PE868-25mW RF Module

User guide version V1.6
Software version V1.0.6

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Information

Document information	
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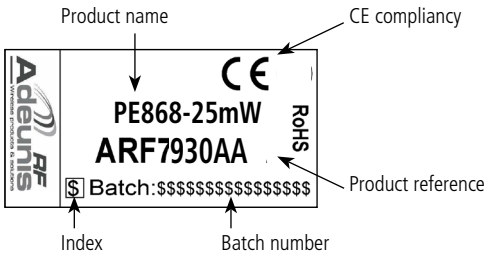
This document applies to the following products

Name	Reference	Firmware version
PE868-25mW	ARF7930AA	PE_AA_1.0.0_AA_A_1.0.6

Labelling



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Website

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Email

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Helpful Information when Contacting Technical Support

When contacting Technical Support please have the following information ready:

- Complete product type & reference (e.g. RF module PE868-25mW - ARF7930AA),
- Firmware version (e.g. PE_AA_V100_AA_A_101)
- Clear description of your question or the problem
- A short description of the application
- Your complete contact details

REGULATORY CONSIDERATIONS

DECLARATION OF CONFORMITY

PE868-25mw MHz RF module

We ADEUNIS RF
283 rue LOUIS NEEL
38920 CROLLES FRANCE

declare under our own responsibility that the products

Name PE868-25mW RF module
Reference ARF7930AA

to which this declaration refers conforms with the relevant standards or other standardising documents:

- EN 300 220-2 (V2.3.1) (2010-02)
- EN 60950-1 (2001) + A11 (2004)
- EN62311 (2008)
- EN301 489-1 (v1.8.1) (2008-04)
- EN 301 489-3 (v1.4.1) (2002-08)

According to the RTTE Directive 99/5/EC

Notes:

- According to the 1999/519/EC «RF signal» recommendations, a minimum distance of 10cm between the product and the body is required.
- Receiver class (if applicable): 2

- Usage restrictions : It is the user responsibility to be sure that the configuration and use of the PE868 module fulfill all the requirements of Rec 70-03 (describing in annex 1, frequency bands, g, g1, g2, g3 or g4) . In certain cases, you may need to notify the final equipment to European administrations. Adeunis RF can assist you on regulatory aspects

Crolles, Septembre 1st, 2014 VINCENT Hervé - CEO

Table of contents

INTRODUCTION

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Environmental recommendations

All superfluous packaging materials have been eliminated. We have done everything possible to make it easy to separate the packaging into three types of materials: cardboard (box), expanded polystyrene (filler material) and polyethylene (packets, foam protective sheets). Your device is composed of materials that can be recycled and reused if it is dismantled by a specialist company. Please observe local regulations concerning the manner in which waste packaging material, used batteries and your obsolete equipment are disposed of.

Warnings

Valid for PE868-25mW modules with the following references: ARF7930AA

Read the instructions in the manual.

The safety of this product is only guaranteed when it is used in accordance with its purpose.
Maintenance should only be carried out by qualified persons.

Please note, do not install the equipment close to a heat source or in damp conditions.

Please note: for your own safety, you must ensure that the equipment is switched off before carrying out any work on it.

Please note: For your safety, the power supply circuit must be SELV (Safety Extra Low Voltage) and must be a limited power sources.

Recommendations regarding use

- Before using the system, check that the power supply voltage shown in the user manual corresponds to your supply. If it doesn't, please consult your supplier.
- Place the device against a flat, firm and stable surface.
- The device must be installed in a location that is sufficiently ventilated so that there is no risk of internal heating and it must not be covered with objects such as newspapers, cloths, curtains, etc.
- The device's aerial must be free and at least 10 cm away from any conducting material.

- The device must never be exposed to heat sources such as heating equipment.
- Do not place the device close to objects with naked flames such as lit candles, blowtorches, etc.
- The device must not be exposed to aggressive chemical agents or solvents likely to damage the plastic or corrode the metal parts.
- Install your device close to its DC power supply.

Disposal of waste by users in private households within the European Union

This symbol on the product or on its packaging indicates that this product must not be disposed off with your other household waste. Instead, it is your responsibility to dispose of your waste by taking it to a collection point designated for the recycling of electrical and electronic appliances. Separate collection and recycling of your waste at the time of disposal will contribute to conserving natural resources and guarantee recycling that respects the environment and human health. For further information concerning your nearest recycling centre, please contact your nearest local authority/town hall offices, your household waste collection company or the shop where you bought the product.

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Gültig für die Relaisempfänger mit den Artikelnummern : ARF7930AA

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Die durch dieses Produkt gewährte Sicherheit kann nur bei einer Anwendung entsprechend dem vorgesehenen Einsatzzweck gewährleistet werden.

Achtung ! Zu Ihrer eigenen Sicherheit ist es unerlässlich, das Gerät vor jedem technischen Eingriff spannungsfrei zu schalten.

Achtung ! Zu Ihrer eigenen Sicherheit die Stromversorgung Schaltung muss SELV (Safety Extra Low Voltage) sein und muss der begrenzten Stromquellen sein.

Empfehlungen für den Einsatz

- Vor dem Einsatz des Systems müssen Sie überprüfen, dass die in der Bedienungsanleitung angegebene Anschlussspannung den Werten Ihrer Stromversorgung entspricht. Anderenfalls wenden Sie sich bitte an Ihren Lieferanten.
- Stellen Sie das Gerät auf einer ebenen, festen und stabilen Fläche auf.
- Um jede Gefahr einer inneren Erwärmung des Gerätes zu vermeiden, ist dieses an einem gut belüfteten Ort aufzustellen und darauf zu achten, dass keine Gegenstände wie Zeitschriften, Matten, Vorhänge u. a. darauf abgelegt werden.
- Die Antenne des Gerätes muss frei liegen und von jeglichen leitenden Werkstoffen mindestens 10 cm entfernt sein.
- Das Gerät darf niemals der Einwirkung von Wärmequellen oder Heizgeräten ausgesetzt sein.
- Das Gerät darf sich niemals in der Nähe von Gegenständen mit offener Flamme befinden, wie brennenden Kerzen, Schweißbrennern usw.
- Das Gerät darf niemals der Einwirkung von aggressiven Chemikalien oder Lösemittel ausgesetzt werden, die geeignet sein könnten, den Kunststoff zu beschädigen oder die Metallteile zu korrodieren.
- Stellen Sie Ihr Gerät in der Nähe der Quelle seiner Spannungsversorgung DC auf.

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1. Modules overview

1.1. Adeunis RF concept

The idea is to provide the user with a module which is ready for sending and receiving data over a radio link thus enabling the user to focus on the development of its application. The aim is to relieve the user of having to deal with the complex radio management.

This specific range of Narrow Band modules has been created to provide extra longe range «point-to-point» transmissions on unlicensed frequency bands and the use of multiple modules in the same environment at maximum power.

1.2. Module functionality

The module consists in a bidirectional RF transceiver implementing an RF-UART gateway. Basically, data sent to the module on its UART interface are transmitted on the air and vis versa.
The module is build around two main components:

- The "Digital" block and «radio» block based on a Silabs Si1002 chip combined to an optimized RF front-end.

The radio block handle RF modulation and demodulation while the digital block drives the radio engine and offers a simplified end user interface with a large panel of functionalities.

The following embedded features are available:

- Programmable RF data rate
- Programmable UART data rate with optional Flow control
- Programmable RF output power
- Large set of RF channels allowing multiple different system to communicate in the same environment
- Embedded protocol for point to point and point to multi-point communication with "Transparent" and "addressing" mode
- Optional control of RF data integrity by CRC
- "WAKEUP mode" for saving energy when radio transmission is not required

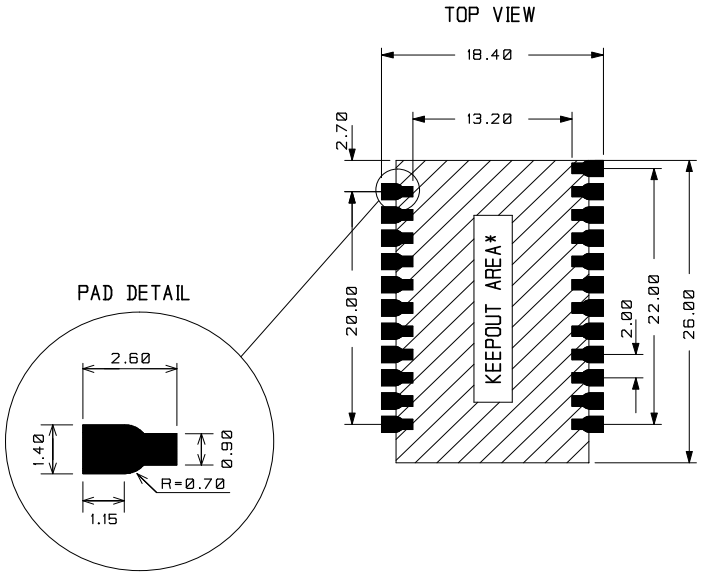
1.3. PE868-25mW Technical specifications

Technical specifications	
Communication	Point-to-point / Point-to-multipoint
Module configuration	Through AT commands
Radio data rate	4.8, 9.6, 38.4 and 115.2 kbps
UART data rate	1.2, 2.4, 4.8, 9.6, 19.2, 38.4, 57.6 and 115.2 kbauds
UART TTL port	TxD - RxD - RTS
Adressing mode	Transparent / Addressed or Repeater
Frequencies	863-870 MHz
Programmable RF output power	Up to 25 mW (14 dBm)
Sensitivity	Down to -117 dBm @ $BER10^{-3}$ (data rate 4.8kbps)
Operating range (open space)	External antenna: up to 2 km
Operating voltage	2v to 3,6v (3,3v nominal)
Tx/Rx consumption (maxi)/Sleep	37mA / 22mA / < 1µA
Operating temperature	-40°C / +85°C
Dimensions	26x 16 x 2.8mm

2. Main characterictics

2.1. Form factor and footprint

Footprint of the module



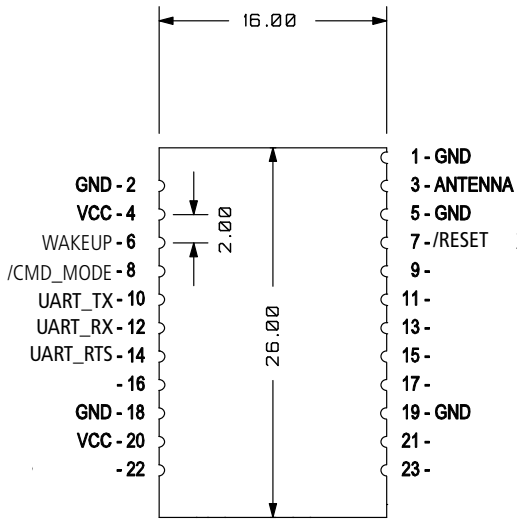
* KEEPOUT AREA : 26 x 16mm (ie the whole bottom of the module)

* NO COPPER AND TRACKS UNDER THE MODULE

Note : dxf and gerber files are available on request

2.2. Pins description

2.2.1 Pinout of the module



2.2.2 Pin configuration

Pin module	Pin name	I/O (1)	Description
1	GND		**Ground** (2)
2	GND		**Ground** (2)
3	ANTENNA		**RF output** Must be adapted with 50 ohms matching
4	VCC		**Supply voltage** (2)
5	GND		Ground (2)
6	/WAKEUP	I Internal pull-up	Apply a high level to enter WAKEUP mode if S232 = 1 or S232=2 Pay attention, if S232=1 or S232=2 and WAKEUP pin left unconnected, the module is in sleep mode
7	/RESET	I	Low pulse to reset the module. May be left unconnected
8	/CMD_MODE	I Internal pull-up	Command mode Should be connected to the host controller, may be left unconnected if command mode not used. Apply a low level to enter command mode
9			(3)
10	UART_TX	O	**Data output** Must be connected to the host controller
11			(3)
12	UART_RX	I Internal pull-up	**Data input** Must be connected to the host controller.
13			(3)
14	UART_RTS	0	**UART flow control** Must be connected to the host controller if hardware flow control is used, must be left unconnected if not used
15			(3)
16			(3)
17			(3)
18	GND		**Ground** (2)
19	GND		**Ground** (2)
20	VCC		**Supply voltage** (2)
21			(3)
22			(3)
23			(3)

(1) Described from the module point of vue (I : Is an input of the module, O is an output of the module) - The internal resistance is between 30Ko and 60Ko, typical 45Ko
(2) All GND and VCC pins must be connected
(3) Must be left unconnected

2.3. Electrical & Radio characteristics

2.3.1 Absolute maximum ratings

Parameter	Conditions	Min	Typ	Max	Units
Voltage on any GPIOs Pin	Vcc > 2.2 V	-0.3		Vcc+0.3	V
	Vcc<2.2	-0.3		Vcc+0.3	V
Vcc		-0.3		3.6	V
RF input Power				10	dBm
Storage Temperature Range		-55		+125	°C

Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the module.

2.3.2 Global Electrical Characteristics

Parameter	Conditions	Min	Typ	Max	Units
Vcc		2V	2.4	3.6	V
Specified Operating Temperature Range		-30		70	°C

2.3.3 IOs Electrical Characteristics

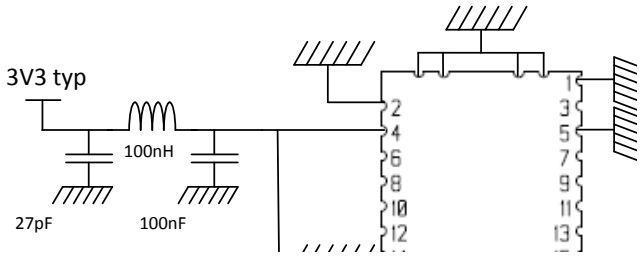
Parameter	Conditions	Min	Typ	Max	Units
Input High Voltage	VCC= 2.0 to 3.6 V	VCC – 0.6			V
Input Low Voltage	VCC = 2.0 to 3.6 V			0,6	V
Output High Voltage	IOH = –1 mA	Vcc – 0.7			V
Output Low Voltage	IOL = 1.4 mA			0.6	V
Input Leakage Current	Weak Pullup On, VIN = 0 V, Vcc = 1.8V		4		µA
	Weak Pullup On, Vin = 0 V, Vcc = 3.6 V		20	30	µA
Vcc Ramp Time for Power On	From 0V to 0,9Vmin			3	ms
Minimum RST Low Time to Generate a System Reset		15			µS
Reset Time Delay	Delay between release of any reset source and code execution		10		µS
Sleep Mode Wake-up Time		10	26		µS
CMD_MODE Time			500		µS
Power ON reset time		16	20		ms
Rise Time	0.1 x VCC to 0.9 x VCC, CL= 5 pF			8	ns
Fall Time	0.9 x VCC to 0.1 x VCC, CL= 5 pF			8	ns
Input Capacitance				1	pF
	0V < Vin < Vcc				
Weak Pull up activated	5			25	µA
Internal Weak Pull up resistor			220		KOhms

(*) Consumption measured in conducted mode.

2.4. Power supply

The module power supply is made between the VCC pin (pins 4 and 20) and GND and must be between 2V and 3.6 V, 3.3 V typical.
As described in the diagram below, we suggest adding a filter cell on the module voltage power supply pin (Vcc).
Each «GND» must be connected by vias to the ground plane of the motherboard (with the shortest distance). The unnumbered «GND» located at the ends of the module are not required but are recommended for maximum receiver sensitivity.

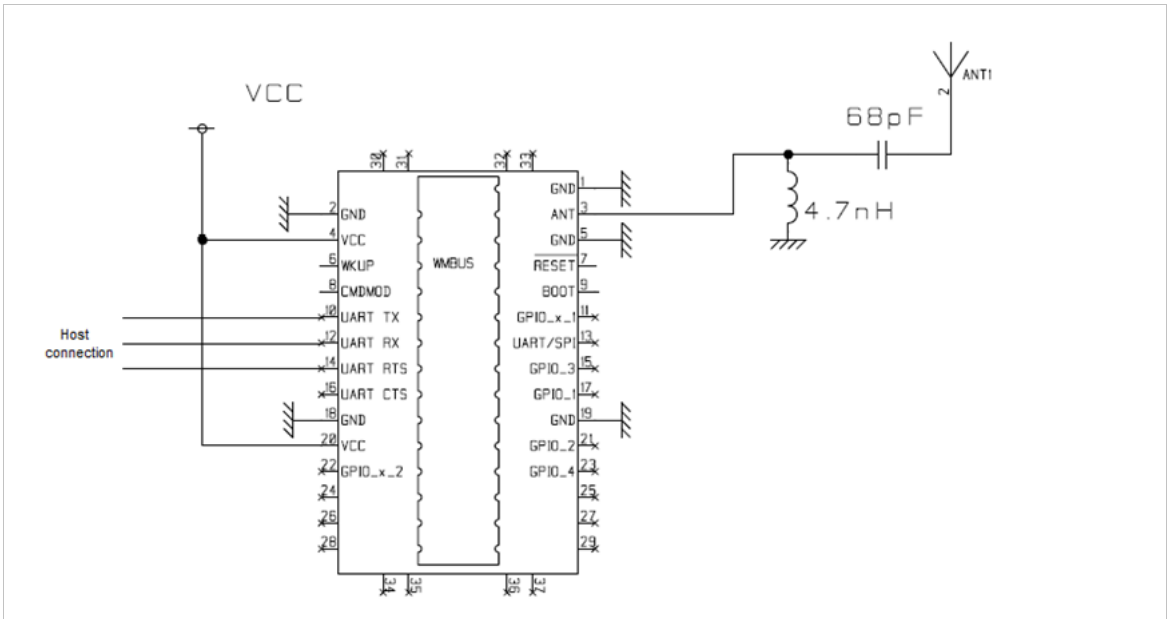
- If used, the100nH inductor will have a resonant frequency> 1GHz in order to be effective at 869MHz, frequency band of the PE868 module
- The design of the power supply must be able to provide a current up to 50mA, corresponding to the maximum consumption of the module transmitting at maximum power.



2.5. Recommended design

ADEUNIS RF will assist you in your choice of antennas so as to optimize the performance of your products. Feel free to contact us for more information. We suggest the schematic below:

- The footprint of the inductor and capacitor are useful to ensure good impedance matching between antenna and modules. The values will depend on the working RF frequency and characteristics of the antenna.
- The SMA connector can be bent or straight depending on the selected antenna but is not essential. We could very well consider 8.6 cm welded wire antennas directly on the PCB either horizontally or vertically. However and wherever possible, it is interesting to keep the footprint of SMAs as to facilitate the development for the degrees of freedom offered an application point of view (offset antenna, etc ...). We would offer the antennas associated with these connectors.
- For a quick set-up, we recommend not to get the self, to install the capacitor to 27 pF (or replace it by a short circuit or a 0 ohm resistor) and solder a 8.6 cm length wire behind the capacitor.



3. Communication mode

The RTU module is ready for transmission and reception operations at first power-up without any configuration effort required. It starts in communication mode allowing to directly sends and receive data. The default UART configuration is set to 9600bps, 8 data bits, 1 stop bit and no parity.

By default, the module is permanently listening the RF interface and the UART port.

- When an incoming frame is demodulated on the RF interface, the data payload of the frame is transmitted on the UART port.
- When an incoming data is detected on the UART port, it is modulated into a frame on the RF interface.

3.1. UART interface

3.1.1 UART settings

The UART port of the module is the main interface for the host controller.

The communication requires 10 bits for each byte to transmit, including one start bit followed by 8 data bits and then one stop bit. The Start bit value is the logical "0" while the stop is the logical "1" value. There is no parity bit in the transmission.

The data rate settings can be configured with the following rate: 1.2 / 2.4 / 4.8 / 9.6 / 19.2 / 38.4 / 57.6 / 115.2kbps using the S210 register.

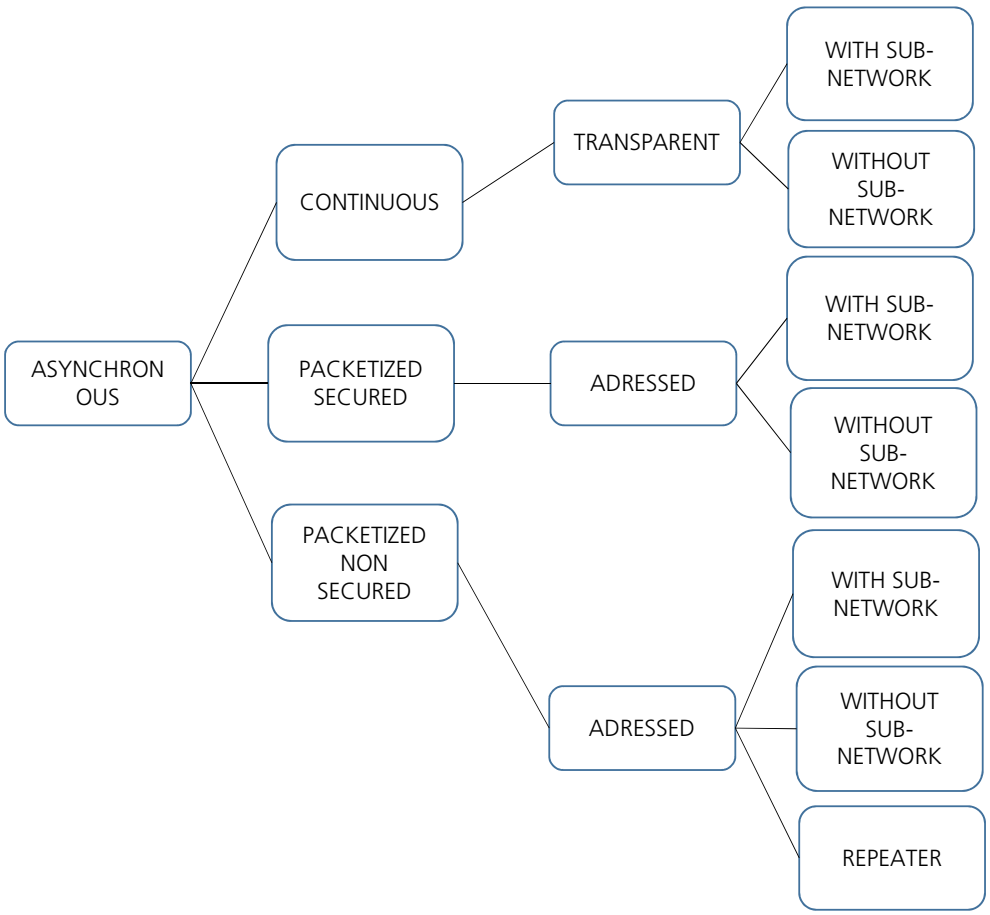
Please note that this UART port does not support electrical RS232 characteristics. An external RS232 driver has to be used if RS232 interface is required.

3.1.2 UART protocol

There is no specific protocol to respect for data transmission and reception. Each byte sent on the UART port is reported on the RF interface and vis versa.

3.2. Radio interface

Principal :



3.2.1 Packet protocol

3.2.1.1 Protocol description

PE868 module uses a packet oriented protocol on its RF interface. The data coming from the UART interface are accumulated in an internal fifo in the module and then encapsulated in an RF frame. The maximum amount of data that can be transferred into a single radio packet can reach 403 Bytes.

The maximum packet size can be set up in S218 register from 1 to 403 bytes. Each new packet introduces some latency in the transmission delay caused by the RF protocol overhead. The RF protocols encapsulate the data payload with the following elements:
- A preamble pattern required for receiver startup time
- A bit synchronization pattern to synchronize the receiver on the RF frame
- Other protocol field such as source address and destination address, payload length, optional CRC and internal packet type field.

The incoming fifo may accumulate up to 550 data byte. No more data has to be set in the fifo while a 550 bytes block of data has not been released by the radio transmission layer. To prevent from input fifo overrun, the hardware flow control may be activated. In this case, the RTS signal (pin 14 of the module) will be set when the incoming fifo is almost full to prevent the host controller from sending new data.

3.2.1.2 Non-secured Packet Protocol

In non-secured mode, each packet is transmitted without acknowledgment; The transmitter doesn't know if packet has been received.

3.2.1.3 Secured Packet protocol

In secured mode, each packet is transmitted and acknowledged by the receiver. If a packet isn't acknowledged, the module proceeds with two other attempts.
Following this sequence, the transmitter returns '>' if the packet has been received, or '#' if no acknowledgement has been received after the three attempts.
Importante note : the addressed mode must be activated in order to use the secured mode.

3.2.1.4 Transmission integrity control

The RF protocol includes a 16 bits CRC. Each data extracted from an RF packet with an invalid CRC is silently discarded by the module state machine. The CRC ensures that all the data received are valid.

3.2.1.5 Implementation

The Packet protocol is selected by the S222 register.
- Non-secured protocol : S222=0
- Secured protocol : S222=2

3.2.1.6 Transmission data path

In packetized mode, the packet size is specified through register S218.
The module starts the transmission of a complete packet when the number of data specified in S218 has been received.
If the number of data is inferior, an incomplete packet will be constituted when time out (specified in register S217) will be reached.

3.2.2 Continuous asynchronous protocol

Available in transparent mode only (S220=0)

3.2.2.1 Description of the protocol

The continuous asynchronous protocol enables data transfer from the UART interface to the radio link with the lowest possible latency. It is associated with radio modulations enabling a wide range of air data rate and ranges to be covered. This is the mode that will allow you to use the PE868 module to the maximum of its possibilities.

- In transmission, data entering on the UART is immediately transmitted into the "air".
- In reception, data from the RF frames is transmitted progressively to the UART interface.

There is no buffering of complete radio frames before or after transmission on the serial link.
However, the product has buffering enabling a buffer to be performed if the radio and UART data rates are different. The UART interface does not require a specific protocol. Each octet transmitted is transferred into the air and vice versa.
Thanks to its low latency and the absence of a protocol on the UART port, the PE868 module used with the continuous asynchronous protocol is completely transparent in the replacement of a wire link.

3.2.2.2 Transmission integrity control

By definition, the continuous protocol can not be cut. There is therefore neither CRC calculation nor control of data integrity.

3.2.2.3 Implementation

The continuous asynchronous protocol is selected by the S222 register.
It can use the following radio data rates: 4.8kbps, 9.6kbps, 38.4kbps and 115.2kbps. The adjustment of the radio data rate is done via the S254 register.

The notions of addressing (broadcast communication, group communication and addressed communication between products) are available and described below.

3.2.2.4 Transmission data path and latency

Transmission delay from one equipment to another will depend on different factor:
- The UART transmission rate of the transmitter
- The UART transmission rate of the receiver
- The radio transmission rate and the radio modulation used
- The radio protocol overhead (packet split, preamble, synchronization and other protocol fields)
- The input data fifo threshold and timeout

An RF transmission can starts according following evens :
- either a timeout (S217)
- or a quantity of data in the buffer memory (S218)

The first of these two limits reached triggers transmission start.
When the number of octets in the buffer memory reaches the threshold of register S218 before the timeout of register S217, it is triggering on data.

On the other hand, when the timeout of register S217 expires before the data in the buffer memory reach the threshold of register S218, it is triggering on time.

It should be noted that programming register S217 to 0 (no timeout) means that the S218 register threshold must be reached to start transmission.

3.3. Addressing

The product has various addressing modes that are configurable via the product registers. The following modes are available:
- Transparent mode without sub-network --> In this mode, UART data rate must be lower or equan than RF data rate
- Transparent mode with sub-network --> In this mode, UART data rate must be lower or equan than RF data rate
- Addressed mode without sub-network --> In this mode, UART data rate must be lower or equan than RF data rate
- Addressed mode with sub-network --> In this mode, UART data rate must be lower or equan than RF data rate

The transparent modes are intended for inter-product communication: all products are recipients of the frames transmitted. The addressed modes enable communication to one or more products (creation of sub-groups).

Transparent mode without sub-network
- In the Transparent mode without sub-network all products within range receive the frames from the transmitting products. The configuration required for this mode of communication is as follows :
- S220=0 (transparent mode)
- S253=0 (no group)

Note : value 0 must not be used with registers S252 & S256

Transparent mode with sub-network:
The sub-networks enable groups of products to be created that communicate with each other within the same sub-network. Products in sub-network 1 cannot see those in sub-network 2 and vice versa. On the other hand all the products are visible between themselves within the same sub-network.

- S220=0 (transparent mode)
- S253=Number of the sub-network varying from 1 to 255

when register S253 is set to 255, the frame is broadcast to the whole of the sub-network.

Addressed mode without sub-network:
In the addressed mode without sub-network a product communicates with a specified addressee. Only the addressee receives the frames from the transmitting products. The configuration required for this mode of communication is as follows:

- S220=1 (address mode)
- S253=0 (no sub-network)
- S252=local address (16 bit address)
- S256=address of the recipient (16 bit address)

When register S256 is set to 65535, the frame is broadcast and visible by all equipment within range.

Addressed mode with sub-network:
The products always communicate within the same sub network. This means that two products with identical addresses and different sub-network numbers do not communicate with each other. The only case of inter-network communication is when S256=255 and S253=255.

- S220=1 (address mode)
- S253= sub network number varying from 1 to 255 (255 is used for broadcast between the sub-network)
- S252= local address (address on 8 bits)
- S256= recipients address (address on 8 bits, 255 is the broadcast address within the sub-network)

3.4. RSSI

The Received Signal Strength Indication or RSSI provides an indication of the RF level in the selected channel.
Depending on the value observed, it indicates the availability of the channel and the noise level in the product's environment, or the quality of reception of the frames from a distant product. The terminals are -127dBm for the lower limit and -20dBm for the upper limit

The RSSI is deactivated (by default) by positioning register S230 at: 0

3.4.1 RSSI continuous

The RSSI is coded on one octet in absolute values of the channel level value in dBm and transmitted to the UART. The RSSI is refreshed continuously every 10 ms. There is no frame demodulation in this mode.

Selection of the continuous RSSI mode is done by register S230, by setting the value to: 4

3.4.2 Frame RSSI

The frame RSSI is the code on one octet at the beginning of each frame transmitted on the UART. The encoding is identical to the continuous RSSI.

Selection of the continuous RSSI mode is done by register S230, by setting the value to: 1

3.5. Repeater mode

The principle of operation of the repeater mode is based on listening to the radio channel on which the product has been programmed and retransmission of RF frames received on the same channel. Repetition is base on time (temporal). Thus, a frame received by a repeater product is retransmitted after a guard time (configurable).

3.5.1 Example of a standard configuration

The following requirements are mandatory when using repetition feature.

- All devices MUST be configured in packetized mode (S222=0), with default preamble value (using another preamble length will alter the repeater propagation delay calculation).

- The size of the exchange message is limited to 403 bytes (for example in a query / answer based exchange, the maximum length for a query or for an answer must not exceed 403 bytes)
- The additional time introduced by the repeater MUST be taken into account in the message path.

3.5.1.1 Settings

Communication mode settings (all the products) :

- Repeater mode note available in transparent mode (S220=0)
- Addressed mode (S220=1)

Choice of RF data rate (all the products) :

- RF data rate at 4.8kbps (S254=2)
- RF data rate at 9.6kbps (S254=3)
- RF data rate at 38.4kbps (S254=6)
- RF data rate at 115.2kbps (S254=9)

Packetized mode settings (all the products):

- Programming product in packetized mode : S222=0, repeater mode not available if S222=2 or S222=3
- Programming maximum packet size in S218 (1 to 403 bytes)
- Programming timeout starting packet (allowing transmission of a data packet which has not reached the maximum size) in S217 (1 to 255ms)

Repeater modem settings :

- Setting the guard time in S250 (from 1 to 65535ms).
  Guard time may well be set in a system with N repeater (with N representing the repeater number starting at 1)
- RF data rate at 4.8kbps (S254=2) : S250 = (32ms + (S218 x 8/4.8)) x (N–1)
- RF data rate at 9.6kbps (S254=3) : S250 = (16ms + (S218 x 8/9.6)) x (N–1)
- RF data rate at 38.4kbps (S254=6) : S250 = (4ms + (S218 x 8/38.4)) x (N–1)
- RF data rate at 115.2kbps (S254=9) : S250 = (2ms + (S218 x 8/115.2)) x (N–1)

4. Product Configuration - Command Mode

The command mode is an embedded tool, accessible by the serial link via a terminal (*), enabling the programming of the module parameters using a set of instructions called: "AT command set". AT commands are used to read and write the module configuration registers. In the command mode, the radio is deactivated (in reception and transmission).
(*): Hercules types

4.1. Command mode input/output

The command mode entry is obtained by applying a rising edge on the CMDE_MODE pin. The pin is debounced for the time configured in the S240 register. The module returns the "CM" string when it has effectively entered command mode. Note that the command mode entry may be differed when an incoming RF frame is pushed on the UART interface. In any case, the "CM<cr><lf>" string is sent. The module backs to the communication mode on a falling edge on the CMDE_MODE pin with respect of the configured debounce time. The module returns the "O<cr><lf>" string when it has effectively leaved command mode.

The command mode entry may also be done with the UART interface by transmission of a sequence of 3 ASCII characters on the serial link. By default, the sequence is: "+++<cr><lf>", however the user can choose its own ASCII character by reprogramming register S214. The ATO command backs the module to the communication mode. The module returns the "O<cr><lf>" string when it has effectively leaved command mode.

It should be noted that exiting from the command mode is also possible automatically (timeout) by programming register S202

Command	Description	Answer
+++	Allows entry into command mode	« CM » to confirm entry in command mode.
ATO	Exit command mode	«O»<cr> if operation OK «E»<cr> if error « W» if the operation has a configuration problem

4.2. AT Commandes

A command starts with the two ASCII characters: "AT", followed by one or more characters and data (see C below for the syntax of AT commands available on the module).

Each command should end with a "CR" or "CR" "LF", the two possibilities are accepted. (CR signifies: Carriage Return, LF signifies: Line Feed)

On receipt of a command the module returns:

- "the data"<cr><lf>, for a reading command, type ATS<n> ? , AT/S or AT/V.
- "O" <cr><lf>, for all other types of commands if it is accepted.
- "E" <cr><lf>, if it refuses the command because of a syntax error, unknown command, unknown register, invalid parameter, etc.
- "W"<cr><lf>, if it refuses the command because the configuration requested is not authorised.
- "CM" <cr><lf>, if it accepts entry into the command mode

Table of AT commands:

Command	Description	Reply
ATS<n> ?	Returns the contents of register **n**	Sn=y where **y** represents the contents of register **n**
ATS<n>=<m>	Transfer the value **m** to register **n**	«O»<cr> if operation OK «E»<cr> if error
AT/S	Display as a list, the content of each User register	Sxxx=y<cr><lf> for each register
AT/V	Display the complete firmware version	Adeunis RF PE868<val> ?????
ATR	Restore the content of registers with default values. This command must be followed by an AT&W command and a module reset to ensure that all parameters have been applied.	«O»<cr> if operation OK «E»<cr> if error
AT&W	Save the register configuration in E2PROM.	«O»<cr> if operation OK «E»<cr> if error « W» if the operation has a configuration problem
ATO	Exit command mode	«O»<cr> if operation OK «E»<cr> if error
AT&RST	Exit command mode and reset	«O»<cr> if operation OK

Example of a series of commands and corresponding replies as one could see them on a terminal:

Syntax of the Command	Description	Syntax of the response to the next line
+++	Request for entry into command mode	**CM**
ATS254=9	Request for RF data rate at 115.2kbps	**O**
ATS200=9	Request for channel selection = 9	**E** -> invalid channel !
ATS200=481	Request for channel selection = 481	**O**
ATS231=5	Request for RF power at 14dBm	**O**
ATS200 ?	Returns S200 register value	**S200=481**
ATS231 ?	Returns S231 register value	**S231=5**
AT&W	Storage request of the registers status	**W** (the selected channel is not available at 115.2kbps RF data rate) The value storage will not be performed.
ATO	Request to exit command mode	**W** (the selected channel is not available at 115.2kbps RF data rate) The Exit will not be performed.

Interpretation of the above example: the user wished to save a new radio configuration (channel 481, power 14dBm) after having made a parameter error (reply **E**) and an unauthorised configuration request (reply **W**). The module allows neither the saving of this invalid configuration nor the use of the product in the communication mode.

4.3. Description of registers

When switching on the PE868 module operates according to the last configuration saved (factory configuration if its the first switching on, or if this configuration has not been changed).

Modification commands, type **ATS<n>=<m>** or **ATR** allow the content of registers to be modified. The product is usable with each new configuration as long as it is not disconnected.

On the other hand the modified values will be applied next time the module is switched on only if they have been saved **AT&W** command

List of the registers accessible on the PE868 module :

Register	Content	Default value	Comments
S200	Channel number : from 23 to 495	487	Some channels will not be available depending on the data rate and the selected power. The module will return an error message if illegal choice.
S202	Timeout to exit command mode : 0 : no timeout, exit through ATO 1 : Automatic programmable output from 1 to 65565 sec.	0	See note 2
S204	Preamble duration 0 : Automatic preamble	0	
S210	UART data rate: 1 : 2.4kbps 2 : 4.8kbps 3 : 9.6 kbps 4 : 19.2 kbps 5 : 38.4 kbps 6 : 57.6 kbps 7 : 115.2kbps 8 : 1.2kbps	3	See note 1 The other parameters of the serial interface are : • 1 stop bit -> fixed • Parity -> See S212 • Data lenght -> Voir S211
S211	UART data lenght : 0 : 7 Bits 1 : 8 Bits	1	If S211 set to 0, then S212 has to be set to 1.
S212	UART parity : 0: No parity 1: Even Parity 2 : Odd Parity	0	Even or odd parity, only if S211 = 0 (data 7 bits)
S214	Input character in command mode : ASCII code (except 0) 0 : Disabling entry into command mode by UART.	43	The input code is 3 times the character : • Example : +++ if the character programmed in S214 is the ASCII code of «+» whether 43 • Value between 1 and 255
S216	RTS UART flow control: 0 : Inactive 1 : Active	0	See note 1
S217	Transmission start-up Timeout : 0 : illegal value 1 à 255 : timeout by step of 1 ms	3	See note 3
S218	Transmission start-up threshold : From 1 to 403 octets	30	The transmission starts when the number of bytes in FIFO memory reaches this threshold. See note 2-3
S220	Communication mode 0 : Transparent 1 : Addressed	0	

Register	Content	Default value	Comments
S222	Radio protocol 0 : Asynchronous paquetized non secured 2: Asynchronous paquetized secured 3: Asynchronous continuous	3	
S230	RSSI mode: 0 : no RSSI 1 : Exit «RSSI frame» on UART 4 : Exit «permanent RSSI» on UART	0	
S231	RF radiated power: 5 : 14 dbm 6 : 10 dbm 7 : 1 dBm	5	
S232	Low Power modes : 0 : no Low power 1 : SHUTDOWN 2: STANDBY	0	Apply a High level on the WAKEUP pin to enter low power mode (SHUTDOWN or STANDBY)
S240	Debouncing filter on CMD & WAKEUP pins Adjustable from 0 to 100 by step of 1ms	3	User adjustable delay to control pin level
S241	Command mode entry Timeout at 9.6kbps at product start-up. 0 : disabled 1 : enabled	1	
S243	Re-emitting time out (when S222=2) Adjustable from 0 to 65535 by step of 1ms	0	
S250	Repeat Time Out 0 : Repeater mode disabled Adjustable from 1 to 65535 by step of 1ms	0	
S252	Source address (or local) from : 1 to 65535	Factory pre-initialized	Used in the addressed mode. This register contains the address of the module. Value 0 must not be used
S253	Network number no network : 0 Network address: from 1 to 254 255=broadcast	0	
S254	2: 4.8Kbps	3	Authorized channels (S200) <23 to 447> & <481 to 495>
	3: 9.6Kbps		
	6: 38.4kbps		
	9: 115.2Kbps		Authorized channels (S200) <29 to 443> & <483 to 492>
S256	Destination address : From 0 to 65534 Broadcast function : 65535	1	In addressed mode, this register must be set with the address of the module to be reached.

Note1 : the UART data rate should be chosen as close as possible to the radio data rate.
This is to limit the use of the buffer memory zone and activation of the RTS UART data rate control signals. E.g. 1: for a radio data rate of 38.4Kbps (S254=9), the choice of UART data rate of 38.4Kbps (S210=6) would be ideal. E.g. 2: For a UART data rate of 9.6Kbps (S210=3), the

radio data rate of 9.6Kbps(S254= 3) is the best possible choice.
If it is not possible to bring the UART and Radio data rates close together the 403 octet buffer memory will compensate for the differences in speed, provided this difference is not significant and/or the size of the data for transmission is limited.
In all other cases, only the use of the UART data rate control (S216=1) enab.les the integrity of the data transmitted to be guaranteed.
In transparent mode the UART data rate must be lower or equal than RF data rate

Note2 : the default choice of manual exiting from the mode is suitable for use during development, when the user needs to maintain control over the exit from the command mode.
Programming of a timeout is recommended for use in operation, to enable an automatic return by the module into the communication mode if a character chain in the data flow is accidentally assimilated to a request for entry into the command mode.

Note3 : registers S217 and S218 are used to synchronise transmission start:
- either a timeout (S217)
- or a quantity of data in the buffer memory (S218)

The first of these two limits reached triggers transmission start.
When the number of octets in the buffer memory reaches the threshold of register S218 before the timeout of register S217, it is triggering on data.
On the other hand, when the timeout of register S217 expires before the data in the buffer memory reach the threshold of register S218, it is triggering on time.

4.4. Configuration coherency

The PE868 module contains monitoring of the configuration coherency and prevents saving and operation of invalid set of parameters.

Radio parameter coherency
Radio data rate and frequency parameters should correspond to valid combinations presented in the table at the beguinning of the document.

Invalid combinations result in the return of a "W" on the AT&W and ATO commands which are not executed in this case.

5. Process

5.1. Description of module ARF7930AA

ARF7930AA module is fully SMT, single side. Assembly process is based on leadfree alloy, no clean flux residues
PCB material is FR4 material, 6 layers, class 6 , nickel-gold finish (ENIG).

5.2. BOM analysis

BOM was analyzed after loading and comparison with SERMA databases; from this job, we get the following data:
- Rohs status
- Obsolescence
- MSL level
- Max peak temp during reflow
- Time max at peak temp
- Number of reflow
- Lead finish of the package
- Termination description for resistor and capacitor chips; presence of nickel barrier or not

The worst case MSL level is 3. Other parts are level 1 classified.
Most parts are compliant with max peak temperature of 260°C during 10 seconds.
Most parts are compatible with 2 reflows.

All resistors and capacitors have nickel barriers in their terminations, which is necessary to avoid leaching effect.

5.3. Risk linked to number of reflows

There is no high risk regarding the assembly of the module on mother board, since the land pattern is larger than the "leads" (maybe the land pattern may be little bit large compared to the "leads" and then there is risk of module slip during reflow soldering)

The stencil foil thickness should be 150 to 170 microns to ensure enough solder fillet; the stencil aperture should be reduced in length and width by 150 microns roughly to avoid solder balling in case misalignment occurs.

Check of maximum temperature (during reflow) on sensitive component body has to be done.

The trickiest point is regarding the moisture sensitivity and the way to consider the module for the assembly on mother board.

Considering the components on the module, we can define the module as a level 3 component, whose floor life under 60% max RH is 168 hours.

Having in mind that module to mother board assembly delay is not under control, same for temporary storage atmosphere, the best solution is to dry the module after test and put it in reels and then pack them in MBB bags.

Jedec JSTD 033 standard is helping us to define the conditions of drying
If drying occurs less than 10 days after first reflow,

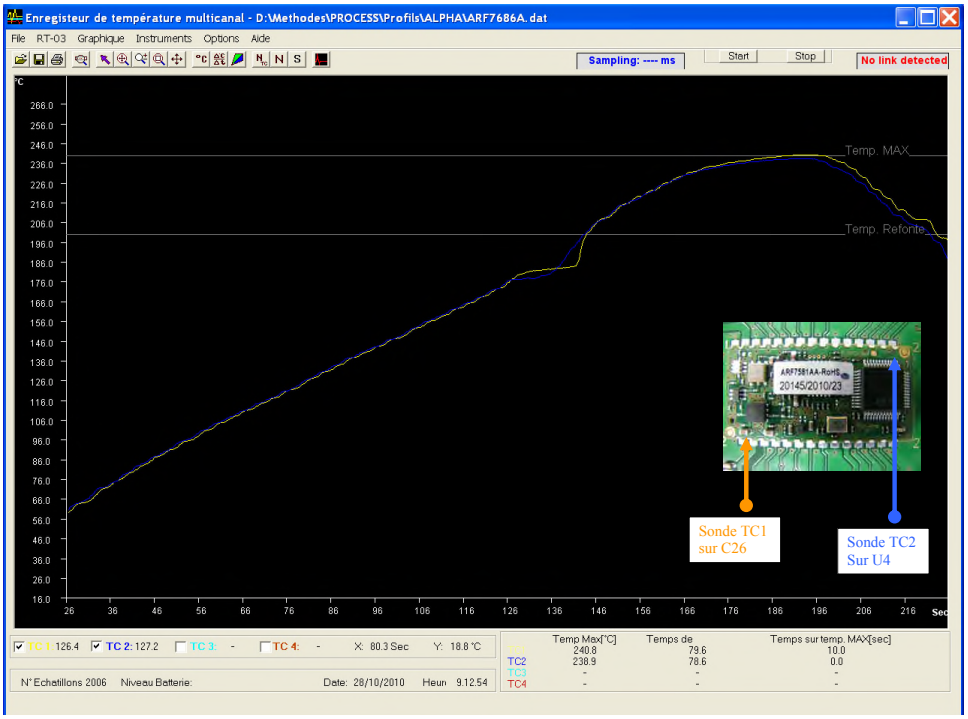
24 hours 90°C seems a good compromise between time and temperature;

If drying occurs more than 10 days after first reflow,

The drying condition becomes 36 hours 90°C ;

Notes:
1) at end of drying , let the parts come back to room temperature slowly to avoid condensation.
2) take care that reel material cannot withstand 90°C .Then it is needed to dry prior reeling.
Reeling should occur within a few hours after drying.

5.4. Soldering curve



6. Appendix

6.1. List of available channels

Available channels at 14dBm

Channel number	4.8kbps	9.6kbps	38.4kbps	115.2kbps
from 23 to 28	14dBm	14dBm	14dBm	
from 29 to 443	14dBm	14dBm	14dBm	14dBm
from 444 to 447	14dBm	14dBm	14dBm	
from 481 to 483	14dBm	14dBm	14dBm	
from 484 to 492	14dBm	14dBm	14dBm	14dBm
from 493 to 495	14dBm	14dBm	14dBm	

7. Version history

User guide version	Contents
V1.6	S232 register correction, list of available channels updated
V1.4	Appendix ¶6 List of available channels
V1.3	Default value S256 and warning note - > Adressing mode (¶3.3)
V1.2	UG for final product (including 4.8kbps & repeater mode)
V1.0	UG released for Engineering samples only