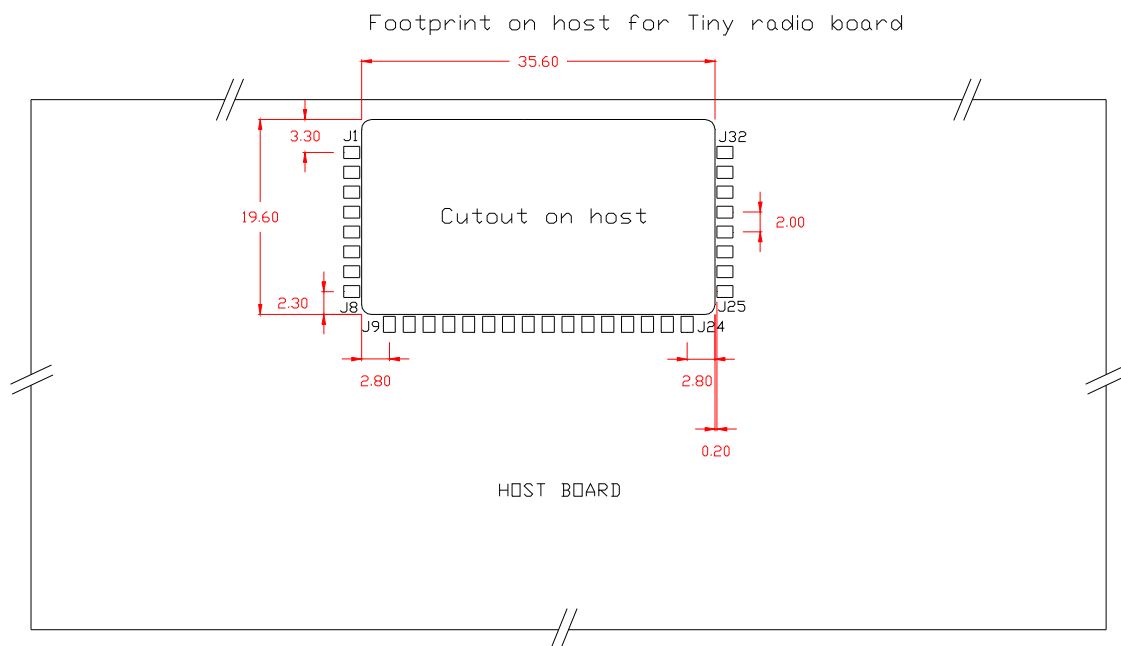
In case of a reflow soldering process, tiny radio modules must be submitted to a drying bake at +60°C during 24 hours. The drying bake must be used prior to the reflow soldering process in order to prevent a popcorn effect. After being submitted to the drying bake, tiny modules must be soldered on host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

VII.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:

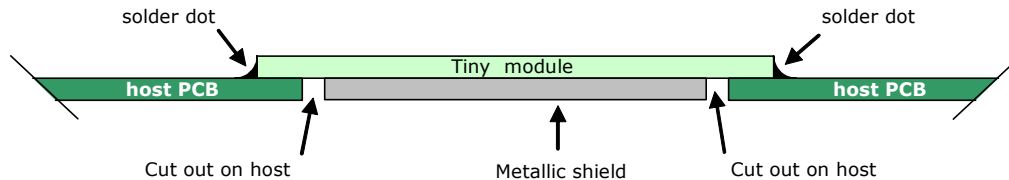


□ Dimension PAD : 1.6mm x 1.2mm

VII.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:



VII.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

VII.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 VIII. BOARD MOUNTING RECOMMENDATION

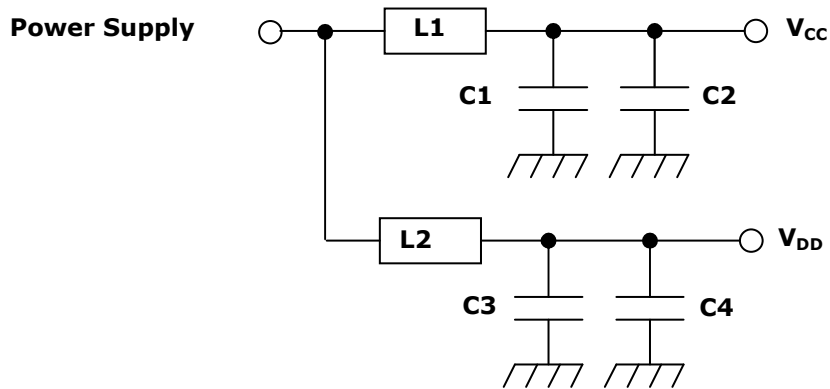
VIII.1. Electrical environment

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.
-

VIII.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 ($< 0.10\Omega$).

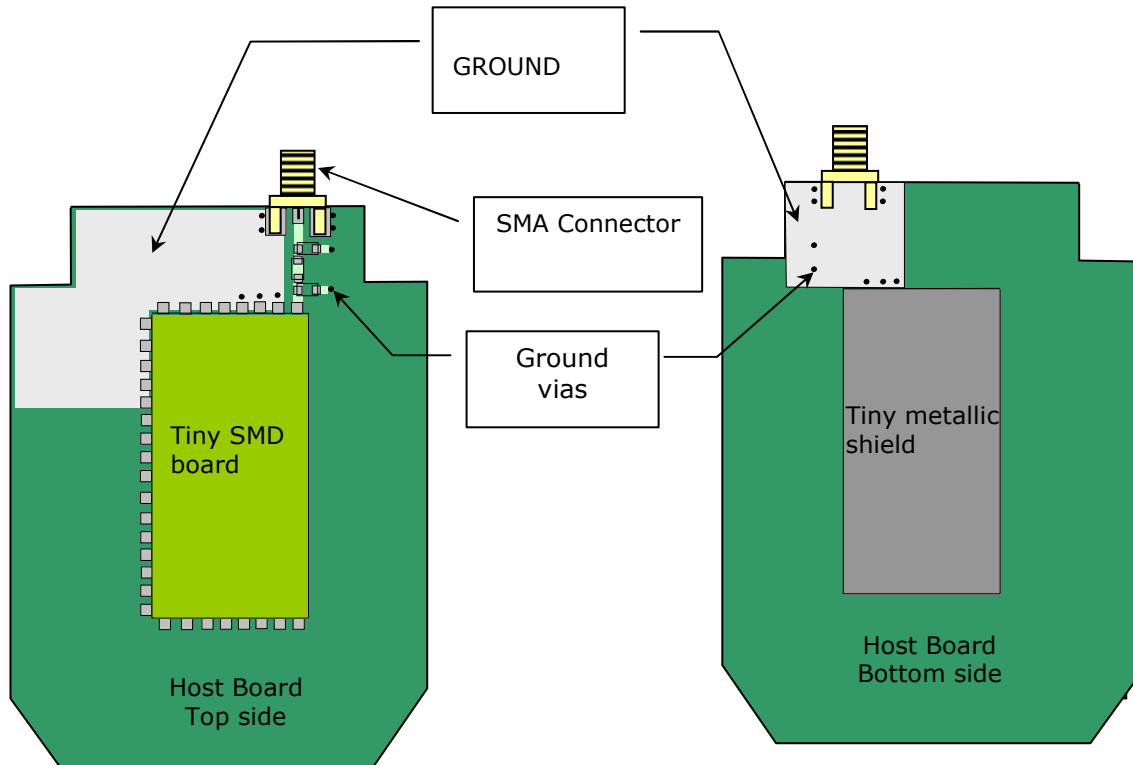
Symbols	Reference	Value	Manufacturer
L1	LQH32CN1R0M33L	1 μ H	Murata
L2	LQH31MN1R0K03	1 μ H	Murata
C1, C3	GRM31CF51A226ZE01	22 μ F	Murata
C2, C4	Ceramic CMS 25V	100nF	Multiple

VIII.3. RF layout considerations

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

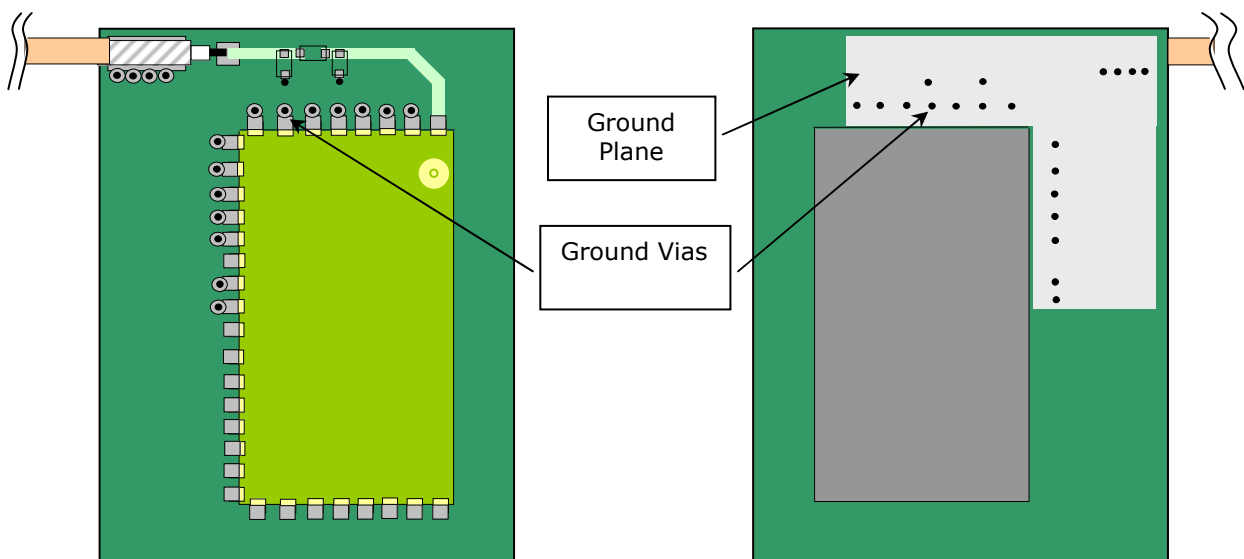
- It is recommended to fill all unused PCB area around the module with ground plane.
- The radio module ground boundaries must be connected to a ground plane.

Layout VIII.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.

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



CHAPTER IX.

ANTENNA CONSIDERATIONS

IX.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 Telit.

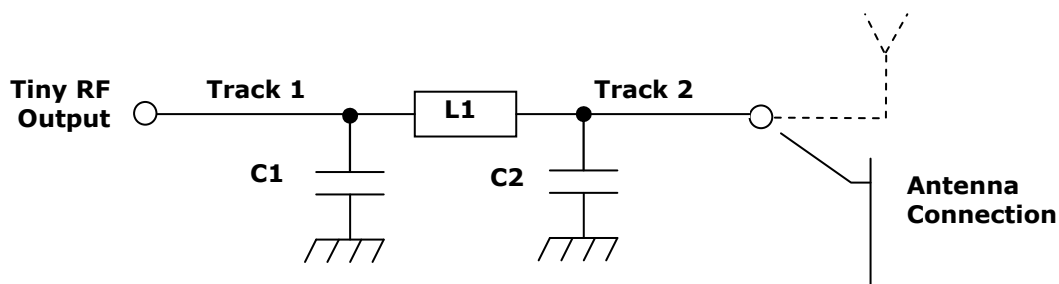
IX.2. Antenna Specifications

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

IX.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	-	These values must be measured and optimized with a Network Analyzer.
C1, C2	Capacitor	0603	-	
Track 1, Track 2	50Ohms 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		
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 required, this network can be used to improve harmonics filtering by using the default values:

Symbols	Reference	Package	Value
L1	Coil	0603	8.2nH
C1, C2	Capacitor	0603	3.3pF

See the layouts §VIII.3 to have an idea of the antenna matching implantation :

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

IX.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)

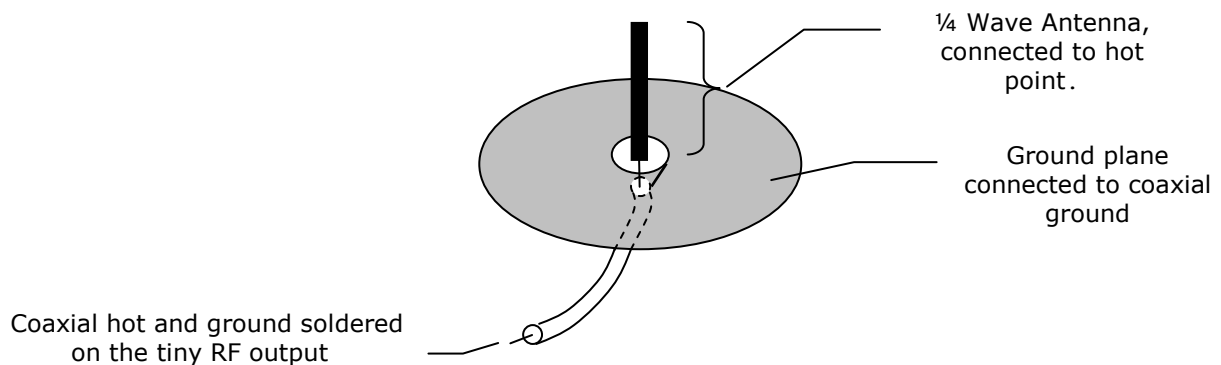
IX.5. External antenna

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!

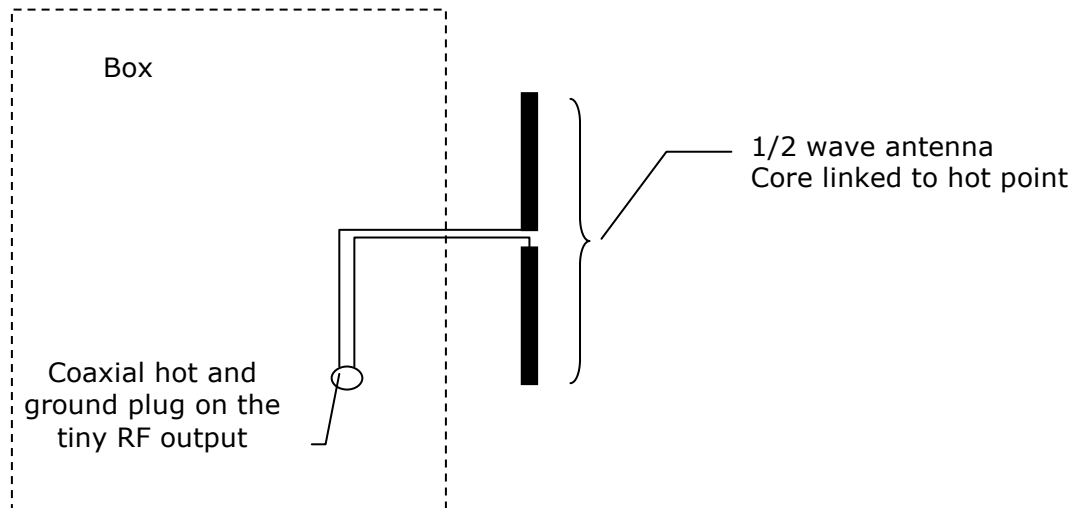
The installation directives are the following:

- 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.

IX.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.

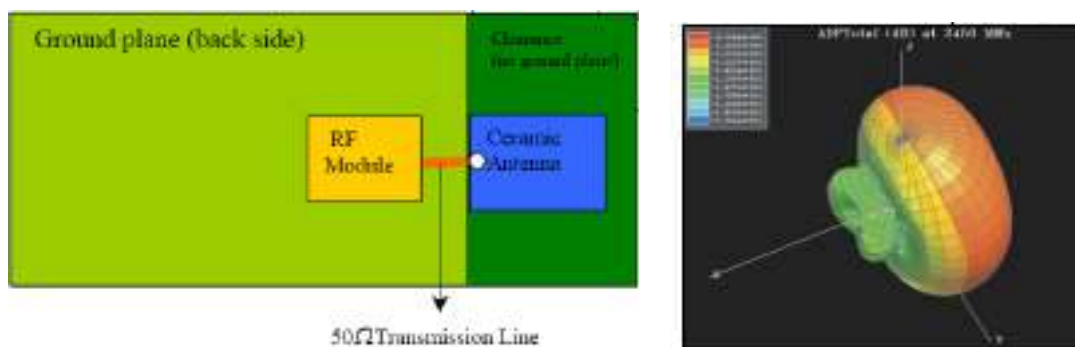
▪ **Basic recommendations:**

- 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 X.

ANNEXES

X.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.

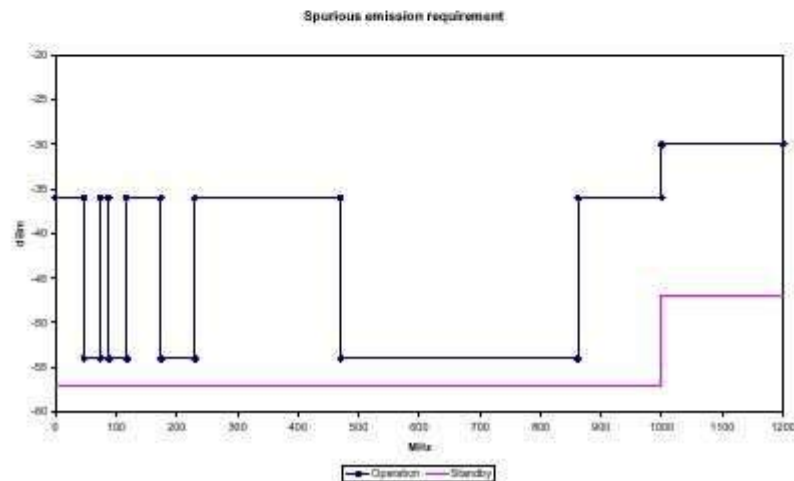
Spurious emission (section 8.7)

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



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.

X.2. Examples of propagation attenuation

Factor	433 MHz		868 MHz		2.4 GHz	
	Loss	Attenuation	Loss	Attenuation	Loss	Attenuation
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.

X.3. Declaration of Conformity

		DECLARATION OF CONFORMITY
TinyOne Pro 868MHz RF Module		
Company:	ONE RF TECHNOLOGY SAS	
Address:	Emerald Square – Bât.D Rue Evariste Galois 06410 Sophia-Antipolis FRANCE	
Contact:	Eric LAGORCE, C.O.O	
<i>Declares that the radio equipment</i>		
Brand :	TinyOne Pro 868MHz RF Module	
Designation :	B868-tiny-pro/40-SMD-WA (ref. 105.000.188) B868-tiny-pro/40-DIP-WA (ref. 105.000.189)	
Type :	Radio module for wireless data transmission	
Antenna Restrictions :	Only antenna with maximum gain of 0dBi are allowed to use	
<i>Conforms to the Recommendation 1999/5/EC and 1999/519/EC</i>		
<ul style="list-style-type: none"> Article 3.1a (Electrical Safety and Health protection): conformity is proven by compliance to harmonised standard EN 60950 -1/A11 and EN 50371 Article 3.1b (Electromagnetic Compatibility): conformity is proven by compliance to the standard EN 301489 -3 Version 1.4.1 Article 3.2 (Radio Spectrum): conformity is proven by compliance to the standard EN 300220 -2 Version 2.1.1 		
<i>Restrictions</i>		
CE marking applies only to End Products. Because this equipment is only a subassembly, compliance tests have been realized with One RF Technology modem. Manufacturer of End Products, based on such a solution, has to insure full conformity to be able to CE label marking.		
<p>Sophia-Antipolis, 25th of September 2007</p> <p>Eric LAGORCE / C.O.O.</p> 		