RT400-M-B - UHF RADIOMODEM

The RT400-M-B Radiomodem is the whole apparatus containing the RT400 UHF transceiver and the RMO2007 Modem Board. The entire Radiomodem is certified under the 1999/5/CE directives.

CE 0678

GENERAL INFORMATIONS

The RT400-M-B is an high-quality UHF Radiomodem in the **440 – 470 MHz** band (other bands on request) characterised by an R.F. Output Power of **2.5** or **10 W** in according to the **European Communication Standards** and the **national rules on the radio-frequency spectrum utilisation.**
The device permits the data communication in **transparent mode** both in **receiving** and **transmitting** conditions through **RS-232** or **RS-485** serial ports and can send / receive, a **digital command** or **actuation**, a feature often required in the remote controls or in the alarm networks.
The device enclosure is an **anodised Aluminium box** with the **supply** and **service** connector, the **DE-9 F Serial Port connector**, for both RS-232 and RS-485 and the **BNC connector** (female) for the **Antenna**. On the box cover, as shown in the above picture, three Leds show the device status and, in particular, the **Power ON** condition **(Green)**, the **ON AIR (Transmitting)** condition **(Red)** and the **DATA Flow** both in transmitting and receiving mode **(Yellow)**.
The device is completely transparent to the user and may be configured by an external PC using the **RT415 configuration software** on **8** operating channels that may be selected by a **dip-switch** bank.
The most important characteristics are the following:

- **Power ON** controlled by the **DTR criterion** of the RS-232 serial port. The device is turned on when the DTR is **high**
- **Low power consumption** both in receiving and transmission using the **Power Saving mode**.
- **Broadcasting** or **static / dynamic addresses management** by the configuration software or the linked DTE
- **Digipeater** operating mode to repeat the message in geographically complex networks
- **Other sophisticated functions** as **ACK**, message repetition, **NAK** to DTE if no ACK is received, **Echo**, **addresses reversal** for the **answer**, **remote configuration** through the communication network and many others functions that may be useful in a communication network
- **Protocol compatibility** to the **RMO 400 Radiomodem** to extend an existing network if necessary. This option may be enabled during the configuration process.

The device is assembled in **SMT technology** with **industrial temperature range** components and it is specifically designed for **Low-Cost** data communication networks in which the **low power consumption** and the **high product quality** are the most important parameters in the device choice.
The Radiomodem may be used as **digipeater** in communication networks containing the **RT400 transceiver modules**. In this case we can supply the communication protocol for the required compatibility.

General		**Radio parameters**	
Supply Voltage (Max)	**16 Vdc, Negative to Ground**	Frequency range	**400 → 470 MHz**
Supply Voltage (Oper.)	**11 → 13,8 Vdc, Negative to Ground**	Channels spacing	**12,5 kHz**
Current consumption	**~ 90 mA in RX mode, reduced by Power Saving**	Synthesis step	**6,25 kHz**
	< 3 A in TX mode	Adj. Channel power	**< -60 dB**
Communication Mode	**Store and Forward**	Modulation	**8K50F1D**
Serial Port Data Rate	**1,200 to 38,400 bps 8,N,1 - 8,E,1- 8,O,1 - 7,E,1 - 7,O,1**	Communication mode	**Simplex or Half-Duplex**
Serial Port Data Level	**RS-232 or RS-485 selected on configuration**	Frequency stability	**2ppm -20C°→+70C°**
RTX Data Rate	**1,200 – 2,400 – 3,600 bps**	Power output	**2.5 or 10 W selectable**
RTX Data I/O Level	**TTL Inp (Schmitt Trigger) - TTL Out (Totem-Pole)**	RX sensitivity	**-118 dBm @12dB Sinad**
DTR Level	**High (ON): >4 Vdc , Low (OFF): <-4 Vdc**	Selectivity	**> -60 dB**
Digital Input I1-I2	**5-26 V AC or DC, fully insulated (optocoupler)**	IMD attenuation	**> -65 dB**
Digital Outp. O1-O2	**2A / 230Vac, relay switch fully insulated**	Spurious radiation	**EN 300 113-2**
Size H x W x D	**205 x 72 x 30 mm (8.07 x 2.83 x 1.18 inches) max.**		
Weight	**255 g – 8.99 oz. av. max.**		
Operating temperature	**-20 to +60 °C (-4 to +140 °F)**	**All stated specifications are subject to change without notice or obligation.**	
Storage temperature	**-20 to +75°C (-4 to +167 °F)**		

The utilisation of the Radiomodem is subjected to the Government Authorisation and to the national rules on the radio-frequency spectrum utilisation.
The Radiomodem unit is CE certified and fully compliant with the following ETSI and European directives: EN 300 113-2, EN 301 489-1, EN 301 489-5 and EN 60950-1

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RT400-M-B - RADIOMODEM UHF

Circuit Description

The **RT400-M-B Radiomodem** utilises both the **RT400 transceiver** and the **RMO2007 Modem** plug-in board and is enclosed in an anodised Aluminium box. The apparatus is completely configurable by a Personal Computer using the adequate configuration software **RT415SW**, available as free download at our website: **www.ere-online.it** Please refer to the **on-line Help** for the correct utilisation of this software.
The **RMO2007** board contains a **Supply** section, a **Microcontroller** section, an **UART switch** section, a **Serial Port switch** section and two **Serial Port Interfaces** for **RS-232** and **RS-485** connection. The modem board fully manages the transceiver unit trough the **Enable RTX**, **PTT**, **RTX Config**, **RTX Freeze**, **RxD Radio** and the **TxD Radio** criteria. For more information on the **RT400 transceiver** and on the **RMO2007 Modem** please refer to the respective instructions manuals.

INTERFACE

1- **A - RS485**
2- **RxD**
3- **TxD**
4- **DTR**
5- **GND**
6- **DSR**
7- **RTS**
8- **CTS**
9- **B - RS485**

CONNECTIONS (Fig.1)

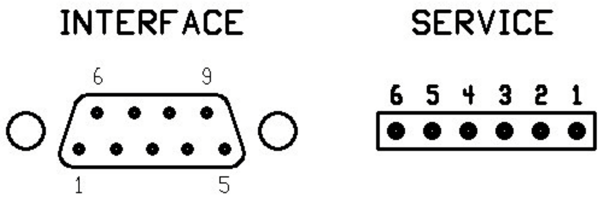

Fig.1 (Front view)

SUPPLY/SERVICE

1- **+Vcc: 11-13,8V**
2- **-Vcc (GND)**
3- **Input 1**
4- **Input 2**
5- **Output 1**
6- **Output 2**

NOTES:
Both inputs and outputs are **electrically insulated** from the modem circuitry.

The RS-232 Serial Cable <u>must be</u> a right cable (NO Null Modem)

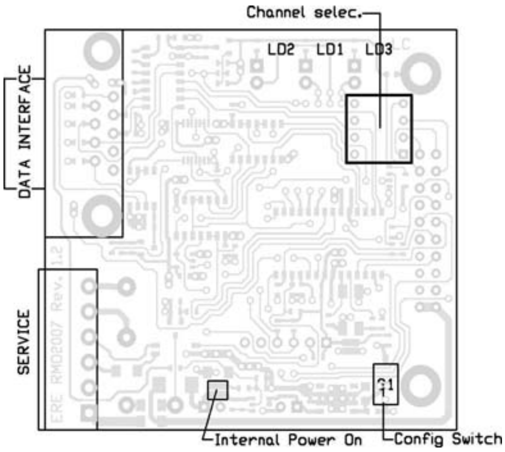

Fig. 2 (Top view)

MODEM BOARD LAYOUT (Fig.2)

Internal Power On – Soldering jumper. If closed, the modem is turned on and the DTR criterion controls the power switch. It **must be** closed if a RS-485 or a 3-wire RS-232 serial line is used.
Channel selec. – This **Dip-switch bank** selects, in binary code, the operating channel between the eight available.
Config Switch - This pushbutton switch, reachable through a hole in the cover, permits the unit configuration as explained in the online Help of the RT 415SW configuration software.

CERTIFIED VERSIONS AND ANCILLARIES

RT150-M The **Open version** of the Radiomodem (without the box)
RT150-M-B The Radiomodem in its anodised aluminium box
DRP-03 DIN Rail locking system, in extruded aluminium, mounted on the box
SP6 6 poles male connector for **Supply/Service** wiring
D9M 9 poles male D-Shell connector for **DATA Interface** wiring, complete of protective and insulating covers

Starting – The radiomodem default configuration is the following: all channels are in **Broadcasting** mode and the operative frequencies are: 1=440 MHz, 2=445 MHz, 3=450 MHz, 4=455 MHz, 5= 460 MHz, 6=465 MHz, 7=470 MHz and 8=470 MHz. The default channel is the 1st on 440 MHz with **3,600 bps** Radio data rate, **RS-232 Interface** operating at **9,600 bps**, **8N1** protocol, **no Flow control** and an **internal buffer** of **640 bytes**. In these conditions the unit can communicate with an other unit with the same configuration. Connect the supply voltage, taking care to avoid the polarity reversal, and check the **Green Led** status. If it is turned on, the radiomodem unit is **ready** while if it blinks, the radiomodem is **not configured** or a **failure** is occurred. In the first condition to make a communication connect an adequate antenna or a dummy load, able to dissipate the total R.F. power, and use a communication software, e.g. Hyper Terminal, to send a characters string from the keyboard or send a file. In both cases the number of bytes must be less of 640 because the Flow control is not enabled. In the second condition configure the unit using the RT415SW.

Notes: The radiomodem requires an adequate supply unit able to supply the maximum required current without voltage drop or ripple increase. The suggested unit must be a stabilised one, both in linear and switching mode, and must be able to supply at least 3.5Adc at the nominal voltage without appreciable ripple noise. A simply filtered and not stabilised unit is **not recommended** because the ripple is generally too high and the output voltage varies excessively during the RX/TX switching.

Digital Input – Its status is sent in the following circumstances: **1st** - at the end of any data transfer, **2nd** – periodically, with the time interval set in the **Digital Repetition Time** field of the configuration panel, **3rd** – at every change of the input status. In the last two cases is necessary to set the adequate device addresses during the configuration process or select the **Rx address for Tx** option. The send of the digital input status automatically enables the **ACK** and, if it isn't received, the status of the digital input is re-transmitted until the receiving of an ACK or up to a maximum of 256 times.

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RT150-M-B RT400-M-B CONFIGURATION

Both **VHF** and **UHF** Radiomodems are configurable using the **RT415SW** software, available as free download from our website :www.ere-online.it

1 – Preliminary operations

At first download and install on your PC the RT415SW following the installing instructions. Connect the serial port of the configuring radiomodem to the available COM Port of your PC, then start the program. Push the **Options label** to choose the used COM Port, the Operative Band and the compatibility with the RMO400, or RMO150, if required. Please note that in this condition the maximum buffer capacity is of **256 bytes** instead of 640 bytes.
Follows the operating instructions as shown in the software Help. This software displays **four pages**: **RTX**, for the transceiver settings, **BASIC**, **ADVANCED** and **LINK TEST** for the Radiomodem operation.

2 – RTX

This section contains all the required parameters to set the RT150, or RT400, transceiver unit. These parameters may be set independently for each of the eight available channels.
RX Freq. – It sets the **receiving frequency** of each channel. The choice of the operating channel is made by the **Dip-switch** bank on the modem board. The **dip-switch n°4** is **not used**.
TX Freq. – Sets the **transmitting frequency** of each channel.
Power Level – Defines the **R.F. Output Power** for each of the eight available channels.
Mode – This field **cannot be modified** and is set in **Digital**.

3 – BASIC

Contains all the essential parameters of the communication protocol of the Radiomodem.
SYSTEM CODE [0….63] – It defines univocally the communication network and, of course, all devices in the network **must have** the same System Code. Messages with **different System Code are not detected**.
BROAD – If **selected**, all units in the network release the incoming message independently from the **target address,** but this **must be assigned** to any units. In this way any unit in the network may be used as digipeater. In a broadcasting network, in which all units utilise the addresses from configuration, it is possible the usage of **only one digipeater**. If an higher digipeater number is required, is possible to set the eight available channels with the same parameters but with **different digipeaters addresses** and changing the operative channel from the DTE in according to necessity.
If the BROAD is **not selected** the incoming message may be released **only** by the **target unit** while all the others **don't release** the message to the linked DTE. In this case the target address is specified in the configuration program or attached to the message by the DTE if is selected the **Addr from DTE** option. Please refer to the **Advance** section for more information. In a network configured with the **Addr from DTE** option may be possible send a **Broad message** simply **setting to 1**the **1st bit** of the **System Code byte** and, in this case, the max number of digipeaters is **8**.
RS232/RS485 – It permits the choice between the two serial port interfaces.
BUFFER SIZE – It defines the capacity of the internal buffer. Maximum admissible value **640 bytes**. In **RMO400 compatible mode** the capacity is of **256 bytes**, automatically set and **cannot be modified** by the user.
FLOW CONTROL – Available **only** in **RS-232,** it controls the **buffer loading**.
TIME DTX – If the FLOW CONTROL is **not used**, indicates the **time lag** between the last transition of the incoming message from DTE and its radio transmission. This time lag is active for both RS-232 and RS-485 while in RS-232 if is enabled the FLOW CONTROL the end of the incoming message is defined by the **RTS transition**. This time may be **increased** from the default value of 10 milliseconds to avoid the **partial sending** of the message. This condition may occurs if the time interval between each byte of the message is higher than TIME DTX. For example the Hyper Terminal under XP, sometimes insert an excessive time interval so that the message is truncated.
BAUD DTE/PARITY – It defines the serial port **Baud rate**, from **1,200** to **38,400 bps** and **parity bit** (**N**,**E**,**O**) both in RS232 and RS-485.
BAUD RATE RADIO – It defines the Baud rate of the radio communication. The **certified values** are **2,400** and **3,600 bps**. The **4,800 bps** choice is **not certified** and is applicable **only** for radio links with **high SINAD ratio**.
DIGITAL IN REPETITION TIME – It defines the **refresh time** of the **Digital Input status**. The time range is **0** to **60 minutes**. The value **0 don't refresh** this status.

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4 – ADVANCED

This section contains all the sophisticated parameters necessary to manage the communication characteristics.

ITS ADDRESS [1…255] – It is the **identification number** of the unit and **must be specified and different** for each unit in the network. Generally the value **1** indicates the **Master unit** of the network and, in the **Power Saving mode**, characterises a particular Master unit, **always switched on,** able to transmit messages with **various preamble length** depending on message destination.

TARGET [1…255] – The **identification number** of the target unit, addressee of the message. This value **must be always specified** independently from the communication mode utilised. For example in **Broadcasting** is not considered and in the **Addr from DTE** mode the Target is contained in the addressing protocol.

DIGIP. [0…255] – The **identification number** of the unit used as **digipeater**, if present. If no digipeater is used, this value **must be set** to **0**. Any unit of the network may be used as digipeater, normally the one with the most favourable position. In **Broadcasting**, the digipeater unit receive the message, repeat and subsequently release it to the DTE. In others mode the digipeater simply repeats the message without releasing it. In the **Addr from DTE** mode this field is **not considered** and the necessary addresses must be indicated by the DTE.

ACK [ON / OFF] – This field enables the **Acnowledge** answer from the target unit to the sending unit, generally the Master, to confirm the receiving of the message. If the ACK is not received, the sending unit repeats the message until a valid ACK is received, or, in alternative, until the maximum number of repetition is reached. The ACK message passes trough the **digipeaters** units as a generic message, without additional repetitions.

NAK TO DTE [ON / OFF] – This field enables the sending of a **NAK** character to DTE (ASCII 21), at the end of the repetition cycle, if no valid ACK is received.

ADDR to DTE [ON / OFF] – This field enables the sending of the address of the source unit of the message. This address byte precedes the received message.

RX ADDR for TX [ON / OFF] – The target modem holds in his memory the addresses of the incoming message and uses them, reversed, for the answer.

ECHO [ON / OFF] – If selected, the received message is **not released** to the serial port but it is re-transmitted to the source unit. This feature, not available in **Broadcasting mode**, may be useful to check the radio link and it is available **also in Addr from DTE mode** if **the bit No. 6 of the System Code Byte** is **set to 1.**

ADDR FROM DTE [ON / OFF] – If selected, the address management is controlled by the **DTE** while the **target** and **digipeater addresses**, set in the configuration process, **are not utilised**. In this case only the **Its Address** is considered. This feature is available **only** if the **Rx Addr for TX** is **not selected**. For the correct addressing is necessary to insert, in the head of **each message** to be sent, an adequate number of bytes, from 3 to maximum 11. The **necessary** bytes are the following:

1st: the **System Code byte [0…63]** to identify the network. In this byte the bits **No. 7** and **No. 6** are the **Broadcasting** and **Echo** switches respectively.

2nd: The **Number of Unit byte [1…9]** indicates the total number of units in the message path comprehending the **target unit** and **all the digipeaters (max. 8)**.

3rd to max 10th: They are the **digipeaters addresses bytes,** listed in the exact sequence of use. If **no digipeaters** are present, as in a two points communication, this byte is the **target address**.

Last byte: The **target address byte** indicating the addressee of the message. Depending on the network complexity this byte may be the **3rd**, in a simple two points network, or the **11th** if the network contains the maximum number of digipeaters.

After this **head,** can start the message to be sent. The maximum message length depends on the selected buffer size, with a maximum of **640 bytes**. In **RMO150/RMO400 Compatible mode** the buffer size is reduced to **256 bytes**. In **Broadcasting** mode, the channel selection from DTE requires the activation of this feature.

REPETITION [0…255] – Available **only** if the ACK option is enabled, it sets the maximum number of repetition of the message in absence of an ACK receiving.

PWSAVOFF [0…240] – In the **Power saving mode** the radiomodem is alternatively switched on and switched off. This parameter indicates the length of the inactivity period during the Power Saving cycle. The value **0 inhibits** the Power Saving and, consequently, the unit is **always active**. The **time unit** is the **millisecond** so the maximum length of the inactivity period is **2.4 seconds** and this value is utilised to calculate the **Preamble length**, before the message sending. The turn on time is set to **70 milliseconds** and cannot be modified.

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PWSAVA [0…255] – It is the time lag between the end of the last message sent or received and the return in the Power Saving Cycle. The time step is of **0.1 second** so the maximum lag is of **25.4 seconds**. The value **0** is admissible **only** if the Power saving Cycle is **inactive(PWSAVOFF=0)** while the value **255** characterises a radiomodem **always active** but able to manage **preambles having different lengths**. This feature may be used in more complex networks utilising the Power saving Cycle to minimise the acquisition times.

5 – LINK TEST

This feature permits the valuation of the quality of the radio link. As explained in the on-line instructions, to start the software it's necessary to insert all the addresses of the units in the path to be checked, digipeaters and target, and the message to be sent. Push the **Start Test** button. The source unit periodically forwards the specified text, through the link path, therefore the target unit sends it back to the source. The software counts the number of sent messages and the number of these correctly received to show the quality of the radio link. Of course, smaller is the difference, better is the radio link quality. It is important to remember how the radio link may be more problematic, in comparison with the wired link, because all noise phenomena, as electrostatic discharges, power relays switching and interference on the selected channel may degrade the communication. A good antenna choice and placing, the usage of the adequate supply units and a DTE correct interfacing may considerably improve the link performance.

6 – Channel Selection

The channel selection may be done in Hardware mode or in software mode, through the linked DTE.

6.1 Hardware (manual) Channel selection.

The **Hardware** channel selection is the **default mode**. The choice is done by the **dip-switches bank** on the RMO2007 printed circuit. The eight available channels are selected by the **1st**, **2nd**, and **3rd** switch while the **4th** is **inactive**. The **1st** channel is selected if **all switches** are in **OFF** while the **8th** channel is selected when they are in **ON**. The intermediate channels are selected in according to binary code.

6.2 Software Channel selection (operated by the linked DTE).

This feature is available **only** if the **Addr from DTE** option is selected in **all operating modes** comprehending the **Broadcasting** one. The initial requirement is the complete configuration of all the eight available channels. To change the channel is sufficient to send to the radiomodem unit the following hexadecimal string containing only 3 bytes:

New channel number(h) – 09h – New channel number(h). At the end of the sending wait **at least 1 millisecond** before use the unit in the normal operation mode. To **restore the manual selection** the required hexadecimal string is **00h – 09h – 00h**. The change by DTE is **not stored** in the **radiomodem memory** therefore its reset restores the **default manual selection**.

7 – Remote Configuration through the radio network

In the standard applications one or more peripherals may be placed in a “problematic” site essentially due to logistic difficulties. To avoid these problems a Remote Programming/Channel selection utility is installed into the configuration software. The programming procedure is exhaustively explained in the **online Help** of the configuration software under the **Remote Configuration**.

8 – Sending of a “Broadcasting” message in the “Addr from DTE” mode

Sometimes may be necessary to send a “Broadcasting” message through a network configured in **Addr from DTE mode**. As previously shown, in these networks it's necessary to send , as “head” of the message, the required addressing bytes. The unique difference between the “Broadcasting” message and the generic one is the value of the **bit No. 7** in the **System Code byte** that **must be** set to **1**. In according to the instructions given for the Addr from DTE mode, this byte is followed by the necessary addressing byte but, the **Target Address byte can take any values** because the Target Address is **not considered,** in according to the properties of a Broadcasting message. In this case, differently to the **Broadcasting mode** above specified, it's possible to use **more than one digipeater** because **only the last digipeater** transmit the message in Broadcasting mode.

For example in a network characterised by a System Code Byte = 01h, and without digipeater, the correct addressing sequence is the following:

A) Normal sending: **01h – 01h – 02h** in which the last byte is the correct target address for each unit in the network.

B) Broad sending: **81h –01h –XXh** in which the 1st byte is the same system code of the previous but with the **bit No.7 set to 1** while the Target address byte (the last) may take any values because it isn't considered.

If the network is characterised by a System Code byte = 01h, two digipeaters with addresses 03h and 04 h respectively, the correct addressing sequence is the following:

A) Normal sending: **01h – 03h – 03h – 04h – 02h** in which the last is the Target address byte.

Broad sending : **81h – 03h – 03h – 04h – XXh** in which the 1st byte is the System code byte with the bit **No.7 set to 1**, the

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2nd is the total number of addresses, the 3rd and the 4th are the digipeaters addresses in the exactly sequence of use and the 5th and last byte may take any values because, as target address, is not considered.

9 – Serial Port Data Acquisition and DTR utilisation.

The available serial ports are, as specified in the technical characteristics, the **RS-232** and the **RS-485** and, **only** for the **RS-232** may be used the **Hardware Flow Control** employing the **RTS/CTS** criteria. In **RS-485**, as formerly explained, the Flow control cannot be activated because the related criteria don't exist. In the most common application, however, the Flow control is rarely utilised because the message length is generally lower than the buffer size. In these situations a simple **3 wires** RS-232 connection may be realised using only the **RxD**, **TxD** and **Ground (GND)** criteria. If the Flow Control is not enabled, the radiomodem waits the **DTX Time** after the last transition of the incoming signal in the serial port, therefore it considers closed the message and sends it to the target unit. As formerly explained the **default value** of the DTX Time is **10 milliseconds** and, generally, it's adequate to all **DTE Baud Rates** selected. In certain condition, e.g. the use of Hyper Terminal, happens that the time interval between two bytes may be higher than 10 milliseconds, so that the entire message is truncated and only a part of it is sent to the target unit. To avoid this phenomenon is sufficient to **increase progressively** the **DTX Time** until its disappearance.
The **Flow Control** reduces the acquisition times because the **end** of the incoming message is indicated by the status change of the **RTS criterion**, so that the transmission of the message can start immediately. Of course, the time saved is more significant for a short message, respect to the long one. The **CTS criterion** indicates the availability of the serial port to receive a message.
In the **Add from DTE mode** it's necessary to insert the required addressing bytes in the head of the message. If the Flow control **is not enabled**, the required addressing bytes **must be inserted each time** a message must be sent while if the Flow control **is enabled** the required addressing bytes **must be inserted only each time** the **RTS criterion is enabled**. The difference between the two situations is fundamental, because in the second the addressing bytes **are stored** in the radiomodem memory between two consecutive activations of the RTS criterion. This feature may be useful if two or more messages must be sent to the same unit because only the first message **must be preceded** by the addressing bytes while the successive **don't require** them.
The **DTR criterion** is used as Radiomodem **Power Switch** through a wired-OR port. In this way the Radiomodem is turned on in absence of this criterion while a complete control is permitted if it is connected.The **switching logic** is the following: if the DTR level is **Low**, the Radiomodem is **turned off** while if it is **High,** the Radiomodem is **turned on**. In particular if **DTR voltage** is **lower than –4 Vdc**, the Radiomodem is **turned off** while if this voltage is **higher than 0 Vdc** the Radiomodem is **turned on**.

10 – Serial Port suggested wiring

The serial port wiring may be realised with a shielded cable with the adequate number of internal conductors. If a complete control of the radiomodem unit is desired, the **RS-232** serial port must be selected and the cable **must comprehend** all criteria and the **ground wire**. In this case a shielded cable with six inner conductors must be used. If the Flow control is not necessary, and the power switching is not required, a more simple wiring may be realised by a shielded cable with 3 inner conductors for **RxD**, **TxD** and **Ground (GND)** connections. If the **RS-485** is selected, the simplest wiring is a shielded cable with two inner conductors for **A** and **B** signals. Theoretically, the **Ground** connection **is not required** because the ground reference is normally realised at the two ends of the RS-485 line through the linked apparatuses. However is preferable the presence of a third conductor, for the ground connection between the radiomodem and its DTE so that the differences between the ground potentials in the respective locations to avoid damages to the serial port integrated circuits. In all cases the shield conductor of the cable **must be** connected to ground **only on one side** of the cable so that it is equipotential and performs the maximum shielding effect against the environmental noise.

11 – Radiomodem Supply

All the Radiomodem units require a **stabilised supply** in the range **11 – 13,8 Vdc** able to deliver a **current of 3 – 4 Adc** during the **transmitting condition**. In this situation the supply unit **must deliver** a **noiseless** voltage **without ripple or hum**.
The supply unit may be both a **linear mode** and a **switching mode** device. The first requires more space and is less efficient than the second but is, generally, less noisy. The second solution is more efficient and requires lower space but the noise level is, generally, higher. To avoid any interference with the radiomodem receiver, the switching supply unit **must be** a **fully screened** one to reduce to the minimum the radiated noise. In practice an high quality switching supply **completely enclosed in a metallic box** is generally sufficient. Because the Radiomodem negative supply is connected to the box, is important to **connect the negative output of the supply unit to the GROUND** because, generally, it is floating. It's important to avoid the electrical connection to **Ground** through the metallic box, the mechanical supporting structure, e.g. the DIN mounting system on a Ω rod, because generally it's not affordable due to the oxidization of the metal parts.

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RT150-M-B RT400-M-B CONFIGURATION

TYPICAL CONFIGURATIONS FOR MOST COMMON UTILISATIONS

<u>COMMUNICATION BETWEEN TWO RADIOMODEMS (POINT TO POINT)</u>

1) Broadcasting Mode.

It is the most simple utilisation. For both radiomodems configure with the same values the **System Code**, the **RXFreq** and the **TXFreq** respectively and the **Baud Rate Radio** (2,400 or 3,600 bps as standard, using the 4,800 bps only in high SINAD networks, as previously specified). Each unit **must have** a specific Its Address, different from the others, and also the Target Address **must be specified** and, of course, they **cannot be equals**. The **Digip** field **must be set** to **0** to exclude the presence of a digipeater unit. For example the 1st unit may be Its Addr=1, Target=2 and Digip=0 while the 2nd one may be Its Addr=2, Target=1 and Digip=0. Select the **Broad** option to enable this mode while the **Baud Rate DTE**, the **Flow control** etc. etc may be set in according to the communication requirements. Some fields are **not active** because their activation **is not compatible** with other settings. The **white** fields are **active** while the others are in **grey**.

2) Broadcasting Mode with Digipeater.

If a repetition is required a third radiomodem unit must be utilised as Digipeater. The new unit must be set with identical values of RX and TX Freq, and the same Baud Rate Radio of the other units to allow the communication. For the digipeater unit is necessary set the **Its Address** field with a **different value** from the others and **0** in the **Digip.** field. In the other units in the **Digip.** fields **must be set** the **Its Address value** of the digipeater unit. The digi-peater unit, however, releases to its serial port the received message so this unit may be utilised also as a peripheral or, vice versa, a peripheral may be used also as digipeater, if requested. All the messages pass through the digipeater unit and, of course, it is possible only if this unit is located in the most favourable site. In the example previously treated, the unit configuration is the following: I=1,T=2 and D=3 for the 1st unit, I=2, T=1 and D=3 for the 2nd unit and I=3, T=1 and D=0 for the digipeater unit.

3) Configuration Addresses with or without Digipeaters.

This mode allows some utilities denied in the Broadcasting mode. To operate in this mode is necessary to **deactivate the Broadcasting option**. Subsequently, both the **Its** and **Target Address** must be configured with two different values. Of course these two addresses **must be reversed** in the two units because the Target Address of the 1st unit is the Its Address of the 2nd unit and vice versa. If a digipeater unit is required, a third different **Its address** value must be as-signed to the additional unit and this value must be set in the **Digip.** fields of the other two radiomodems. In the digipeater unit the **Digip.** fields must be **0**. In this configuration the **ACK, Repetition, NAK to DTE, Addr to DTE** and **ECHO** are available. The activation of ACK utility allows an high quality communication avoiding the packets losses. Of course, this improvement slows the communication, due to the ACK answer. It's important to notice also the presence of the Digipeater slows the communication process because the repetition of the message requires an adequate time interval. Only with a **RS-232** communication port is possible to select the **Hardware Flow Control RTS/CTS** to send messages longer than 640 bytes. Using the **RS-485** serial port this feature is not available because the communication port don't support the Flow Control criteria. If the **RMO150/400 Compatible Mode** is selected, the maximum message length is of 256 bytes to permit the correct communication with the RMO150/400 radiomodems and the **Flow Control** is available **only** in **RS-232** mode. In the previous examples is sufficient to deactivate the **Broadcasting** option, without modify the other parameters, to change the operating mode.

4) Networks with Power Saving Mode.

If one or more units must be supplied by a battery or solar cells and the available energy is not sufficient to energise the system, is possible to activate the **Power Saving** utility. In this operating mode the unit will be supplied with a duty cycle equals to **70 / PwSavOFF** in which all time units are the milliseconds. The total cycle time is **70 + PwSavOFF** in milliseconds. In this way the fixed power consumption of the receiver is reduced by the **duty cycle factor** to save energy and to increase the battery life. For correct operation the **PwSavOFF** time **must be the same** in all units because the **preamble time** is equal to **PwSavOFF + 100** milliseconds. The correct choice of the **PwSavOFF** time is a compromise result between the achievable energy saving and the admissible communication speed slow down. After a successful communication the radiomodem waits a **PwSava time** before to come back in the Power saving cycle. The **PwSava time** starts at the end of a valid received message, in a receiving unit, or at the end of a repetition in a digipeater unit.

The choice of this value depends on the following considerations:

1 – The time must be adequate to permit the transit of the query, and of the related answer, in the unit.
2 – All units, digipeaters included, in the power saving mode transmit with a **long preamble**.
3 – All units in the power saving mode **recognize only** messages having a **long preamble**.
4 – During the **PwSava time** all units, digipeaters included, transmit messages with a **standard (short) preamble** and, at the sa-me time they can recognise messages having any **preamble lengths**.
5 – As specified for the **PwSavOFF**, also the **PwSava** time **must be the same** in **all units**.
6 – The **ACK** and **Echo** messages are **always** sent with a **standard (short) preamble**.

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TYPICAL CONFIGURATIONS FOR MOST COMMON UTILISATIONS

COMMUNICATION BETWEEN TWO RADIOMODEMS (POINT TO POINT)

7 – In the **digipeater** units the value **PWSAVA=255** forces them in an **continuous operating** condition, but it can generate a preamble length, depending on the **PWSAVOFF** value. The units can recognise incoming messages with **any preamble lengths**.

8 – In the **Master** unit characterised by an **Its address > 1** the value **PWSAVA=255** forces it in the **same operating conditions** shown for the **digipeater** unit.

9 – In the **Master** unit characterised by an **Its Address = 1** the value **PWSAVA=255** forces this unit in an **continuous operating** condition able to generate preambles with **different lengths**. In particular, if the target unit is an **always operative digipeater**, the message is sent with a **standard (short) preamble**, while if the target unit is a **peripheral,** the message is sent with a **long preamble**, depending on the selected **PWSAVOFF** time. In this case the digipeater **must be set** with a **PWSAVA=255**.

The correct setting of the **PWSAVA time** in the unit of the communication network is explained in the communication timing paragraphs and, in particular, the considerations shown in the last three points are particularly suited for **high speed acquisition networks** in which the Master unit is followed by a continuous operating digipeater.

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TYPICAL CONFIGURATIONS FOR MOST COMMON UTILISATIONS

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5) Broadcasting Mode.

It is the most simple utilisation. The communication protocol is completely managed by the network firmware. All units of the network, digipeaters included, release the received message to their serial ports. Follow the instructions shown in the points **1** and **2** for the correct unit configuration. Any units may be chosen as digipeater. All the communications pass through the digipeater unit to reach their targets and, of course, the digipeater unit must be located in the most favourable site. If a digipeater change or a direct transmission between two radiomodems is required, is possible to configure the others channels with the same operating frequency but with different parameters, e.g. a different System Code, and use the **channel change by DTE**. In this case the option **Addr from DTE must be selected** as formerly explained on page 5. It is important to remember that the use of a digipeater slows down the communication therefore if two or more peripherals may be reached without passing through the digipeater, may be useful to exclude the digipeater from the message path. Of course, this increasing in the network management complexity must be evaluated for each practical application.

6) Broadcasting Mode with Power Saving.

A typical network configuration shows a **Master unit**, normally connected to the ac line, one or more **Slave units** and, eventually, one or more **Digipeaters**. Although the majority of the peripherals are fed by the ac line, some of these may be supplied by a batteries system or solar cells. In these situations the available energy may be insufficient to allow a continuous service. The solution to the low energy availability is the **Power Saving Mode**. As explained in the specific paragraph, please refer to page 6, all units **must have the same PwSavOFF time** and his choice is a compromise between the required amount of energy saving and the maximum permissible slow down of the communication speed. The **PwSava** time must be selected in according to the following consideration: when the peripheral unit is in the PwSava time it can decode a **short preamble** message, otherwise if this time is expired, a **long preamble** is required to decode the message. Of course the power consumption is higher for messages with a long preamble than a short one, so an operative status of the unit is preferable. Consequently the recommended configuration is the following:

A) The **Master unit** must be always switched on. Setting to **255** the **PwSava** time, this unit is always operative and can manage packets with **different preamble lengths**.

B) All **Slave units** will be set with a **PwSava** time sufficient to allow the answers of their DTE to an incoming query, with an adequate time margin. It is essentially related to the answer times of the DTE.

C) All **Digipeaters units**, if presents, will be set with a **PwSava** time slightly shorter than the answer time-out of the DTE linked to the **master unit**. In this way all the digipeaters are active during the answer.

D) For **all units** the **PwSava** time counter **starts** at **the end** of any transmitting or receiving cycles. The 1st case interests the digipeaters unit, the 2nd the peripherals.

NOTES

1) If the radio network is very busy or very extended, the **Addr from DTE operating mode** is recommended rather than Broadcasting. In fact in Broadcasting mode **all units** decode and release on the serial port the received message independently from the message address. In this way the unused units are activated without necessity, causing an unnecessary loss of energy that may be a problem for the units powered by an autonomous energy source. The possible solutions are **the use of a different System Code**, one for the mains powered units and an other for the remaining ones, otherwise **the channel change** to split the entire network in two, or more, smaller groups.
In the first case all units exit from power saving cycle but only those receiving the correct System Code remain active while the others come back immediately to the power saving cycle.
In the second case only the units of the specific group exit from power saving cycle while the others continues it.
Because these Radiomodem are subjected to a **Government Authorisation is not possible to change the operating frequency except in case of a multiple frequency authorisation** e.g. a **duplex authorisation**.

2) The **Master unit** transmits **always** with a **long preamble**, depending on the PwSavOFF time, and can receive messages having **any preamble lengths**.
The **peripherals** and the **digipeaters units** exit from power saving cycle when a **long preamble** message is detected and remain active for all the PwSava time. During this interval they transmit with a **short (standard) preamble** and can receive messages having any preamble lengths. After the end of this time interval they transmit with a **long preamble**.

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7) Addresses from DTE Mode with or without Power Saving.

It is the most favourable operating mode to reduce the power consumption using all the utilities provided by the communication protocol. It's necessary to select the **Addr from DTE** for any units in the network, **deactivate** the **Broadcasting** option and choose an appropriate value of the **System Code** that **must be the same** for all units. In the **Master unit** this value is directly set by the **DTE** and, of course, must be the same of the peripherals. Each unit **must have** an **univocal It's Address**, generally **1** for the **Master unit**, while both the Target and Digipeater addresses are not considered. In any cases a generic value must be set in these fields. The default values of the configurations software may be an adequate choice. In the peripherals the **Addr from DTE** option must be selected if the linked DTE is able to manage the addressing process. In alternative, and only for the peripherals, the **Rx Addr for TX** option **must be activated**.
The **ACK** options permits the repetition of the message but a repetition managed **directly by the application firmware** is recommended to minimise the time losses.
The **Flow Control** option is available **only** if is selected the **RS-232** serial port, because the Flow control criteria (RTS/CTS) are not available in RS-485.
The **NAK to DTE** option is available only if the **ACK** is selected.
The **Addr to DTE** option, selectable **only** in the **Master unit**, send the **address byte** of an incoming message to the DTE.
The **Rx Addr for TX** option may be selected in the peripherals, if their DTE is not able to address the answer message. In the **Master unit** this choice is automatically inhibited by the Addr from DTE.
The **ECHO** option may be directly activated in the **System Code byte** sent by the DTE therefore don't select it in the configuration.
The **Repetition** option is not available if the **ACK** is unselected.
The next two parameters, the **PWSAVOFF Time** and the **PWSAVA Time** characterise the network for a continuous or intermittent activity. In the first case both **PWSAVOFF** and **PWSAVA are set to 0** in any unit and the network is always **active**. If all the units are fed by the AC mains, this is the recommended configuration. In this case, due to the continuous activity of the units, it's possible to configure the network for the highest possible communication speed.
If one or more unit in the network is fed by a battery or a solar cell may be necessary to enable the **Power saving Cycle** to enable the energy saving. In this case the **PWSAVOFF Time** must be selected as compromise between the required energy saving and the communication slow down, and **must be the same for all units**. The choice of the**PWSAVA Time** depends on the location of the unit in the network. For example the **Master unit** may have a **PWSAVA = 255** to permit a continuous activity, while the PWSAVA Time of each peripheral must be slightly higher than the answer lag of the linked DTE. In the digipeaters, if they are present, the PWSAVA time depends on their position in the network, as explained in the next paragraphs and this time counter is reset each time a receiving or transmitting cycle is completed, as formerly explained at page 6.

Requested data stream from DTE.

To allow the correct addressing the DTE linked to the **Master** unit **must send** an adequate numbers of bytes before the message sending. The length of this "head" depends on the communication route and the bytes sequence is the following:
1st : The **System Code byte** (values from 1 to 63) in which the bits **Nos. 7** and **6** are the **Broadcasting** and **Echo switches** respectively.
2nd : The **Number of unit**, a **byte** indicating the **total number** of units in the route. It contains both all **digipeaters** and the **target**. The maximum admissible value is **9**, equivalent to eight digipeaters plus the target.
The successive bytes are **the addresses of each digipeater** in the **correct sequence of use** and finally the **last address byte** is the **target address**. It's possible to send a **Broadcasting message** also in this operative mode. Please refer to page 5 for more information.

NOTES

1 – If one or more peripherals are linked to the master directly or through **only one digipeater**, is possible, in these units, to configure the addresses and disable the Addr from DTE option so that the DTE may send a message without any addressing. For more complex addressing it's useful the **Rx Addr for Tx** option. In this way, as explained at page 4, the received address string is reversed for the answer.
2 – In more complex networks, in which the power saving is essentially, it's possible to reduce the power consumption dividing the entire network into two or more groups having different operating frequencies. In this case only the units of a specific groups leave from the power saving cycle while the others remaining in this status. In the active group only the unit recognising his address remain active for the entire message time while the others return immediately to the power saving cycle. To allow this feature is necessary to use the **Channel change from DTE** procedure as explained on page 5.
3 – The **Master** unit **must be set** with **Its Address=1** so this unit is **always operative** and transmit with a **long preamble**, depending on PwSavOFF time, and can receive messages with both **short (standard)** and **long preamble**.

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NOTES (continued)

4 – All the **Slave** units (peripherals) and all the **Digipeaters** unit exit from power saving cycle by a **long preamble** message and remain operative for all the **PwSava** time. During this interval they answer with a **short (standard) preamble** and can receive messages with both short and long preambles. After the end of this time interval these units transmits with a **long preamble**.

5 - If the answer is longer than **640 bytes**, or **256 bytes** for the **RMO150/400 Compatible Mode**, is possible to set, for this peripheral, both the **ACK** and the **Flow control** options. In the networks **without** the **Power Saving Cycle** the ACK don't create any problems, instead in the networks **using** the **Power Saving Cycle** the presence of the digipeaters may create a timing conflict because, as formerly explained, the **ACK** message is **always** sent with a **standard (short) preamble** and , if one ore more digipeaters are in the Power saving Cycle, they can't receive and repeat the ACK message. In these cases the recommended solution is the division, realised by the DTE, of the message to be sent in two or more shorter parts. A detailed discussion on the PWSAVA Time is present in the next paragraphs.

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COMMUNICATION TIMING

The correct timing is fundamental for a successful communication. Because the radiomodem is a **Store & Forward** system the communication process contains three sequential phases.
In the **first** the **internal buffer is loaded** by the incoming data from a generic DTE. The buffer size is **640 bytes**. If the **RMO150/400 Compatible Mode** is selected, the buffer size is of **only 256 bytes**.
In the **second** the stored message is managed by the firmware in according to the communication protocol and is **transmitted** to the target unit trough the requested route. The route may contains one or more digipeaters.
In the **third** the received message, **if and only if** is correctly decoded, will be released to the communication port of the target unit.
The answer, if present, follows the same steps of the query but in a reverse path.

1 – Buffer Loading Time.

The requested buffer loading time is the sum of the time of the sending message, depending on message length and serial port speed, and the fixed **Time DTX** can be set in configuration in according to the DTE timing characteristics.
The resultant time T_{BL} is given by the following formula:

$T_{BL} = N \times T_{SB} + \text{Time DTX}$ **(1)** where:
N is the number of the bytes in the sending message. Due to the buffer size limit this number is ≤ **640** (**<256** in **RMO150/400 Compatible Mode**).
T_{SB} is the **Byte time length** in **milliseconds**. It depends on the selected **Baud rate DTE** and it's computable as:
$T_{SB} = 10{,}000 / \text{Baud Rate DTE}$.
The **Time DTX**, in **milliseconds**, is the same set in the initial configuration process and is **not used** if **Flow Control is selected**.
For example a 120 bytes message is sent by a DTE using a 9,600 bps communication speed with a Time DTX of 10 milliseconds. The resulting T_{BL} is $T_{BL} = 120 \times (10{,}000 / 9{,}600) + 10 = 125 + 10 = 135$ **milliseconds**.

2 – Transmitting time.

After the buffer loading the communication protocol takes the stored data, adds the requested bytes for addressing, quality control etc. etc., inserts a preamble and, finally, send the resultant message on the air. To simplify the computation of the total time required to transmit the entire message the following information must be considered:

A – The preamble is placed before the entire message.
B – The added bytes are, in the worst case, in number of **20** therefore the total message maximum length may be of **660 bytes** or **276 bytes** in the **RMO150/400 Compatible Mode**.

Consequently the **maximum Transmitting (On Air) time** T_{OA} is given by the following formula:

$T_{OA} = 25 + T_{pre} + (N+20) \times T_{RB}$ **(2)** where:

25 is a **fixed time** in **milliseconds**.
N is the number of bytes of the sending message.
T_{RB} is the time length of a byte in the radio transmission. It depends on the selected **Baud Rate Radio** in the configuration process and its value is computable as $T_{RB} = 10{,}000 / \text{Baud Rate Radio}$ in **milliseconds.**
T_{pre} is the **preamble time** and depends on the operating characteristics. If the operating mode **avoid** the **power saving cycle,** the preamble length is fixed and equal to **22 milliseconds**. If the power saving is used, the preamble length is:
$T_{pre} = 100 + \text{PwSavOFF}$ in **milliseconds**.
Of course the **PwSavOFF** time is the same set during the configuration process.
For example the above message of 120 bytes is sent by a Baud rate Radio of 3,600 bps without power saving. In this case the maximum Transmitting time T_{OA} is:
$T_{OA} = 25 + 22 + (120 + 20) \times (10{,}000 / 3{,}600) = 47 + 140 \times 2.778 = 47 + 388{,}92 = 441{,}92 = 436$ **milliseconds**.
If a power saving cycle with a PwSavOFF time of **500** milliseconds is used, the transmitting time T_{OA} is:
$T_{OA} = 25 + (100 + 500) + (120 + 20) \times (10{,}000 / 3{,}600) = 25 + 600 + 389 = 625 + 389 = 1{,}014$ **milliseconds**.
As shown in the above examples, the employ of the power saving mode **increases** substantially the transmitting time.
The total number of added bytes depends on the operative mode selected. For example using the **Addr from DTE** mode in a complex network with more digipeaters the number of these bytes is higher than in a simple point to point communication.

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COMMUNICATION TIMING

3 – Releasing time.

After the correct decoding of the incoming message the radiomodem firmware release the original message to its communication ports. All the added bytes during the transmission are deleted and the released message is the original message to be sent. The total **Releasing Time T_{REL}** depends on the message length and the serial port data rate. The following formula indicates the releasing time.

$T_{REL} = N \times T_{SB}$ **(3)** where:

N is the number of received bytes

T_{SB} is the **Byte time length**. It depend on the selected **Baud Rate DTE** in the configuration and its value is computable as **T_{SB} = 10,000 / Baud Rate DTE** in **milliseconds**.

For example if the Baud Rate DTE is equal to 9,600 bps the above mentioned message of 120 bytes requires a releasing time **T_{REL} = 120 x (10,000 / 9,600) = 120 x 1.0416 = 125 milliseconds** to be sent to the linked DTE. Of course the Baud Rate Radio of the two radiomodems **must be the same** for both units otherwise no decoding is possible, while the Baud Rate DTE may be different and in this case in each calculation is necessary to choose the corresponding Baud Rate DTE.

4 – Total Communication Time and Notes.

The indicated process is referred to a simple unidirectional communication between the source and the target radiomodems. For the above mentioned example the **Total communication Time T_{COMM}** is the sum of the three partial times and its value is: **$T_{COMM} = T_{BL} + T_{OA} + T_{REL}$ = 135 + 436 + 125 = 696 milliseconds** at least.

It's evident how the major delay time is imputable to the **ON AIR time** therefore the maximum allowable speed must be selected in according to the environmental conditions of the radio link. The choice of the Baud Rate DTE is forced by the DTE characteristics and, if possible, may be set to the highest allowable value for both units.

If an **answer is requested**, the related timing is computable with the same method, reversing the source and the target units.

5 – ACK message timing.

If the ACK option is selected, at the **end** of decoding and **before** of the message releasing the **ACK** message is transmitted from the target unit to the source unit. This message is **always sent** with a **standard (short) preamble**. The **ACK message Time T_{ACK}** is the transmitting (On Air) time of a message of **20 bytes** and, in according to the formula No. 2, its value is **$T_{ACK} = 47 + 20 \times T_{RB}$** in which the **$T_{RB}$** time is the same defined in the formula No. 2. For example at 3,600 bps of Baud Rate Radio the ACK time is **T_{ACK} = 47 + 55.6 = 102.6 = 103 milliseconds**.

6 – Waiting Time without Digipeaters.

At the end of the transmission cycle the **serial port** is re-activated and it is available for a new incoming message. At the same time the **target modem** is in the releasing mode and its µC is not able to receive a new message from the radio. In this time interval the eventual new message can't be decoded and therefore will be lost. To avoid this behaviour an adequate **Waiting Time T_{WAIT}** between the **end** of the previous message and the **start** of the following one **must** be inserted. The requested time is given by the following formula:

$T_{WAIT} = T_{OA} + 5 + T_{REL} - T_{BL}$ **(4)** in which:

5 is a fixed time in millisecond necessary to compensate all the time losses due to both the internal switching and the radio link and the others are the same defined on pages 10 and 11.

It's important to notice that the **T_{REL}** is referred to the **Target unit** while the **T_{BL}** to the **Source unit** and depends on the Baud Rate DTE configured in each unit. This waiting time is **essential** if a very long message, beyond the buffer size limits, is sent **without** the **Flow Control** as for a **RS-485** link. In this case the entire message **must be split** into two or more parts lower than 640 bytes (256 in the RMO150/400 compatible mode) by the DTE. If the **Flow Control** is enabled, this time **is internally calculated** by the firmware and the **CTS** criteria drives correctly the communication port.

This waiting time is useful if **no answer is expected** by the DTE. If an answer is requested, the related timing calculations will be explained later in the dedicated paragraph.

7 - Waiting time with Digipeaters.

The insertion of one or more digipeaters in the message route increases the communication timing and, consequently, the waiting time. In fact each digipeater in the route repeats immediately the incoming message, if it is correctly decoded, and successively release it to its serial port if the **Broadcasting Mode** is selected, otherwise it repeats the message and don't release it.

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If **D** is the **total number of the digipeaters units** the **total Waiting time T_{WAIT},** in milliseconds**,** requested between the **end** of the previous message and the **start** of the next one on the **Master side** of the system is given by the following formula:

$T_{WAIT} = (D + 1) \times (T_{OA} + 5) + T_{RELtarget} - T_{BL}$ **(5)** where:

$T_{RELtarget}$ is the **Releasing time** of the **Target unit**, **5** is the fixed time defined in the previous paragraph and T_{OA} and T_{BL} are the same defined on page 12. The **target unit** is commonly a **peripheral** but may be also one of the **digipeaters** in the system because a digipeater unit **may be** a **peripheral unit** with its DTE. In these cases the **digipeaters unit number** comprehends **only the previous digipeaters** in the route and the $T_{RELtarget}$ time is referred to the **digipeater unit used as target**.
For example a complete network contains one master unit, three digipeaters and seventy peripherals units splitted into four groups.The first group of peripherals are linked using all the three digipeaters, the second using only two digipeaters, the third using only one digipeaters and the last one is directly linked with the master unit without any digipeaters. Of course the **D number** for the units of the first group is **3**, for the second is **2**, for the third is **1** and for the last one is **0**. In this case the Total Waiting time is different between the four groups therefore this time must be managed by the firmware of the DTE linked to the Master unit. An other way is using the higher of this waiting times for all the groups. This choice is not the most favourable for the system speed but is the simplest to manage. If an answer is requested the related timing calculations will be explained in a dedicated paragraph.

8 – Waiting times for ACK.

The ACK option permits an higher quality control of the communication but adds a further lag time in the process. If the network firmware can manage the repetition of the queries, this solution is **better** than the activation of the **ACK option**.
If **R** is the **maximum Repetition number** of a single packet set in configuration, the **maximum total Waiting time** in millise-conds is given by the following formula:

$T_{WAITack} = (R + 1) \times (T_{OA} + 5 + T_{ACK})$ **(6)** where all the parameters are defined as in pages 11 an 12. The formula is valid in the case of a system without digipeaters. If one or more digipeaters are used, the resulting waiting time, in milliseconds, is given by the next formula:

$T_{WAITackdigip} = (D + 1) \times [(R + 1) \times (T_{OA} + 5 + T_{ACK})]$ **(7)**.
This is the maximum time if all the repetitions are unsuccessful and, of course, if a success happens with a lower number of repetitions, this time is proportionally reduced.

9 – Timing of the Answers.

The most common application consists in a query from the master to the target unit with an answer in the reversed direction.
Normally, after a query, the Master's DTE waits an adequate time interval before repeat the query or skip to an other peripheral.
The answer is a packet, longer or shorter than query, depending on the requested applications. Because the modem configuration parameters are the same for both query and answer, the time calculation is the same in both directions. The unique difference is the **DTE answer delay time T_{DTE}** depending on its characteristics and, in many cases, it is configurable by the DTE firmware. Some DTE units are characterised by an **immediate answer** and the RT150/400 can manage these situations. In the next formulas the **query timing** is in normal bold characters while the **answer timing** is in bold and **italics** characters to divide the specific timings. In a direct communication, **without digipeaters**, the requested **total waiting time** for answer T_{AWAIT}, in milliseconds, between the **end** of the previous query and the **start** of the next one is given by the following formula:

$T_{AWAIT} = (T_{OA} + 5) + T_{REL} + T_{DTE} + T_{BL} + (T_{OA} + 5) + T_{REL}$ **(8)**

If **D** digipeaters are used in the message route, the resulting waiting time $T_{AWAITdigip}$,between the **end** of the previous query and the **start** of the next one, will be given by the next formula:

$T_{AWAITdigip} = (D + 1) \times (T_{OA} + 5) + T_{REL} + T_{DTE} + T_{BL} + (D + 1) \times (T_{OA} + 5) + T_{REL}$ **(9)**.

In this particular application it's important to remember that all the query timings are generally different from all answer timings due to the different packet length between query and answer. Using the results of these calculations as **minimum** answer time-out, the Master's DTE is properly configured for the communication.

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10 – Power Saving Mode in a Point-Multipoint network.

This operating mode is specific for all the applications in which a supply by the ac mains is not available and the energy saving is requested. As previously explained to exit both the **digipeaters** and the **peripherals** from the power saving cycle it's necessary a **long preamble** message therefore all these units remain active for the PwSava time and successively they return in the power saving cycle. The **Master unit** must be configured with **255** as **PwSava** as explained in page 8. In the most common applications the **query** starts from the Master when all the network is in Power saving cycle while the **answer** come back to the Master during the operative condition. In this conditions the answer is faster than the query and in this way the entire radio network is active for the minimum required time. If the radio network is in operative conditions, i.e. all the units are in the **PwSava** interval, the **total waiting time for answer** $\mathbf{T_{AWAIT}}$ is the same calculated by the formula No. **9** in the previous page. If only a unit come back in the Power Saving mode during the answer cycle, this will be lost because the unit in the power saving mode requires a long preamble to decode the incoming message while the others transmit with a short preamble, since they are in the PwSava interval.
In the following formulas all the **query timings** are indicated in a normal bold characters while all the **answer timings** are indicated in **bold and italics** characters to divide the specific timings.
The requested PwSava time , in milliseconds, for the generic target unit depends on the DTE answer delay time $\mathbf{T_{DTE}}$ and may be set in according to the following formula:

$\mathbf{PwSava_{TARGET} \geq 100 + T_{DTE} + T_{REL} + \boldsymbol{T_{BL}}}$ **(10)** where:

$\mathbf{T_{DTE}}$ is the answer delay time, in milliseconds, of the DTE connected to the considered target modem and **100**, in milliseconds, is an additional fixed time necessary to ensure a safe margin. If a total number of **D** digipeaters are present, the **intermediate I digipeater** of the route, counted from the Master unit, requires a **minimum** $\mathbf{PwSava_{DIGIP}}$, in milliseconds, given by the following formula:

$\mathbf{PwSava_{DIGIP\text{-}I} \geq 100 + (D - I + 1) \times T_{OA} + T_{REL} + T_{DTE} + \boldsymbol{T_{BL}} + (D - I + 1) \times \boldsymbol{T_{OA}}}$ **(11)** where:

D is the number of the digipeaters in the network, **I** is the position of the intermediate digipeater to be configured counted from the master and **100**, in milliseconds, is a additional time necessary to ensure an adequate safe margin. This time may be increased by steps of 100 milliseconds if necessary.
For example in a network with four digipeaters the PwSava required in the second digipeaters from the master is:

$\mathbf{PwSava_{DIGIP2} = 100 + (4\text{-}2\text{+}1) \times T_{OA} + T_{REL} + T_{DTE} + \boldsymbol{T_{BL}} + (4\text{-}2\text{+}1) \times \boldsymbol{T_{OA}}}$

The time $\mathbf{T_{OA}}$ contains the **PwSavOFF time** set during the configuration process and, as requested for the correct application of the Power Saving Mode, this time **must be the same** in **all units** of the network. Of course, the resulting time interval is much longer than the same used in the normal operative conditions. Because the answer starts during the PwSava time it is sent with a **short preamble**, therefore the $\boldsymbol{T_{OA}}$ **time** do not include the PwSavOFF.

11 – Master's DTE Time-out between queries.

In the Power Saving Mode the query travels much slower than the answer and this causes the lengthening of the time interval between two queries to permit the answer reception. It's a good practice to send the next query when **all units** are certainly returned in the Power Saving cycle. Because the last digipeater coming back in the power saving cycle is the **nearest** to the master unit, it's necessary to wait the coming back of this digipeater in the Power saving cycle. The resulting **Master's DTE time-out** $\mathbf{T_{WAITMaster}}$ between the **end** of the previous query and the **start** of the next one is given by the following formula:

$\mathbf{T_{WAITMaster} = T_{OA} - T_{BLMaster} + 2 \times [\ 100 + D \times T_{OA} + T_{REL} + T_{DTE} + \boldsymbol{T_{BL}} + D \times \boldsymbol{T_{OA}}\ ]}$ **(12)** where the time $\mathbf{T_{BLMaster}}$

is generally the shortest and, consequently, negligible.
In more complex networks alternating the queries between the sections having different digipeaters units is the best solution to reduce the Master's DTE time-out between the queries. In this case the section interested by the previous query can come back in the Power Saving cycle while the other sections are active. With an appropriate selection the $\mathbf{T_{WAITMaster}}$ may be substantially reduced and, in the best case, may be reduced to the value indicated by the formula No. 9 on page 14.

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11 – Power Saving in an high acquisition speed network.

In a very complex network, using the Power Saving Mode, the acquisition speed may be very slowed down if the message route contains many digipeaters. As explained in the previous paragraph, the PwSava time of each digipeater must increase from the target to the master unit, therefore the first digipeater in the chain has got the maximum PwSava time. Moreover the time interval between two successive queries is, in practice, the double of the PwSava time set in the first digipeater unit.
In many cases the use of the Power Saving mode is imposed by a small part of the network that can't be fed by the ac mains.
The resulting PwSavOFF time is chosen to obtain the requested energy saving in the more critical unit, and, of course, the same value is set in all units of the network. As function of both this fixed value and the network complexity, all the other timings, PwSava included, are automatically derived by the calculations shown in the previous paragraphs and, consequently, the related time interval between the queries may be too long to allow the requested acquisition speed.
The unique solution is to configure the network with all digipeaters fed by the ac mains otherwise the network **can not be optimised** for the maximum acquisition speed.
To configure the network for this operating condition the following settings must be used:

A – Master Unit.

The master unit is normally placed in a location fed by the ac mains and although the network employ the Power Saving Mode this unit must be always operative. To obtain this operating condition the **PwSava must be set to 255**. The transmitted preamble length depends on the **Its Address** value in according with the following rules:
A.1 – Its Address = 1 → The unit transmits both **Data** and **ECHO request** with a **long preamble** to **all peripherals** in the **Power Saving Mode** while utilises a **standard (short) preamble** if the 1st unit is a **digipeater**. In this case the **digipeater** unit **must have** a **PwSava** value of **255** to recognise the standard preamble. The **ACK** message and the **ECHO answer** are **always** sent with a **standard (short) preamble**.
A.2 – Its Address > 1 → The unit transmits both **Data** and **ECHO request** with a **long preamble** while the **ACK** and the **ECHO answer** is sent with a **standard (short) preamble**. In any cases the Master unit **can recognise preambles with any length**.

B – Target Units.

All the target units **must have** an **Its Address higher than the Master one**. During the Power Saving Mode they recognise and transmit with a **long preamble** while during the PwSava time they transmit with a **short preamble** and can recognise both **long** and **standard (short) preamble** incoming messages.

C – Digipeater Unit.

Setting the **PwSava** of a digipeater to **255** the unit is configured as an always operative unit compatible with the Power Saving Mode. The **Its address** of the digipeater **cannot be 1** because this value is **reserved** to the **Master unit** as previously explained. In this mode the digipeater unit is always active but can generate message with short or long preamble depending on the message route. In particular the messages directed to the **target unit** are transmitted with a **long preamble** while the messages directed to the next digipeater is transmitted with a **short preamble** and, of course, this one **must have PwSava = 255** to recognise the standard (short) preamble incoming message.
The **PwSavOFF** time **must be the same** for all the units. In this operating conditions the time interval between two queries, in the DTE linked to the master unit, is given by the following formula:

$$\mathbf{T_{WAIT} = T_{OAS} - T_{BLM} + 2\ x[100 + D\ x\ T_{OAS} + T_{OAL} + T_{REL} + T_{DTE} + \mathit{T_{BL}} + (\mathit{D} + \mathit{1})\ x\ \mathit{T_{OA}} + \mathit{T_{REL}}](13)}$$

where:
$\mathbf{T_{WAIT}}$ is the resulting time interval between two queries
$\mathbf{T_{OAS}}$ is the transmitting time of the query with a **short preamble** (please refer to the formula No. **2** on page 12)
$\mathbf{T_{OAL}}$ is the transmitting time of the query with a **long preamble** (please refer to the formula No. **2** on page 12)
$\mathbf{T_{BLM}}$ is the buffer loading time of the query in the master unit (please refer to formula No. **1** on page 12)
100 in **milliseconds** is the usual fixed time for a safe margin
D is the **total number** of digipeaters in the network
$\mathbf{T_{REL}}$ is the releasing time of the query in the **target unit** (please refer to the formula No. **3** on page 3)
$\mathbf{T_{DTE}}$ is the delay time of the target DTE to answer
$\mathit{T_{BL}}$ is the **answer** buffer loading time in the **target unit** (please refer to the formula No. **1** on page 12)
$\mathit{T_{OA}}$ is the **answer transmitting time** with a **short preamble** (please refer to formula No. **2** on page 12)
$\mathit{T_{REL}}$ is the **answer releasing time** in the **master unit** (please refer to the formula No. **3** on page 13)
Between all these time intervals the shortest one is, generally, the $\mathbf{T_{BLM}}$ that may be neglected in the calculation.

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