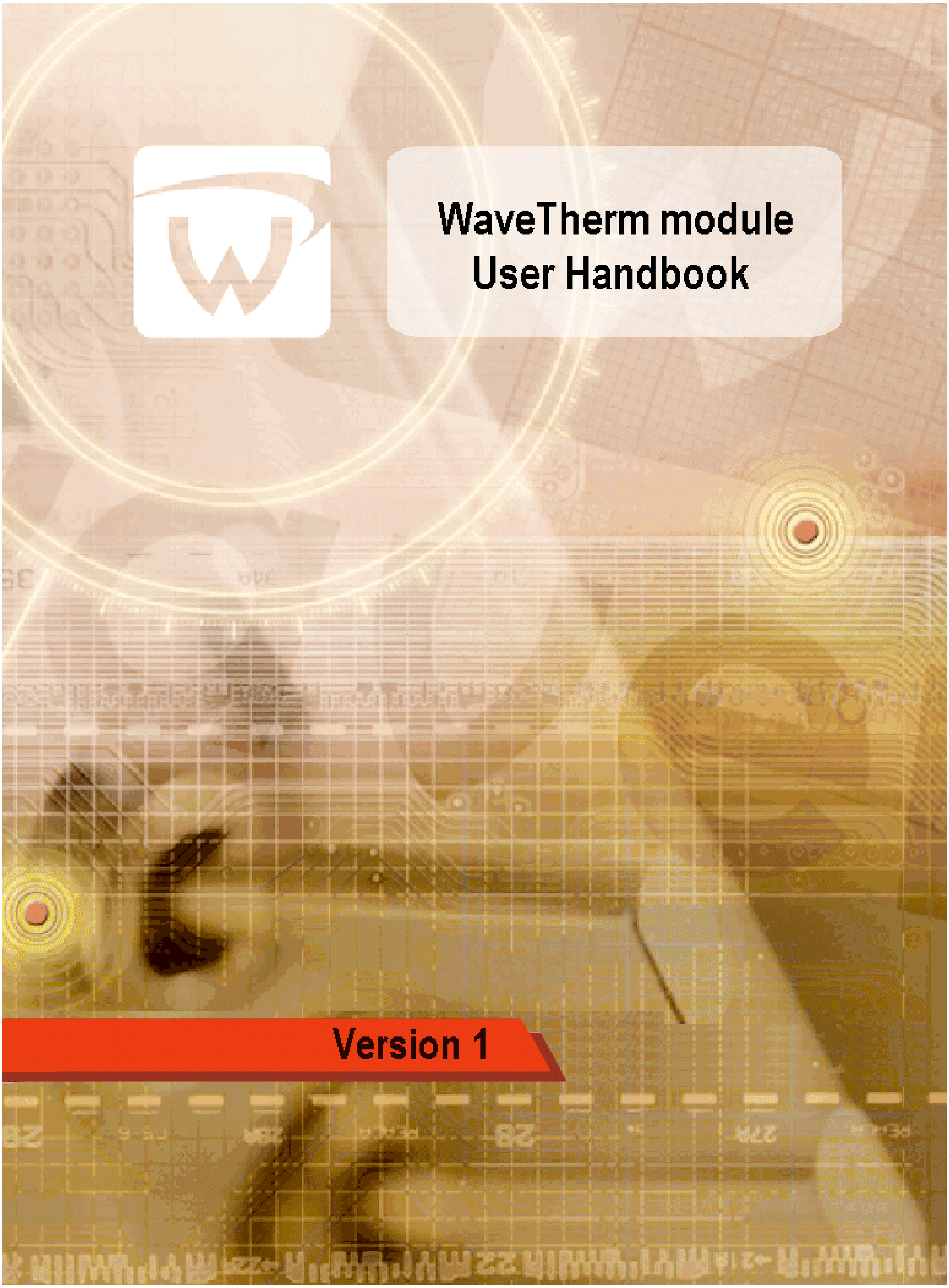


WaveTherm module User Handbook

Version 1

REVISIONS HISTORY

Rev. #	Description	Author	Date	Comments
1	Original document	RCS	02/02/05	Version 1
2	Addon text FCC	RCS	17/02/05	Version 2

SUPPORTED FIRMWARE VERSION

➢ WaveTherm - DALLAS

- European Version

Manual version	Firmware version	Date
1.0	V 01.04	15/10/04

- US Version

Manual version	Firmware version	Date
1.0	V 81.05	15/10/04

➢ WaveTherm - PT100

Manual version	Firmware version	Date
1.0	V 01.02	15/10/04

➢ WaveTherm - PT1000

Manual version	Firmware version	Date
1.0	V 01.00	15/10/04

This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions : this device may not cause harmful interference, and this device must accept any interference received, including interference that may cause undesired operation.

Caution : any changes or modifications not expressly approved by Coronis-Systems could void the user's authority to operate the equipment.

TABLE OF CONTENTS

1 PRESENTATION

This document describes the functionalities of *WaveTherm* radio modules :

WaveTherm – DALLAS	*Used with DALLAS sensor*
WaveTherm – PT100	*Used with PT100 sensor*
WaveTherm – PT1000	*Used with PT1000 sensor*

This document defines in an exhaustive way the applicatives data relating to serial dialog frames between a *Wavecard* and a host equipment , used to reach the data of the *WaveTherm* radio module.

2 REFERENCE DOCUMENTS

Ref	Title	Reference	Version	Date
DR[1]	WaveCard user handbook			

3 PRESENTATION OF THE WAVETHERM MODULES FUNCTIONALITIES

3.1 SENSORS INTERFACE

- **WaveTherm – DALLAS :**

  The module is designed to manage to the maximum two DALLAS temperature sensors (type DS18B20).
  This DALLAS sensor of 1-wire type integrates a 12-bit internal converter.
  Each external sensor is connected to the module by a cable equipped with a BINDER connector of 3-pin type.

  An automatic identification of the temperature sensors allows to memorize the identifier of the sensors. This phase is automatically carried out when powering the module
  and is also activated on a specific radio request (in this case, The module returns by radio the identifiers of the sensors).

- **WaveTherm – PT100 :**

  The WaveTherm-PT100 module has the possibility to manage 1 or 2 PT100 temperature sensors.
  The probes are connected to the module through impervious connectors allowing to connect 2, 3 or 4 wires probes.

- **WaveTherm – PT1000 :**

  The WaveTherm-PT1000 module has the possibility to manage 1 or 2 PT1000 temperature sensors.
  The probes are connected to the module through impervious connectors allowing to connect 2, 3 or 4 wires probes.

3.2 READ TEMPERATURES

The WaveTherm module has the following possibilities:

- To read the current temperature ;
- To transmit the last N temperatures stored, in one frame.

If two temperature sensors are used, then the WaveTherm return the last N/2 values of each sensor.

WaveTherm – DALLAS :	N = 48 temperatures
WaveTherm – PT100 :	N = 24 temperatures
WaveTherm – PT1000 :	N = 24 temperatures

3.3 PERIODIC TEMPERATURE READING (DATALOGGING)

Periodic reading of temperatures is available in two versions. In both cases, the module may be configured to store the temperatures measured periodically (in time intervals ranging from a minute to several hours), once a week or once a month.

- **Standard datalogging :**

Periodic collection of temperature measurements up to N temperatures. In this case, it functions in *'permanent loop'* mode, i.e. the most recent measurements replace the oldest measurements.

WaveTherm – DALLAS :	N = 48 temperatures;
WaveTherm – PT100 :	N = 24 temperatures;
WaveTherm – PT1000 :	N = 24 temperatures.

- **Advanced datalogging:**

Periodic collection of temperature measurements up to M temperatures. In this case, it functions in *'stop memory full'* mode.

WaveTherm – DALLAS :	M = 4500 temperatures;
WaveTherm – PT100 :	M = 2000 temperatures;
WaveTherm – PT1000 :	M = 2000 temperatures.

> ***Remark :** Only the 'Stop memory full' mode is currently operational : when the memory corresponding to N temperatures is full, datalogging stops automatically.*
>
> *A new parameter setting cycle must then be started with a specific radio command.*
>
> *A future upgrade will enable permanent looping with indication of looping.*

3.4 MANAGEMENT OF THRESHOLD ALARMS

The **WaveTherm** module detects when the values exceed the threshold levels (high or low) for a given period of time.
The WaveTherm – PT100 and PT1000 may be configured with a precision level offering a more reliable measurement even in environments with excessive interference (see chapter 7.2.1).

Three types of threshold alarm detection methods may be programmed :

- immediate threshold alarm detection
- threshold alarm detection for a given continuous period of time (successive mode)
- threshold alarm detection for a total period of time (cumulative mode)

3.4.1 Threshold Alarm Detection

Threshold alarm detection requires periodic measurement of the temperature for a predefined period. The value of this period enables establishment of the threshold alarm detection reactivity.

This period is set independent of the datalogging period. However, for power saving reasons, it is recommendable to set the datalogging period as a multiple of the threshold alarm detection period.

The following parameters apply to this function:

- High threshold alarm,
- Low threshold alarm,
- Threshold excess time (used in cumulative and successive mode),
- Mode parameter setting byte (high threshold enabled, low threshold enabled, immediate, successive or cumulative mode).

3.4.2 Storage of Threshold Alarm occurences

Threshold alarms are stored in a memory zone which may be accessed by radio. If the number of threshold alarms exceeds the memory storage capacity, the oldest alarms recorded are deleted.
The following information is recorded in the table:

- Threshold alarm detection date
- Threshold alarm detection duration
- The average value of all measurements recorded during the alarm period.

3.4.3 Transmission of a Threshold Alarm Frame

The module may be programmed to transmit a radio frame as soon as a threshold alarm is detected.

3.5 STORAGE OF CALIBRATION PARAMETERS

The WaveTherm module manage a non-volatile memory area accessible by radio command, and allowing to store up to 32 bytes.

This area is not used by the internal process, and is generally used to store the parameters relative to the calibration of the module, and can be read, or modified by specifying the start address, and the size of the data.

3.6 WAKE-UP SYSTEM MANAGEMENT

In order to reduce module power consumption, a wake-up period parameter setting system is incorporated. This system enables modification of the module wake-up period (default setting 1 s) by entering a time and day of the week :

- The wake-up period default value may be modified;
- Two time-windows with different wake-up periods may be defined;
- Each day of the week may be set in one of the following three cases :
  - Wake-up period default setting
  - Wake-up according to predefined time windows
  - No wake-up period (for safety reasons, the module is not disabled on reception and it wakes up every 10 seconds)

> ***Note :** The system is disabled by default and must be enabled by writing a specific profile in the wake-up system status word.*

3.7 AUTOMATIC TRANSMISSION OF FAULTS

The WaveTherm module offers the possibility to automatically transmit radio frames when an occurrence is detected.

The following occurrences may provoke an automatic alarm:

- Threshold detection (see chapter 7.6)
- End of battery life detection (see chapter 7.8)
- Probe fault detection *(WaveTherm – PT100 and PT1000 only)*

It is possible to select for each type of occurrence whether or not an alarm frame is to be sent.
The radio address of the receiver module and the repeater path must be preset with a radio signal.

3.8 SENSOR FAULT DETECTION (if supported by the module)

For all modules, temperature probe absence or error detection is carried out during a write request and is indicated by the presence of a specific value which does not correspond to a possible temperature value.

However, in the case of the **WaveTherm – PT100 and WaveTherm – PT1000 modules only**, after detection of a probe fault, the module carries out the following operations:

- records the detection date in internal parameters (0x91 ; 0x92).
- If required, transmits an immediate probe fault detection radio frame.

3.9 END OF BATTERY LIFE DETECTION

To detect the end of battery life, the **WaveTherm** module uses the power metering principle rather than measurement of the battery voltage. Lithium batteries are, in particular during passivation, unsuitable for the voltage measurement method to determine the remaining capacity.

The **WaveTherm** records and evaluates all events (measurements, transmissions) to decrement the power meter according to the battery used. When the meter passes below a predefined threshold, the “end of battery life” is signalled with the *Application Status* byte.

The initial value of the end-of-life meter is factory-set. It depends on the type and number of batteries used. *When the end of battery life is detected, the detection date is memorised and may be read with a radio command.*

Please refer to the WaveTherm module technical specifications, for more details on the life of the modules.

4 DATA EXCHANGE PRINCIPLE WITH A WAVETHERM MODULE

The WaveTherm module uses the **WAVENIS** protocol.

The choice of mode used is initiated by the read element which uses a different set of commands (see WaveCard document) when sending commands to the WaveCard.

The following chart indicates the read modes possible as well as their typical applications.

Read mode	Description	Recommendations
Peer-to-peer	Individual reading with re-transmission management in case of no reply	Standard use
Polling	This mode enables successive polling of several modules in a single operation . The principle consists of waking up several modules with the 1st radio transmission.	To be used when module reading time is an important factor. Re-transmission not possible.
Broadcast and multicast (*)	This mode enables use of a single frame to address all radio modules within reception range. The multicast mode may only address one group of modules.	This mode enables reading of modules without knowing their radio address. Type of use: detection of radio modules within range of the emitter module (installation phases).

- **Additional functions:**

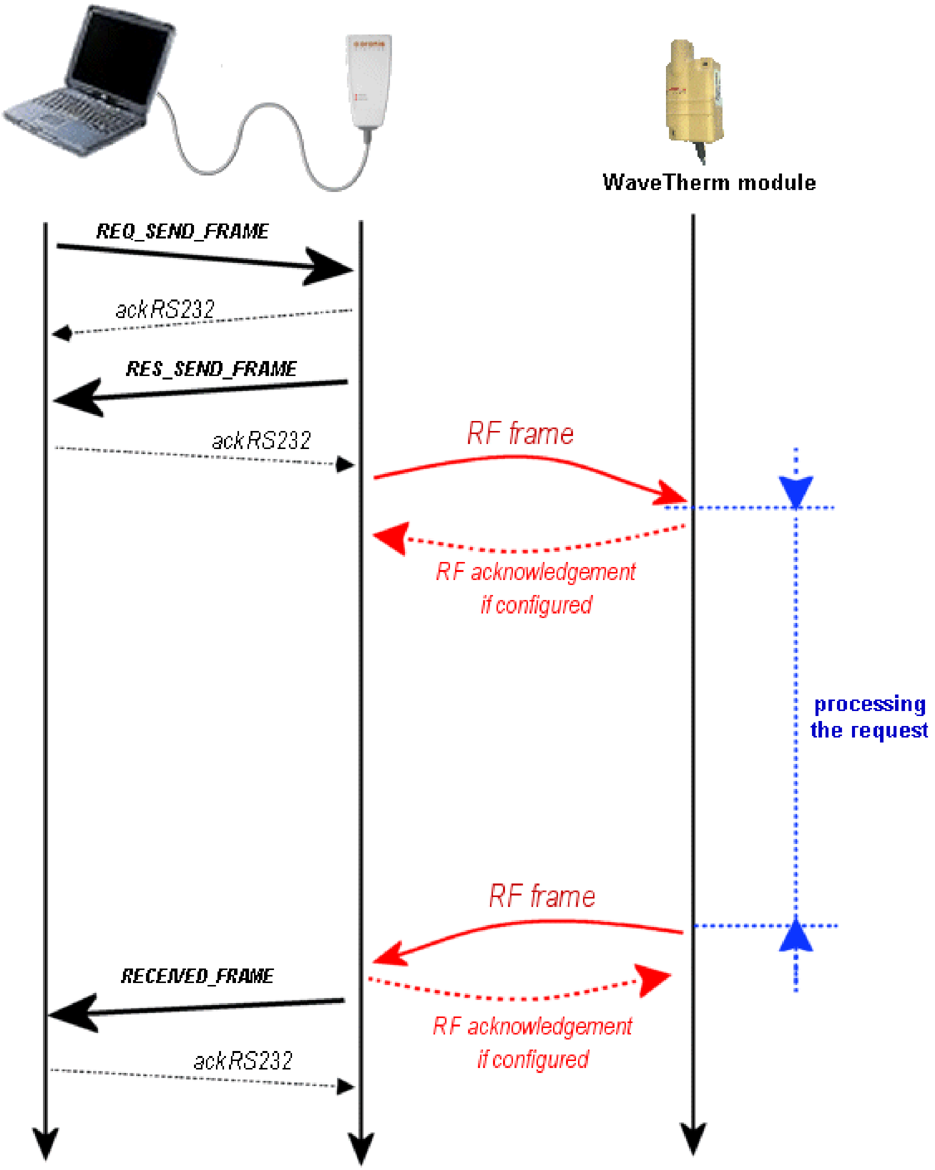
Additional functions	Compatibility	Description	Recommendations
Repeater	Only used in point-to-point mode.	This function enables use of a radio module to relay a frame which was not initially intended for this module. This is a default function of the WaveTherm module, i.e. it may be read via several repeaters but may also act as a repeater itself when reading another unit.	This function is used when the caller module and the target WaveTherm module are outside radio range. The maximum number of repeaters is limited to 3.

Attention: collection of data in multi-frame mode (advanced datalogging) is not possible in repeater mode.

- **Example in Point-to-point mode :**

Remark *: Generally, the exchanges examples given in this document will be in Point-to-point mode, except when the context depends directly on the mode of exchanges.*

This type of radio exchange allows to send a request, then to await a response of the remote equipment.



Note : the commands of Point-to-point exchanges, have the following format: (all the exchanges modes are treated in document [DR1])

CMD	NAME	DESCRIPTION
0x20	REQ_SEND_FRAME	Request to send a radio frame with the waiting for the radio response.
0x30	RECEIVED_FRAME	Received radio frame by the radio board.

The data field of each command must be formatted according to the following table :

CMD	**DATA**	
	6 bytes	variable (max : 152 bytes)
0x20	**Radio address from equipment to reach**	**Data to transmit**
0x30	**Radio address from transmitter equipment**	**Received Data**

the first byte of the field 'data to transmit' (or 'Received Data') contains an applicative command (or its acknowledgement). That allows to the receptor of the frame to identify the type of requests (or of responses).

	Data to Transmit or Received Data	
	1 byte	151 bytes
REQ_SEND_FRAME	Applicative command	Data relating to the request
RECEIVED_FRAME	Acknowledgement of the applicative command	Data relating to the response

The commands set is available in Appendix A.

⚠ *ATTENTION, This document describes only the format of the fields 'Data to Transmit', 'Received Data'. These fields are directly dependent on the access to the functionalities of the WaveTherm modules. The other fields of the radio frame depend on the exchanges modes chosen, and are detailed in document [DR1].*

5 INFORMATION RELATIVE TO THE PROBES ASSOCIATED WITH THE WAVETHERM MODULES

5.1 DALLAS Probes

5.1.1 Coding of temperatures for the DALLAS probe type DS18B20

These probes have a resolution of 12 bits and their value is coded on two bytes (MSB first)
Negative values are expressed in two's complements with addition of a sign.

MSB							LSB	MSB							LSB
Most Significant Byte								Leasr Significant Byte							
b7	b6	b5	b4	b3	b2	b1	b0	b7	b6	b5	b4	b3	b2	b1	b0
S	S	S	S	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}

Unit : Celsius degree (°C)
Bits [b7:b3] : sign bit.

***Remark:** The hexadecimal value 0x4FFF indicates the absence of a probe, or a connection error between the module and the probe.*

- Some temperature values:

Temperature	Binary value (MSB First)	Hexadecimal value
+125°C	0000 0111 1101 0000	0x07D0
+85°C	0000 0101 0101 0000	0x0550
+25°C	0000 0001 1001 0000	0x0190
0°C	0000 0000 0000 0000	0x0000
-10.125°C	1111 1111 0101 1110	0xFF5E
-55°C	1111 1100 1001 0000	0xFC90

5.1.2 Probe ID

The probe ID corresponds to a unique code attributed to each DALLAS temperature probe in the factory.
This code is composed of 8 bytes defined as follows:

MSByte		LSByte
1 byte	6 bytes	1 byte
Family Code	Serial n° (48 bits)	CRC Code

The family code is used to distinguish between the probes used:
Probe DS18S20 : 0x10
Probe DS18B20 : 0x28

5.1.3 Setting of the probe coefficient parameters

The precision of DALLAS probes is indicated by the manufacturer as ±0.5°C (-10°C to +85°C) and requires no calibration before use.

However, it is possible to improve this precision if the user wishes to calibrate the probe. In this case, the WaveTherm module contains a 32-byte memory zone for storage of transfer coefficients after calibration.

Initially, two parameters was created (size: 2 bytes per parameter), each one being able to store the value of a coefficient of transfer.
After calibration, this allowed to refine measurement with a 2 degrees polynomial to the maximum.

Thereafter, a more important memory area was implemented, in order to store user data. Users can use this area for whatever they want, but in order to increase the measurement precision, this 32-bytes area allows to store a more significant number of coefficients.

Consequently the polynomial used can be superior degrees to 2; and allows to obtain a finer sleeking of information. Management of this memory area is described further in chapter 7.1.5.

Remark : *To maintain compatibility with old versions of the modules (Is)Thermeter), the storage parameters of the coefficients are always existing, and are accessible by commands of reading and writing of internal parameters.*

- *Parameter 0x25 : parameter A relating to sensor 1*
- *Parameter 0x26 : parameter B relating to sensor 1*
- *Parameter 0x27 : parameter A relating to sensor 2*
- *Parameter 0x28 : parameter B relating to sensor 2*

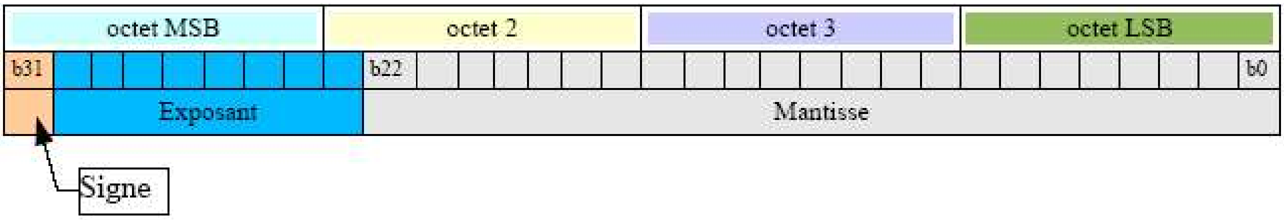
5.2 PT100 and PT1000 probes

5.2.1 Representation of temperature values

Due to the high level of precision required of the temperature values processed by the module, WaveTherm PT100 or PT1000 are true numbers (with a mantissa and exponent).
They are represented in the form of a 32-bit floating number.

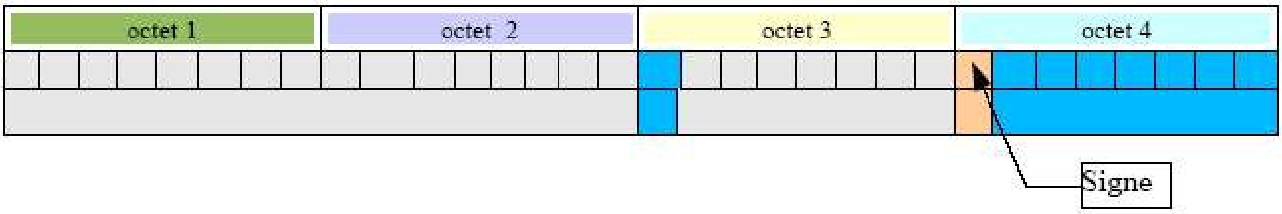
The format used is the standard IEEE format with precision coded on 32 bits (+/-5.8774e-39 to +/- 170,14e36)

- Theoretic representation of a floating IEEE 32-bit in bytes :



- Representation of the floating numbers in the radio buffer:

The radio module represents the 32-bit floating data in its buffers by coding them in LSB first. This is the standard representation format used by the compilers C/C++ on PC.



A shift of the exponent allow to code it from E-127 to E+128

5.2.2 Calibration of radio module

- **Factory calibration**

The precision of PT100 and PT1000 probes is such that the WaveTherm module measurement chain requires calibration.
This calibration is carried out automatically in the factory and the product is supplied ready for use.

- **Re-calibration on site**

Re-calibration on site is possible under certain conditions.
To carry out this operation, it will be necessary to connect two calibration precision resistances.

> ***Remark:*** *Calibration is therefore only possible on WaveTherm PT100 (or PT1000) modules equipped with two probe inputs.*

The WaveTherm PT100 and PT1000 modules possess two module calibration parameters. These parameters are accessible in read-only and are updated with a calibration command
They contain the internal reference resistance values used during temperature measurement.

- *Parameter 0x30 : value of the internal reference resistance very low*
- *Parameter 0x31 : value of the internal reference resistance very high*

Calibration is therefore carried out using precision calibration resistances for accurate measurement of the internal reference resistances and storage of the associated results in internal parameters. These values are then used during temperature measurement.

> ***Remark :*** *Calibration resistance value:*
> *- for WaveTherm – PT100 : 60 and 160 ohms.*
> *- for WaveTherm – PT1000 : 160 and 1600 ohms.*

- **Associated radio commands**

Applicative Command	Description
0x08	Request to calibrate the radio module
0x88	Response to the request to calibrate the radio module

- contents of REQ_SEND_FRAME request

Data Field (max : 152 bytes)		
Applicative Command	**Value of the internal reference resistance very low (float - LSB First)**	**Value of the internal reference resistance very high (float - LSB First)**
1 byte	4 bytes	4 bytes
0x08		

> ***The fields concerning the values of the internal reference resistors must be indicated with 32-bits floating numbers (LSbyte first). A more precise description of the 32-bits floating number format is indicated in chapter 5.2.***

- contents of RECEIVED_FRAME response

Data Field (max : 152 bytes)			
Acknowledgement of the applicative command	**Status de l'étalonnage**	**Reference resistance A (LSB First)**	**Reference resistance B (LSB First)**
1 byte	1 byte	4 bytes	4 bytes
0x88	**0x00** : calibration OK **0xFF** : calibration error		

Resistances A and B are restored in the 32-bits floating numbers format (LSB first). Format described in chapter 5.2.

5.2.3 Setting of probe coefficient parameters

The PT100 and PT1000 probes have a coefficient providing a linear temperature response.

Remark : *The European standard EN60751 relative to probes defines 3 coefficients A,B and C used in the calculation of the relationship : resistance = f (temperature).*

- *In the -200 to 0°C range :* **$R = R0[1+At + Bt^2 + C(t – 100°C)t^3)$**
- *in the -0°C to 850°C range:* **$R = R0(1+At + Bt^2)$**

R0 : Resistance at 0°C
A, B and C: transfer coefficients

As the WaveTherm module operating mode consists of measuring the probe resistance and then calculating the temperature, it requires coefficients in order to calculate the relationship between these values:

temperature = f (resistance)
and not *resistance = f (temperature).*

The relationship T = f(R) must therefore be calculated according to the relationship provided in standard EN60751.
The following polynomial is used:

$$T = C_7.R^7 + C_6.R^6 + C_5.R^5 + C_4.R^4 + C_3.R^3 + C_2.R^2 + C_1.R + C_0$$

where *C_7, C_6, C_5, C_4, C_3, C_2, C_1, and C_0 are the parameters to be transferred to the radio module*

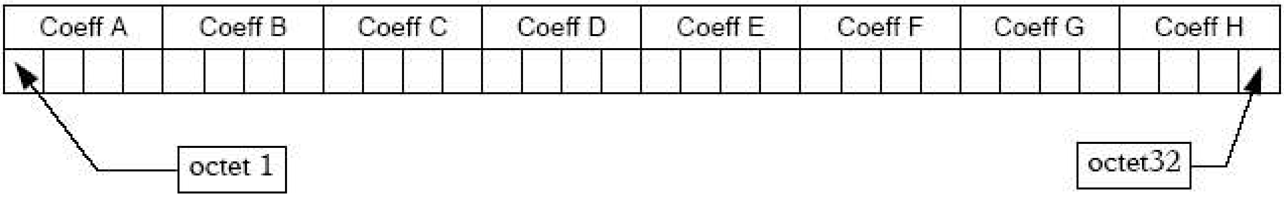
The coefficients to be transferred to the radio module are based on the coefficients A,B and C (given by the manufacturer of the PT100 or PT1000 probes) in a mathematical formula. When required, CORONIS is able to provide a utility enabling calculation of these coefficients. There are 8 in total (coeff A to H).

They are managed with standard internal parameters read and write commands. (see chapter 6.2).

All coefficients are regarded by the radio module as a single parameter.

Parameters	Description
0x32	Coefficients of probe 1
0x33	Coefficients of probe 2

Each parameter is composed of 8 coefficients of 32 bits (floating IEEE) with a total size of 32 bytes.
The coefficients are represented in the radio buffer during use of the parameter read/write commands as follows :



Remark: *Coeff A : C_0* *Coeff E : C_4*
Coeff B : C_1 *Coeff F : C_5*
Coeff C : C_2 *Coeff G : C_6*
Coeff D : C_3 *Coeff H : C_7*

6 MODIFICATION OF THE INTERNAL PARAMETERS

6.1 INTERNAL PARAMETERS LIST ACCESSIBLE BY RADIO COMMANDS

6.1.1 Parameters common to all WAVETHERM versions

The table below describes the internal parameters accessible by standard read and write commands.

N°	Description	Size (in bytes)	Access right	Default value	
				Hexa.	Decimal
0x01	Operating Mode	1	R/W	Depending of the module used (see 6.1.5)	
0x02	WakeUp system status word	1	R/W	0	0
0x03	Default WakeUp period (in second)	1	R/W	0x01	1
0x04	Start time for 1st time window	1	R/W	0x07	7
0x05	WakeUp period for 1st time window (in second)	1	R/W	0x01	1
0x06	Start time for 2nd time window	1	R/W	0x12	18
0x07	WakeUp period for 2nd time window (in second)	1	R/W	0x01	1
0x08	Enalbe time windows by day of the week	1	R/W	0xFF	255
0x09	Enable WakeUp periods by day of the week	1	R/W	0x00	0
0x0A	number of loop of the datalogging storage table	1	R	0x00	0
0x0B	Number of temperature values stored in the table (LSB first)	2	R	0x0000	0
0x19	Numbers of retries of transmission of alarm frames	1	R/W	0x03	3
0x1A	Delay between two retries of transmission of alarm frames	1	R/W	0x3C	60
0x20	Application Status	1	R/W	0x80	128
0x22	Alarm Configuration byte	1	R/W	0x00	0
0x80	Measurement Period (datalogging in time steps)	1	R/W	0x13	19
0x81	Start hour of the datalogging in time steps	1	R/W	0x08	8
0x82	Day of the week, or of the month (datalogging)	1	R/W	0x01	1
0x83	Time of measurement (datalogging once a week, or once a month)	1	R/W	0x08	8
0x85	Group number to use in polling mode	1	R/W	0x00	0
0x90	Date of detection of end of battery life	6	R/W	0	0
0xA1	Firmware version	1	R	-	-
0xA2	Battery life duration counter	2	R	Depending of the power supply profile	
0xB0	Number of repeaters used to transmit an alarm frame	1	R/W	0x00	0
0xB1	Address of the 1st repeater used to transmit an alarm frame	6	R/W	-	-
0xB2	Address of the 2nd repeater used to transmit an alarm frame	6	R/W	-	-
0xB3	Address of the 3rd repeater used to transmit an alarm frame	6	R/W	-	-
0xB4	Address of the recipient of the alarm frame	6	R/W	0x010A030000BD	-

6.1.2 Parameters specific to the WaveTherm – DALLAS module

N°	Description	Size (in bytes)	Access right	Default value	
				Hexa.	Decimal
0x25	Parameter A relative to the sensor 1	2	R/W	0xFFFF	-
0x26	Parameter B relative to the sensor 1	2	R/W	0xFFFF	-
0x27	Parameter A relative to the sensor 2	2	R/W	0xFFFF	-
0x28	Parameter B relative to the sensor 2	2	R/W	0xFFFF	-
0x23	Measurement period of the threshold detection (in minutes)	1	R/W	0x00	0
0x15	High Threshold Alarm – Sensor 1	2	R/W	0x01A0	**26°C**
0x16	Low Threshold Alarm – Sensor 1	2	R/W	0x0100	**16°C**
0x17	High Threshold Excess Time – Sensor 1 (multiple of the measurement period of threshold detection)	1	R/W	0x04	4
0x18	Low Threshold Excess Time – Sensor 1 (multiple of the measurement period of threshold detection)	1	R/W	0x04	4
0x2B	High Threshold Alarm – Sensor 2	2	R/W	0x01A0	**26°C**
0x2C	Low Threshold Alarm – Sensor 2	2	R/W	0x0100	**16°C**
0x2D	High Threshold Excess Time – Sensor 2 (multiple of the measurement period of threshold detection)	1	R/W	0x04	4
0x2E	Low Threshold Excess Time – Sensor 2 (multiple of the measurement period of threshold detection)	1	R/W	0x04	4

6.1.3 Parameters specific to the WaveTherm – PT100 module

N°	Description	Size (in bytes)	Access right	Default value	
				Hexa.	Decimal
0x0C	Precision level of the measurement	1	R/W	0x00	0
0x21	Extended Application Status	1	R/W	0x00	0
0x23	Measurement period of the threshold detection (in minutes)	1	R/W	0x00	0
0x15	High Threshold Alarm – Sensor 1	4	R/W	0x0000C041	**24°C**
0x16	Low Threshold Alarm – Sensor 1	4	R/W	0x0000A041	**20°C**
0x17	High Threshold Excess Time – Sensor 1 (multiple of the measurement period of threshold detection)	1	R/W	0x04	4
0x18	Low Threshold Excess Time – Sensor 1 (multiple of the measurement period of threshold detection)	1	R/W	0x04	4
0x2B	High Threshold Alarm – Sensor 2	4	R/W	0x0000C041	**24°C**
0x2C	Low Threshold Alarm – Sensor 2	4	R/W	0x0000A041	**20°C**
0x2D	High Threshold Excess Time – Sensor 2 (multiple of the measurement period of threshold detection)	1	R/W	0x04	4
0x2E	Low Threshold Excess Time – Sensor 2 (multiple of the measurement period of threshold detection)	1	R/W	0x04	4
0x30	Value of the internal reference resistance very low (32-bit float in LSB First)	4	R	0x00000000	0 Ω
0x31	Value of the internal reference resistance very high (32-bit float in LSB First)	4	R	0x00000243	130 Ω
0x32	Coefficients of probe 1	32	R/W	-	-
0x33	Coefficients of probe 2	32	R/W	-	-
0x91	Date of probe fault detection on sensor 1	6	R/W	0	0
0x92	Date of probe fault detection on sensor 2	6	R/W	0	0

6.1.4 Parameters specific to theWaveTherm – PT1000 module

N°	Description	Size (in bytes)	Access right	Default value	
				Hexa.	**Decimal**
0x0C	Precision level of the measurement	1	R/W	0x00	0
0x21	Extended Application Status	1	R/W	0x00	0
0x23	Measurement period of the threshold detection (in minutes)	1	R/W	0x00	0
0x15	High Threshold Alarm – Sensor 1	4	R/W	0x0000C041	**24°C**
0x16	Low Threshold Alarm – Sensor 1	4	R/W	0x0000A041	**20°C**
0x17	High Threshold Excess Time – Sensor 1 (multiple of the measurement period of threshold detection)	1	R/W	0x04	4
0x18	Low Threshold Excess Time – Sensor 1 (multiple of the measurement period of threshold detection)	1	R/W	0x04	4
0x2B	High Threshold Alarm – Sensor 2	4	R/W	0x0000C041	**24°C**
0x2C	Low Threshold Alarm – Sensor 2	4	R/W	0x0000A041	**20°C**
0x2D	High Threshold Excess Time – Sensor 2 (multiple of the measurement period of threshold detection)	1	R/W	0x04	4
0x2E	Low Threshold Excess Time – Sensor 2 (multiple of the measurement period of threshold detection)	1	R/W	0x04	4
0x30	Value of the internal reference resistance very low (32-bit float in LSB First)	4	R	0x00002A44	680 Ω
0x31	Value of the internal reference resistance very high (32-bit float in LSB First)	4	R	0x0080BB44	1500 Ω
0x32	Coefficients of probe 1	32	R/W	-	-
0x33	Coefficients of probe 2	32	R/W	-	-
0x91	Date of probe fault detection on sensor 1	6	R/W	0	0
0x92	Date of probe fault detection on sensor 2	6	R/W	0	0

6.1.5 Definition of the module control bytes

- Definition of the ***Operating Mode*** byte (0x01) :

MSB **LSB**

Operanting Mode							
Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
-	**Threshold Detection Mode** **0** : successive mode **1** : cumulative mode	**Low Threshold Detection** **0** : deactivated **1** : activated	**High Threshold Detection** **0** : deactivated **1** : activated	**Datalogging** **00** : deactivated **01** : time steps **10** : once a week **11** : once a month		**Stop Mode of the Datalogging** **0 :** permanent loop **1 :** stop memory full	-

> *Attention, it is advised the greatest prudence when modifying the parameter setting of the* ***Operation Mode*** *variable. Indeed, the modifications on this variable generally requires the update of the associated parameters.*

Defautl value :

WaveTherm – DALLAS :	0x0A
WaveTherm – PT100 :	0x08
WaveTherm – PT1000 :	0x08

- Definition of the ***Application Status*** byte (0x20) :

It is possible to reinitialize to zero the bits by a write to the ***Application Status*** parameter.

MSB **LSB**

Application Status							
Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Reset detection **0:** not detected **1**: detected	**Low Threshold of sensor 2** **0:** not detected **1**: detected	**High Threshold of sensor 2** **0:** not detected **1**: detected	**Low Threshold of sensor 1** **0:** not detected **1**: detected	**High Threshold of sensor 1** **0:** not detected **1**: detected	**number of detected sensors** **0 :** 0 or 1 sensor detected **1 :** 2 sensors detected	-	**End of battery life** **0:** not detected **1**: detected

- Definition of the ***Extended Application Status*** byte (0x21) :

MSB **LSB**

Extended Application Status							
Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
-	-	-	-	-	-	**Probe fault on sensor 2** **0:** not detected **1**: detected	**Probe fault on sensor 1** **0:** not detected **1**: detected

> ***Remark : The probe fault bits are set only when a problem is detected on WaveTherm – PT100, and WaveTherm – PT1000 probes.***

6.2 PRINCIPLE OF READING AND WRITING OF INTERNAL PARAMETERS

Document [DR1] details the exchanges modes, and their associated requests; with an aim of sending data to a distant module.

This chapter details the data field in order to configure the internal parameters of the WaveTherm modules.

	DATA Field	
	1 byte	Max = 151 bytes
REQ_SEND_FRAME	Applicative Commands	Data
RECEIVED_FRAME	Acknowledgement of the applicative commands	Data

There are two commands used to configure the internal parameters of the WaveTherm modules, and each one has a corresponding acknowledgement command.

Applicatives Commands	Description
0x10	Request of parameter(s) reading
0x90	Acknowledgement of the request of parameter(s) reading
0x11	Request of parameter(s) writing
0x91	Acknowledgement of the request of parameter(s) writing

Remark : *In the command byte coding, the Response frame type are taking the Request command byte value with the MSB bit set to 1.*

It is possible to access up to 9 parameters simultaneously for writing or reading *(all for reading, or all for writing).*

➢ Format of access for parameter(s) reading

- contents of request REQ_SEND_FRAME

Data Field (max : 152 bytes)						
Applicative command	**Number of parameters to be read**	**Number of the 1st parameter**	**Size of the 1st parameter**	**Number of the 2nd parameter**	**Size of the 2nd parameter**	**...**
1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	...

- contents of response RECEIVED_FRAME

Data field (max : 152 bytes)								
Acknowledgement of the applicative command	**Number of parameters read**	**Number of the 1st parameter**	**Size of the 1st parameter**	**Data of the 1st parameter**	**...**	**Number of the nth parameter**	**Size of the nth parameter**	**Data of the nth parameter**
1 byte	1 byte	1 byte	1 byte	variable	...	1 byte	1 byte	variable

n_{max} = 9

When a parameter is not known by the system, or the size is configured with a wrong value, the corresponding data byte in response is set to 0xFF.

➢ Format of access for parameter (s) writing

- Contents of request REQ_SEND_FRAME

Data field (max : 152 bytes)								
Applicative command	**Number of parameters read**	**Number of the 1st parameter**	**Size of the 1st parameter**	**Data of the 1st parameter**	**...**	**Number of the nth parameter**	**Size of the nth parameter**	**Data of the nth parameter**
1 byte	1 byte	1 byte	1 byte	variable	...	1 byte	1 byte	variable

n_{max} = 9

- Contents of response RECEIVED_FRAME

Data Field (max : 152 bytes)						
Acknowledgement of the applicative command	**Number of parameters written**	**Number of the 1st parameter**	**Update Status**	**Number of the 2nd parameter**	**Update Status**	**...**
1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	...

'Update Status' : *0x00 : update OK*
0xFF : update error

Attention, some of the parameters are limited, i.e. their values should not be written out of the limits.
If a value is written out of the limits, the value will be written but not managed, the status of writing will be OK.

Example: parameter 0x04 (hour of the first time-window) this parameter is set up from 0 to 23. Thus if value 40 is set, it will be written, but is not managed by the system.

7 WAVETHERM MODULE FUNCTIONS

7.1 Parameter setting of the WaveTherm module

some of the parameters of module information are accessible by standard internal parameters read and write commands, described in chapter 6.2; whereas other parameters of information are accessible by specific applicative commands.

7.1.1 Reading of the module type

The module type is obtained by interrogating the WaveTherm module, with the GET_TYPE command.

Applicative Commands	Description
0x20	Request to read the module type
0xA0	Response to the request to read the module type

Remark : *In the command byte coding, the Response frame type are taking the Request command byte value with the MSB bit set to 1.*

- Contents of request REQ_SEND_FRAME

Data Field (max : 152 bytes)	
Applicative command	**-**
1 bytce	-
0x20	-

- Contents of response RECEIVED_FRAME

Data Field (max : 152 bytes)				
Acknowledgement of the applicative command	**Module Type**	**RSSI level ***	**Current Awakening period (in second)**	**Equipment Type**
1 byte	1 byte	1 byte	1 byte	1 byte
0xA0	0x19 : WaveTherm		Default value = 0x01	0x19 for WaveTherm

**** the RSSI level (Received Signal Strength Indicator) indicates the reception level of the received frame. This parameter can be used for the installations but is not useful from an application point of view.***

The equipment type indicates if a Wavenis module is integrated in more complex equipment. The equipment type, and module type have the same value :

Module Type :

◆ *WaveTherm – DALLAS :*	*0x19*
◆ *WaveTherm – DALLAS (US version) :*	*0x33*
◆ *WaveTherm – PT100 :*	*0x29*
◆ *WaveTherm – PT1000 :*	*0x28*

7.1.2 Reading of the firmware version

The firmware version of the module is obtained by interrogating the distant module with GET_FIRMWARE_VERSION command.

Applicative command	Description
0x28	Request of reading the firmware version (GET_FIRMWARE_VERSION)
0xA8	Response to the request of reading the firmware version

- Contents of request REQ_SEND_FRAME

Data Field (max : 152 bytes)	
Applicative command	Data
1 byte	-
0x28	-

- Contents of response RECEIVED_FRAME

Data Field (max : 152 bytes)			
Acknowledgement of the applicative command	Character 'V' in ASCII format	Mode of transmission	Firmware version
1 byte	1 byte	2 bytes	2 bytes
0xA8	0x56	Default value = 0x00A3	

***Remark 1** :The coding of the US firmware version takes the standard coding with the MSbit set to 1.*
Example : firmware = 0x0104
firmware (US version) = 0x8104

***Remark 2 :** Possible values for the mode of transmission*

	Value
868 MHz single channel 4800 baud	0x0012
868 MHz frequency hopping 9600 baud	0x00A3
Frequency Band from 902 Mhz to 928 Mhz – frequency hopping – 19200 baud (US version)	0x00B9

7.1.3 Reading of the date and time of the module

Applicative command	Description
0x12	Request to read the date and time of the module
0x92	Response to request to read the date and time of the module

Remark : *In the command byte coding, the Response frame type are taking the Request command byte value with the MSB bit set to 1.*

- Contents of request REQ_SEND_FRAME

Data Field (max : 152 bytes)	
Applicative command	**Data**
1 byte	-
0x12	-

- Contents of response RECEIVED_FRAME

Data Field (max : 152 bytes)						
Acknowledgement of the applicative command	**Day**	**Month**	**Year**	**Day of the week**	**Hour**	**Minute**
1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte
0x92			**(1)**	**(2)**		

(1) *Year = current year - 2000*
(2) *day of the week : value from 0 to 6*

Value	Day of Week
0	Sunday
1	Monday
2	Tuesday
3	Wednesday
4	Thursday
5	Friday
6	Saturday

7.1.4 Setting the date and time of the module

Applicative command	Description
0x13	Request to set the date and time of the module
0x93	Response to request to set the date and time of the module

> ***Remark :*** *In the command byte coding, the Response frame type are taking the Request command byte value with the MSB bit set to 1.*

- Contents of request REQ_SEND_FRAME

Data Field (max : 152 bytes)						
Applicative command	**Day**	**Month**	**Year**	**Day of the week**	**Hour**	**Minute**
1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte
0x13			**(1)**	**(2)**		

(1) *Year = current year - 2000*
(2) *day of the week : value from 0 to 6*

Value	Day of Week
0	Sunday
1	Monday
2	Tuesday
3	Wednesday
4	Thursday
5	Friday
6	Saturday

- Contents of response RECEIVED_FRAME

Data Field (max : 152 bytes)		
Acknowledgement of the applicative command	**Update Status**	**-**
1 byte	1 byte	-
0x93	0x00 : update OK 0xFF : update error	-

7.1.5 Access to the user data area

The WaveTherm module manage a non-volatile memory area accessible by radio command, and allowing to store up to 32 bytes.

This area is generally used to store the parameters relative to the calibration of the module, and can be read, or modified by specifying the start address, and the size of the data.

Commande Applicative	Description
0x16	Request to read the user data area
0x96	Response to the request to read the user data area
0x17	Request to write the user data area
0x97	Response to the request to write the user data area

- **Access in Reading**

To read the user data area, the user has to specify the address of the first byte to be read, and the total number of bytes to be read.

> ***Remark :*** *Even if the size of the memory area is of 32 bytes, the address of the first element to be read is coded on two bytes ; because this area is more important on other equipments.*

- Contents of the request REQ_SEND_FRAME

Data Field (max : 152 bytes)			
Applicative Command	**MSB address of the fisrt byte to be read**	**LSB address of the fisrt byte to be read**	**Number of bytes to be read**
1 byte	1 byte	1 byte	1 byte
0x16	0x00	**from 0 to 31**	**from 0 to 31**

- Contents of the response RECEIVED_FRAME

Data Field (max : 152 bytes)				
Acknowledgement of the applicative command	**MSB address of the fisrt byte to be read**	**LSB address of the fisrt byte to be read**	**Number of bytes read**	**Data read**
1 byte	1 byte	1 byte	1 byte	variable
0x96	0x00	**from 0 to 31**	**from 0 to 31**	

Access in Writing

The user has to specify the address of the first byte to be written, the total number of bytes to be written, and then the data.

- Contents of the request REQ_SEND_FRAME

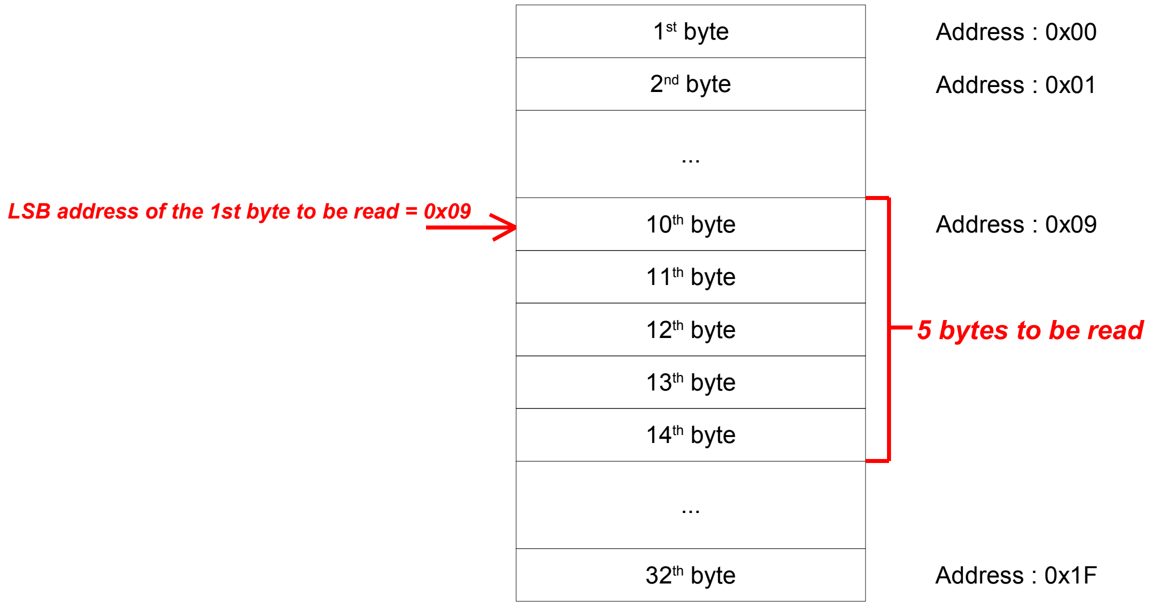
Data Field (max : 152 bytes)				
Applicative Command	**MSB address of the fisrt byte to be written**	**LSB address of the fisrt byte to be written**	**Number of bytes to be written**	**Data**
1 byte	1 byte	1 byte	1 byte	variable
0x17	0x00	**from 0 to 31**	**from 0 to 31**	

- Contents of the response RECEIVED_FRAME

Data Field (max : 152 bytes)			
Acknowledgement of the applicative command	**MSB address of the fisrt byte to be written**	**LSB address of the fisrt byte to be written**	**Number of bytes written**
1 byte	1 byte	1 byte	1 byte
0x97	0x00	**from 0 to 31**	**0x00 if Error**

- **Example :** Reading a part of the memory area

The user wants to read 5 bytes from memory area, starting from the tenth bytes.



7.1.6 Initialization of the sensors

The initialization command returns the number of sensors detected.

> ***Remark :*** *For the WaveTherm – DALLAS only, when the sensors are detected, the module returns their identifier.*

Applicative Command	Description
0x04	Request to initialize the sensors
0x84	Response to the request to initialize the sensors

- Contents of the request REQ_SEND_FRAME

Data Field (max : 152 bytes)
Applicative command
1 byte
0x04

- Contents of the response RECEIVED_FRAME

Data Field (max : 152 bytes)			
Acknowledgement of the applicative command	**Number of sensors detected**	**Identifier of the sensor 1**	**Identifier of the sensor 2**
1 byte	1 byte	8 bytes	8 bytes
0x84	**0x00** : no sensor **0x01** : 1 sensor detected **0x02** : 2 sensors detected	**(*)**	**(*)**

(*) the identifier field is filled only when using WaveTherm – DALLAS, and if the sensor is detected ; Else the field is not used (0 byte).

The probe ID corresponds to a unique code attributed to each DALLAS temperature probe in the factory. This code is composed of 8 bytes defined as follows:

MSByte		LSByte
1 byte	6 bytes	1 byte
Family Code	Serial number (48 bits)	CRC Code

The family code is used to distinguish between the probes used :
probe DS18S20 : 0x10
probe DS18B20 : 0x28

➢ **Case of the WaveTherm - PT100 ; and WaveTherm PT1000 modules :**

During initialization, if only one sensor is used, it can be connected indifferently to the input 1 or 2.
If the sensor is initialized on input 2, it will correspond to the Sensor 1, i.e. when reading the temperature value, the first temperature information returned correspond to the Sensor 1 (see chapter 7.2).

7.2 READING THE CURRENT VALUE OF THE TEMPERATURE SENSORS

The WaveTherm module has the possibility to read the current temperature when the sensors are wired, and initialized. If not the input relative to the sensor not wired (or initialized) returns the following values :

WaveTherm – DALLAS :	0x4FFF
WaveTherm – PT100 :	0xFFFFFFFF
WaveTherm – PT1000 :	0xFFFFFFFF

In addition, this command returns the *Operating Mode*, and *Application Status* bytes.

7.2.1 Information concerning precision

Compatibility : - WaveTherm – PT100
- WaveTherm – PT1000

Temperature measurement may be started with one of several precision levels (0 to 3). In general, precision level 0 is sufficient. The other precision levels are used in difficult environments.

The aim of these precision levels is to compensate for measurement errors induced by the 50 Hz frequency. In practice, this precision is increased by increasing the number of measurement sequences for the same temperature. Each measurement sequence is offset in relation to the previous sequence by 50Hz.

The precision levels may be described as follows,

Precision = 0x00 :	normal precision	(fastest measurement)
Precision = 0x01 :	high precision	
Precision = 0x02 :	very high precision	
Precision = 0x03 :	maximum precision	(slowest measurement)

Remark: Above all, the primary function is to preserve measurement precision, even in an environment with considerable interference, and not to improve the measurement precision of the probe itself.

Furthermore, the higher the precision, the higher the module power consumption. It is therefore important to find the best possible consumption/precision compromise.

The choice of the precision level is coded in the command used to read the current value of the temperature sensors.

7.2.2 Description of the commands to be used

Applicative Command	Description
0x01	Request to read the current temperature values
0x81	Response to the request to read the current temperature values

- Contents of request REQ_SEND_FRAME

Data Field (max : 152 bytes)	
Applicative Command	**Precision level**
1 byte	1 byte
0x01	**(*)**

(*) The precision field is used only for the modules :
- WaveTherm – PT100
- WaveTherm – PT1000

The WaveTherm – DALLAS doesn't support the precision capability. In this case the precision field doesn't exist (size = 0 byte).

Thus, the format of the reponse varies according to the module used :

- **WaveTherm – DALLAS :**

- Contents of the response RECEIVED_FRAME

Data Field (max : 152 bytes)						
Acknowledgement of the Applicative Command	**Operating Mode**	**Application Status**	**MSB Temperature A**	**LSB Temperature A**	**MSB Temperature B**	**LSB Temperature B**
1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte
0x81			**(*)**	**(*)**	**(*)**	**(*)**

(*) *These fields are set only if the sensors are wired, and initialized, otherwise the returned value is 0x4FFF.*

The format of the temperature is described in chapters 5.1.1 and 5.2.

- **WaveTherm – PT100 and WaveTherm – PT1000 :**

- Contents of the response RECEIVED_FRAME

Data Field (max : 152 bytes)				
Acknowledgement of the Applicative Command	**Operating Mode**	**Application Status**	**Temperature A (Float 32 bits LSB First)**	**Temperature B (Float 32 bits LSB First)**
1 byte	1 byte	1 byte	4 bytes	4 bytes
0x81				**(*)**

(*) *These fields are set only if the sensors are wired, otherwise the returned value is 0xFFFFFFFF.*

7.2.3 Reading the current ohmic values of the sensors

Compatibility : - WaveTherm – PT100
- WaveTherm – PT1000

When using WaveTherm – PT100, or PT100 modules, it is possible to read the current ohmic value of the sensors.
This type of reading may be started with one of several precision levels (0 to 3). In general, precision level 0 is sufficient. The other precision levels are used in difficult environments (refer to chapter 7.2.1).

Applicative Command	Description
0x07	Request to read the current ohmic value of the sensors
0x87	Response to request to read the current ohmic value of the sensors

- Contents of request REQ_SEND_FRAME

Data Field (max : 152 bytes)	
Applicative Command	**Precision level**
1 byte	1 byte
0x07	

- Contents of the response RECEIVED_FRAME

Data Field (max : 152 bytes)				
Acknowledgement of the Applicative Command	**Operating Mode**	**Application Status**	**Resistance A (32-bit Float LSB First)**	**Resistance B (32-bit Float LSB First)**
1 byte	1 byte	1 byte	4 bytes	4 bytes
0x87				

The format of the temperature is described in chapters 5.1.1 and 5.2.

7.3 WAKE-UP SYSTEM MANAGEMENT

In order to reduce module power consumption, a wake-up period parameter setting system is incorporated. This system enables modification of the module wake-up period (default setting 1 s) by entering a time and day of the week :

- The wake-up period default value may be modified;
- Two time-windows with different wake-up periods may be defined;
- Each day of the week may be set in one of the following three cases :
    - Wake-up period default setting
    - Wake-up according to predefined time windows
    - No wake-up period (for safety reasons, the module is not disabled on reception and it wakes up every 10 seconds)

7.3.1 Description of the parameters used

Parameter number	Description	Size (in bytes)	Access rights	Default value
0x01	Operating mode	1	R/W	Depending of the module used (see 6.1.5)
0x02	Wake-up system status word	1	R/W	0x00
0x03	Default wake-up period (in s)	1	R/W	0x01
0x04	Start time for 1st time window (in hour)	1	R/W	0x07
0x05	Wake-up period - 1st time window (in s)	1	R/W	0x01
0x06	Start time for 2nd time window (in hour)	1	R/W	0x12
0x07	Wake-up period - 2nd time window (in s)	1	R/W	0x01
0x08	Enable time windows by day of week	1	R/W	0xFF
0x09	Enable wake-up periods by day of week	1	R/W	0x00

7.3.2 Choice of wake-up mode

These modes are directly dependant on the *'wake-up system status word'* configuration and the values of parameters associated with each mode.

Wake-up system status word							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
-	-	-	-	-	-	**Enable day-of-week selection** 0 : disabled 1 : enabled	**Enable time windows** 0 : disabled 1 : enabled

Wake-up system status word	Wake-up mode
0x00	Case n°1 : Periodic wake-up, without distinction of day of the week
0x01	Case n°2 : Periodic wake-up in specific time windows for certain days of the week, periodic wake-up for the other days
0x02	Case n°3 : Periodic wake-up for certain days of the week, periodic wake-up disabled for the other days
0x03	Case n°4 : Periodic wake-up in specific time windows for certain days of the week, periodic wake-up for some days and periodic wake-up disabled for the remaining days

Remark: before enabling a specific wake-up mode, the parameters associated with this mode must first be set.

7.3.3 Set a new wake-up period

The WaveTherm module wake-up default setting is every second. The wake-up period may be easily modified by entering a new value in the '*default wake-up period parameter*'.
Attention, the value associated with this parameter may not exceed 10 seconds.

> ***Attention, an erroneous value of this parameter involves a wake-up every second, the maximum value is 0x0A (10 seconds).***

7.3.4 Set a fixed wake-up period for certain days of the week

The wake-up system parameters may be set to allow disabling of WaveTherm module periodic wake-up for certain days of the week.

> ***In practice, when periodic wake-up is disabled, the WaveLog polls every 10 seconds.***

The parameter setting procedure is as follows :

- ***disable periodic wake-up for certain days****, with the 'Enable periodic wake-up for certain days of the week' parameter.*
- ***Enable selection of the days of the week****, with the 'wake-up system status word' parameter; 'wake-up system status word' = 0x02*

In this way, on days when periodic wake-up is disabled, the module polls every 10 seconds, whereas for the rest of the week the module wakes up at the default period setting.

Enable wake-up periods by day of week							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
-	**Sunday** 0 : enabled 1 : disabled	**Saturday** 0 : enabled 1 : disabled	**Friday** 0 : enabled 1 : disabled	**Thursday** 0 : enabled 1 : disabled	**Wednesday** 0 : enabled 1 : disabled	**Tuesday** 0 : enabled 1 : disabled	**Monday** 0 : enabled 1 : disabled

> ***Attention, the coding of each bit is reversed, compared to the parameter ' Enable time windows by day of the week'.***

7.3.5 Set day/night system parameter without distinction of days of the week

The wake-up system parameters may be set to enable configuration of the time windows with different wake-up periods.

> ***Whether the user wants a distinction of the days of the week, or not; the parameter ' Enable time windows by day of the week' must be suitably configured. Thus in the case of a time windows activation without distinction of the days of week, every day of the week must be enabled (' Enable time windows by day of the week' = 0x7F).***

The time windows function as follows,

- Set the start time for the first time window and its wake-up period ;
- Set the start time for the second time window and its wake-up period ;
- Select the days of the week during which the time windows are enabled ;
  'Enable time windows by day of the week' = 0x7F
- Validate the time window mode with the 'wake-up system status word'.
  'Wake-up system status word' = 0x01

> ***Note: The format of the parameters 'Start time for time windows' is expressed in hour, and its value lies between 0 and 23.***
> ***For example, if the start time of time windows at 12h00; the value 0x0C should be configured.***
> ***The format of the wake-up periods of each time windows, is the same one as the default wake-up period; i.e. it is expressed in seconds, and cannot exceed value 0x0A.***

The format of the applicatives commands for reading and writing internal parameters, is described in chapter 6.2.

Enable time windows by day of week							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
-	**Sunday** 0 : enabled 1 : disabled	**Saturday** 0 : enabled 1 : disabled	**Friday** 0 : enabled 1 : disabled	**Thursday** 0 : enabled 1 : disabled	**Wednesday** 0 : enabled 1 : disabled	**Tuesday** 0 : enabled 1 : disabled	**Monday** 0 : enabled 1 : disabled

> ***Attention, the coding of each bit is reversed, compared to the parameter ' Enable wake-up periods by day of the week'.***

7.3.6 Set the day/night system parameters according to day of the week

The day/night system according to the day of the week parameter setting procedure is the same as that described in the previous chapter with the exception that the “*Enable time window according to the day of the week*” parameter is only set for days required.

For example, we wish to enable the time window from Monday to Wednesday.

The *'Enable time windows according to day of the week' parameter is set to* 0x07.
In this way, the module wakes up during these time windows for a period set in the associated parameters with a specific start time for each window from Monday to Wednesday.

For the other days of the week, the wake-up mode depends on the '*wake-up system status word*' :

- '*Wake-up system status word*' = 0x01

  the bit 1 is not enabled, thus the parameter 'Enable wake-up periods by day of week' is not used ; so the rest of the week, the module uses the default wake-up period.

- '*Wake-up system status word*' = 0x03

  the bit 1 is enabled, thus the parameter 'Enable wake-up periods by day of week' is used, so the wake-up for the rest of the week will depend on this parameter.
  Days with wake-up period enabled : default wake-up period
  days with wake-up period disabled : periodic wake-up disabled (polling every 10 sec.)

The format of the applicatives commands for reading and writing internal parameters, is described in chapter 6.2.

7.4 PARAMETER SETTING OF THE DATALOGGING MODE

The Datalogging mode enables periodic logging of temperatures at each input (by selecting the precision index for PT100 and PT1000 probes). The frequency of these readings may be set in three modes:

- index logging in time steps
- index logging once a week
- index logging once a month

When the storage table is full, the most recent measurements crush the oldest values , this mode is called *permanent loop*.
The standard datalloging doesn't support the 'Stop Memory Full' Capability. Thus, it cannot be enabled in the *Operating Mode* byte.

7.4.1 Description of the parameters used

According to the datalogging type (time steps, once a week, once a month), some specific parameters must be used.

Parameter number	Description	Size (in bytes)	Access Right	Default value
0x01	Operating mode	1	R/W	Depending of the module used (see 6.1.5)
0x0C	Precision level of measurement	1	R/W	0x00
0x80	Measurement period (datalogging in time steps)	1	R/W	0x13
0x81	Start hour of the datalogging in time steps	1	R/W	0x08
0x82	Day of the week, or of the month	1	R/W	0x01
0x83	Time of measurement (datalogging once a week, or once a month)	1	R/W	0x08

These specific parameters must be initialized before activating the datalogging mode.

7.4.2 Precision level of the measurement

Compatibility : - WaveTherm – PT100
- WaveTherm – PT1000

Temperature measurement may be started with one of several precision levels (0 to 3). In general, precision level 0 is sufficient. The other precision levels are used in difficult environments.

The aim of these precision levels is to compensate for measurement errors induced by the 50 Hz frequency. In practice, this precision is increased by increasing the number of measurement sequences for the same temperature. Each measurement sequence is offset in relation to the previous sequence by 50Hz.

The precision levels may be described as follows,

- Precision = 0x00 : normal precision (fastest measurement)
- Precision = 0x01 : high precision
- Precision = 0x02 : very high precision
- Precision = 0x03 : maximum precision (slowest measurement)

Remark: Above all, the primary function is to preserve measurement precision, even in an environment with considerable interference, and not to improve the measurement precision of the probe itself.

Furthermore, the higher the precision, the higher the module power consumption. It is therefore important to find the best possible consumption/precision compromise.

The precision level in datalogging mode is selected by configuring the parameter 0x0C.

7.4.3 Activating the datalogging mode

The datalogging mode is activated (or deactivated) by setting the bits [b3:b2] in the *Operating Mode* byte. In standard datalogging, the 'Stop Memory Full' mode is not allowed.

- **Operating Mode** :

MSB **LSB**

Operanting Mode							
Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
-	**Threshold Detection Mode** **0** : successive mode **1** : cumulative mode	**Low Threshold Detection** **0** : deactivated **1** : activated	**High Threshold Detection** **0** : deactivated **1** : activated	**Datalogging** **00** : deactivated **01** : time steps **10** : once a week **11** : once a month		**Stop Mode of the Datalogging** **0 :** permanent loop **1 :** stop memory full	-

Attention, stopping then restarting the datalogging mode induce the re-initialization of the storage table. In this case, the logged values will be lost.

7.4.4 Index logging in time steps

This type of datalogging is used to log the index value for each input at periods ranging from one minute to over thirty hours. The time of the first logging may be set with a parameter.

When the datalogging mode in time steps is enabled, the system only logs the memorised index values as soon as the preset time is attained; and this until the datalogging mode is disabled.

The parameters to be used, are the following :

- measurement period of the datalogging in time steps (parameter 0x80)
- start hour of the datalogging in time steps (parameter 0x81)

> ***These parameters must by initialized before activating the datalogging mode.***
>
> ***The format of the applicatives commands for reading and writing internal parameters, is described in chapter 6.2.***

➢ **Measurement period of the datalogging in time steps (parameter 0x80)**

Measurement period of the datalogging in time steps (parameter 0x80)							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
[b7:b2] : measurement period expressed in time units min : once a minute max : 63 times 30 minutes = 31 h 30 min						**[b1:b0] : time unit** 00 : 1 minute 01 : 5 minutes 10 : 15 minutes 11 : 30 minutes	

➢ **Start hour of the datalogging in time steps (parameter 0x81)**

This parameter allows to synchronize the periodic measurement. It is expressed in multiples of hour, and its value must set from 0 to 23.
When the datalogging mode in time steps is enabled, the system only logs the memorised index values as soon as the preset time is attained

> ***Example :*** *a user wants to log the temperature every 4 hours. And the first value mus be log at 19:00.*
>
> - *Parameter 'measurement period of the datalogging in time steps' (0x80) = 0x23*
> - *Parameter 'start hour of the datalogging in time steps ' (0x81) = 0x13*
> - *bits [b3:b2] of 'Operating Mode' byte (0x01) set to '01'*

7.4.5 Index logging once a week

This type of datalogging is used to log the index value for each input once a week. The time and day of the week logging is carried out may be set with a parameter.

The parameters to be used, are the following :

- Time of measurement (datalogging once a week, or once a month) (parameter 0x83)
- Day of the week, or of the month (datalogging once a week, or once a month) (parameter 0x82)

> ***These parameters must by initialized before activating the datalogging mode.***
>
> ***The format of the applicatives commands for reading and writing internal parameters, is described in chapter 6.2.***

- **Time of measurement (datalogging once a week, or once a month) (parameter 0x83)**

This parameter allows to synchronize the periodic measurement. It is expressed in multiples of hour, and its value must set from 0 to 23.

- **Day of the week, or of the month (datalogging once a week, or once a month) (parameter 0x82)**

Value	Day of the week
0	Sunday
1	Monday
2	Tuesday
3	Wednesday
4	Thursday
5	Friday
6	Saturday

> ***Example :*** *a user wants to log the temperature every monday, at 12:00 am.*
>
> - *Time of measurement (datalogging once a week, or once a month) (0x83) = 0x0C*
> - *Day of the week, or of the month (0x82) = 0x01*
> - *bits [b3:b2] of 'Operating Mode' byte (0x01) set to '10'*

7.4.6 Index logging once a month

This type of datalogging is used to log the index value for each input once a month. The time and day (from 1 to 28) logging is carried out may be set with a parameter.

The parameters to be used, are the following :

- Time of measurement (datalogging once a week, or once a month) (parameter 0x83)
- Day of the week, or of the month (datalogging once a week, or once a month) (parameter 0x82)

> ***These parameters must by initialized before activating the datalogging mode.***
>
> ***The format of the applicatives commands for reading and writing internal parameters, is described in chapter 6.2.***

➢ **Time of measurement (datalogging once a week, or once a month) (parameter 0x83)**

This parameter allows to synchronize the periodic measurement. It is expressed in multiples of hour, and its value must set from 0 to 23.

➢ **Day of the week, or of the month (datalogging once a week, or once a month) (parameter 0x82)**

Here, the format is different from the datalogging once a week. Indeed, the day of measurement is set from 0 to 28. And, the system does not manage changes in the number of days in a month.

> ***Example** : a user wants to log the temperature the 5th day of the month, at 12:00.*
>
> - *Time of measurement (datalogging once a week, or once a month) (0x83) = 0x0C*
> - *Day of the week, or of the month (0x82) = 0x05*
> - *bits [b3:b2] of 'Operating Mode' byte (0x01) set to '11'*

7.4.7 Reading the logged temperature values

Standard datalogging allows a periodic collection of temperature measurements up to N temperatures. If two temperature sensors are used, then the WaveTherm return the last N/2 values of each sensor.

It functions in *'permanent loop'* mode, i.e. the most recent measurements replace the oldest measurements.

◆ WaveTherm – DALLAS :	N = 48 temperatures;
◆ WaveTherm – PT100 :	N = 24 temperatures;
◆ WaveTherm – PT1000 :	N = 24 temperatures.

The reading of N logged temperatures is accomplished by sending the following commands :

Applicative Command	Description
0x03	Request to read the datalogging storage table
0x83	Response to the request to read the datalogging storage table

The format is as follow :

- Contents of the request REQ_SEND_FRAME

Data Field (max : 152 bytes)
Applicative Command
1 byte
0x03

- Contents of the response RECEIVED_FRAME

Data Field (max : 152 bytes)						
Acknowledgement of the applicative command	**Operating Mode**	**Application Status**	**Sensor A storage table**	**Sensor B storage table**	**Date of the last logged temperature**	**Measurement period**
1 byte	1 byte	1 byte	48 bytes	48 bytes	6 bytes	1 byte
0x83			**(3)**	**(3)**	**(2)**	**(1)**

(1) Measurement period : *the format of this byte is given in chapter 7.4.4.*

> ***ATTENTION : The 'Measurement Period' field is updated only when datalogging in time steps is enabled. In the other modes, this field is not significant.***

(2) Date of the last logged temperature : *the format of this field is equivalent to the standard date and time format (see chapter 7.1.3).*

(3) Temperature storage table : *the format is different according to the module used, see next page.*

WaveTherm – DALLAS :

The maximal number of logged values is 48 if only one sensor is activated, and 24 when two sensors are activated.

The storage table is defined as follow :

Number of activated sensor	Number of values per sensor	Structure of the storage table	
		Size	Description
1	48 temperatures from sensor A	2 bytes	Temperature A (instant t)
		2 bytes	Temperature A (instant t – 1T)
			...
		2 bytes	Temperature A (instant t – 47T)
2	24 temperatures from sensor A	2 bytes	Temperature A (instant t)
		2 bytes	Temperature A (instant t – 1T)
			...
		2 bytes	Temperature A (instant t – 23T)
	24 temperatures from sensor B	2 bytes	Temperature B (instant t)
		2 bytes	Temperature B (instant t – 1T)
			...
		2 bytes	Temperature B (instant t – 23T)

'T' is the measurement period of each temperature sensor.

The format of the temperature is describes in chapter 5.1.1.

WaveTherm – PT100 and WaveTherm – PT1000 :

The maximal number of logged values is 24 if only one sensor is activated, and 12 when two sensors are activated.

The storage table is defined as follow :

Number of activated sensor	Number of values per sensor	Structure of the storage table	
		Size	Description
1	24 temperatures from sensor A	4 bytes	Temperature A (instant t)
		4 bytes	Temperature A (instant t – 1T)
			...
		4 bytes	Temperature A (instant t – 23T)
2	12 temperatures from sensor A	4 bytes	Temperature A (instant t)
		4 bytes	Temperature A (instant t – 1T)
			...
		4 bytes	Temperature A (instant t – 11T)
	12 temperatures from sensor B	4 bytes	Temperature B (instant t)
		4 bytes	Temperature B (instant t – 1T)
			...
		4 bytes	Temperature B (instant t – 11T)

'T' is the measurement period of each temperature sensor.

The format of the temperature is describes in chapter 5.2.

7.5 ADVANCED DATALOGGING

When the WaveTherm support the Advanced Datalogging, the datalogging allows a periodic collection of temperature measurements up to M temperatures. If two temperature sensors are used, then the WaveTherm return the last M/2 values of each sensor.

◆ WaveTherm – DALLAS :	M = 4500 temperatures;
◆ WaveTherm – PT100 :	M = 2000 temperatures;
◆ WaveTherm – PT1000 :	M = 2000 temperatures.

This functionality is principally used with the index logging in time steps, but it can be also used with index logging once a weel, or once a month.

In the current firmware version, the Advanced Datalogging only supports the 'stop memory full' mode. Thus the 'permanent loop' mode cannot be activated.

This chapter describes the following procedure :

- Parameter setting of the Advanced Datalogging mode,
- Reading of the logged temperature values,
- re-initalizing the storage table, and re-starting a new datalogging cycle.

7.5.1 Description of the parameters used

According to the datalogging type (time steps, once a week, once a month), some specific parameters must be used.

Parameter number	Description	Size (in bytes)	Access Right	Default value
0x01	Operating mode	1	R/W	Depending of the module used (see 6.1.5)
0x0A	number of loop of the datalogging storage table	1	R	0x00
0x0B	Number of temperature values stored in the table (LSB first)	2	R	0x0000
0x0C	Precision level of the measurement	1	R/W	0x00
0x80	Measurement Period (datalogging in time steps)	1	R/W	0x13
0x81	Start hour of the datalogging in time steps	1	R/W	0x08
0x82	Day of the week, or of the month (datalogging)	1	R/W	0x01
0x83	Time of measurement (datalogging once a week, or once a month)	1	R/W	0x08

These specific parameters must be initialized before activating the datalogging mode.

7.5.2 Parameter setting of the Advanced Datalogging mode

To activate the advanced datalogging, the user have to follow the following steps :

- Configure the index logging in time steps (see chapter 7.4.4);
- Choose the measurement period;
- Select the start time of the first measurement ;
- Select the precision level (only for the PT100, PT1000 sensors).

When the datalogging mode in time steps is enabled, the system only logs the memorised index values as soon as the preset time is attained; and this until the datalogging mode is disabled.

7.5.3 Principle of reading the temperature, and re-initializing the storage table

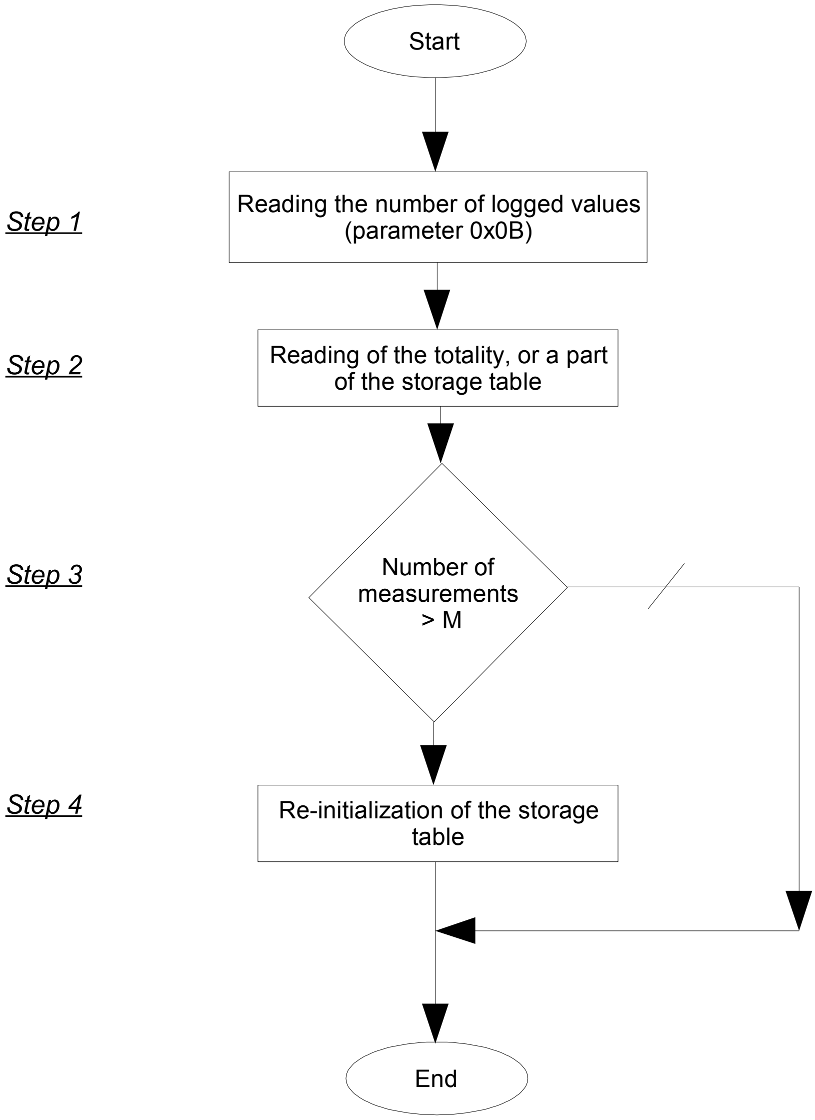
The concept of reading the logged values of the advanced datalogging is to interrogate periodically the module with a long period of time, so that the consumption won't be penalized by too frequent readings.

The advised method is to read periodically the stored values, then to re-initialize the advanced datalogging in order to flush the old values.

The reading radio command uses the **Multi-frame** mode of the Wavenis protocol (except in repeater mode). The use of this command is describes in the WaveCard application handbook.

The re-initialization of the storage table is accomplished by stopping, then by re-starting the datalogging mode through the Operating Mode byte.

The synoptic of the following page presents the principle to be applied.


Start
Step 1
Reading the number of logged values (parameter 0x0B)
Step 2
Reading of the totality, or a part of the storage table
Step 3
Number of measurements > M
Step 4
Re-initialization of the storage table
End

Remark : *The step 3 could be suppressed. Indeed, after reading the totality of the storage table, the user can systematically re-initialize the storage table.*

- **Reading the number of logged values**

WaveTherm modules supporting the Advanced Datalogging has the possibility to store up to M temperature values.

If one sensor is wired, up to M values are affected to this sensor,
if two sensors are wired, up to M/2 values are affected to each sensor.

◆ WaveTherm – DALLAS :	M = 4500
◆ WaveTherm – PT100 :	M = 2000
◆ WaveTherm – PT1000 :	M = 2000

An internal parameter (0x0B) allow to know precisely the number of logged values, since the beginning of the datalogging cycle.

Attention, This parameter is coded in LSB first.

7.5.4 Reading the totality, or a part of the storage table

As the date of each recording is not stored, the equipment wishing to recover recordings in a given section of time must calculate the dates of the desired recordings, according to the number of recording and date of the last recording.

Applicative Command	Description
0x06	Request to read the storage table of the advanced datalogging
0x86	Response to the request to read the storage table of the advanced datalogging

- Contents of the request REQ_SEND_FRAME

Data Field (max : 152 bytes)		
Applicative Command	**Number of recordings to be read (MSB First)**	**Number of the most recent recording (MSB First)**
1 byte	2 bytes	2 bytes
0x06		

Note : When the field 'number of the most recent event to be read' is set to 0x0000, the module sends the latest events to facilitate the reading.

➢ In case of error

If the numbers of the requested recordings doesn't exist, then the response frame will have the following format :

- Contents of the response RECEIVED_FRAME

Data Field (max : 152 bytes)	
Applicative Command	**Frame number**
1 byte	2 bytets
0x86	**0xFF : Error**

Attention, if the number of requested recordings is higher than the number of available recordings, then :

- The WaveTherm – DALLAS returns the error frame.

- The WaveTherm – PT100 returns the available recordings.

- The WaveTherm – PT1000 returns the available recordings.

➢ In case of success

The size of the information returned by the Wavetherm module is such as the radio module must transmit several radio response frame.

The module uses the Multi-Frame mode of the Wavenis protocol which allows to optimize the radio exchanges with the interrogator equipment. It successively transmit to the interrogator equipment several frames containing the recordings from the most recent to the oldest one.

The radio acknowledgement mechanism is automatically activated by the WaveTherm, when successively transmitting its response frames.

- Contents of the responses RECEIVED_MULTIFRAME

Structure of the first response frame :

Data Field (max : 152 bytes)				
Acknowledgement of the applicative command	**Frame number**	**Total number of frames**	**Date of the last recording**	**Data relative to the recordings**
1 byte	1 byte	1 byte	6 bytes	variable
0x86	**0x01**			**(*)**

Structure of the following frames :

Data Field (max : 152 bytes)			
Acknowledgement of the applicative command	**Frame number**	**Total number of frames**	**Data relative to the recordings**
1 octet	1 octet	1 octet	variable
0x86			**(*)**

(*) see next page

(*) Data relative to the recordings :

The format of this field varies according to the type of WaveTherm used.

- WaveTherm – DALLAS :

Data relative to the recordings						
Number of the first recording returned (MSB First)	**Number of the last recording returned (MSB First)**	**Temperature of the sensor**	**Temperature of the sensor**	**Temperature of the sensor**	**…**	**Temperature of the sensor**
2 bytes	2 bytes	2 bytes	2 bytes	2 bytes		2 bytes

- WaveTherm – PT100 and WaveTherm – PT1000 :

Data relative to the recordings						
Number of the first recording returned (MSB First)	**Number of the last recording returned (MSB First)**	**Temperature of the sensor**	**Temperature of the sensor**	**Temperature of the sensor**	**…**	**Temperature of the sensor**
2 bytes	2 bytes	4 bytes	4 bytes	4 bytes		4 bytes

7.5.5 Structure of the data when two sensors are activated

When two sensors are wired to the module, the numbering of the recordings is processed as follow :

Number of the recordings, from the most recent to the oldest	Description
n	Most recent recording of the **input 2**, at instant t
n-1	Most recent recording of the **input 1**, at instant t
...	...
4	Recording of the **input 2**, at instant (t – (n-1))
3	Recording of the **input 1**, at instant (t – (n-1))
2	Recording of the **input 2**, at instant (t – n)
1	Recording of the **input 1**, at instant (t – n)

Remark : The odd recordings corresponds to the input 1 ; and the even recordings corresponds to the input 2.

***Example** : request of reading when the number of recordings is 30.*

Contents of the request REQ_SEND_FRAME

Data Field (max : 152 bytes)		
Commande applicative	**Nombre d'enregistrement à lire (MSB First)**	**Numéro d'enregistrement le plus récent (MSB First)**
1 octet	2 octets	2 octets
0x06	**0x001E**	**0x001E**

The structure of the data relative to the recordings is as follow :

Data relative to the recordings									
Number of the first recording returned (MSB First)	**Number of the last recording returned (MSB First)**	**Sensor 2 value n°30**	**Sensor 1 value n°29**	**...**	**Sensor 2 value n°4**	**Sensor 1 value n°3**	**Sensor 2 value n°2**	**Sensor 1 value n°1**
0x001E	0x0001							

The size (in bytes) of the temperature information depend of the type of the module used, please refer to chapter 5.1.1, and 5.2.

7.5.6 Usage limit of the multi-frame mode

The Wavenis protocol doesn't allow the usage of the multi-frame mode in repeater mode, i.e. When the module is reach through relaying equipments.

It is up to the interrogator equipment to format the frames so that the response fit in a single frame.

Typically in repeater mode, the interrogator module have to read the logged temperature values by packets of M measurements (M corresponding to the maximal number of measurements that can be read through 3 repeaters).

◆ WaveTherm – DALLAS :	M = 59 measurements
◆ WaveTherm – PT100 :	M = 29 measurements
◆ WaveTherm – PT1000 :	M = 29 measurements

Example for a WaveTherm – DALLAS :

if the number of recordings is 2000, the interrogator equipement have to send the following frames :

frame 1 : *reading of 59 recordings, starting from the 2000th;*
frame 2 : *reading of 59 recordings, starting from the 1941th;*
frame 3 : *reading of 59 recordings, starting from the 1882th;*
...
frame 33 : *reading of 59 recordings, starting from the 112th*
frame 34 : *reading of 59 recordings, starting from the 53th.*

Attention when reading in repeater mode, it is advised to stop the datalogging to ensure that no new recording will shift the storage table.

7.6 MANAGEMENT OF THRESHOLD ALARMS

The **WaveTherm** module may be configured to detect when the values exceed threshold levels (high or low). Three types of threshold alarm detection methods may be programmed :

- immediate threshold alarm detection
- threshold alarm detection for a given continuous period of time (successive mode)
- threshold alarm detection for a total period of time (cumulative mode)

7.6.1 Description of the parameters used

Each sensor has its own parameters, which are as follows:

- High threshold alarm,
- High threshold excess time,
- Low threshold alarm,
- Low threshold excess time,
- selection of the threshold detection mode (immediate, successive, or cumulative)

- A parameter common to both temperature sensors allows to regulate the measurement period used for the detection. (parameter 0x23)

> ***Note** : The WaveTherm – PT100 and PT1000 may be configured with a precision level offering a more reliable measurement even in environments with excessive interference.*

Parameter number	Description	Size (in bytes)	Access Right	Default value
0x01	Operating Mode	1	R/W	Depending of the module used (see 6.1.5)
0x0C	Precision level of the measurement	1	R/W	0x00
0x23	Measurement period of the threshold detection (in minutes)	1	R/W	0x00
0x15	High Threshold Alarm – Sensor 1	**Cf. 6.1.2**	R/W	**Cf. 6.1.2**
0x16	Low Threshold Alarm – Sensor 1	**Cf. 6.1.2**	R/W	**Cf. 6.1.2**
0x17	High Threshold Excess Time – Sensor 1 (multiple of the measurement period of threshold detection)	1	R/W	0x04
0x18	LowThreshold Excess Time – Sensor 1 (multiple of the measurement period of threshold detection)	1	R/W	0x04
0x2B	High Threshold Alarm – Sensor 2	**Cf. 6.1.2**	R/W	**Cf. 6.1.2**
0x2C	Low Threshold Alarm – Sensor 2	**Cf. 6.1.2**	R/W	**Cf. 6.1.2**
0x2D	High Threshold Excess Time – Sensor 2 (multiple of the measurement period of threshold detection)	1	R/W	0x04
0x2E	Low Threshold Excess Time – Sensor 2 (multiple of the measurement period of threshold detection)	1	R/W	0x04

> ***According to the type of the module used, the default value of the high and low threshold are different. Please refer to chapter 6.1.2 for more details.***

7.6.2 Precision level of the measurement

Compatibility : - WaveTherm – PT100
- WaveTherm – PT1000

Temperature measurement may be started with one of several precision levels (0 to 3). In general, precision level 0 is sufficient. The other precision levels are used in difficult environments.

The aim of these precision levels is to compensate for measurement errors induced by the 50 Hz frequency. In practice, this precision is increased by increasing the number of measurement sequences for the same temperature. Each measurement sequence is offset in relation to the previous sequence by 50Hz.

The precision levels may be described as follows,

◆ Precision = 0x00 :	normal precision	(fastest measurement)
◆ Precision = 0x01 :	high precision	
◆ Precision = 0x02 :	very high precision	
◆ Precision = 0x03 :	maximum precision	(slowest measurement)

Remark: Above all, the primary function is to preserve measurement precision, even in an environment with considerable interference, and not to improve the measurement precision of the probe itself.

Furthermore, the higher the precision, the higher the module power consumption. It is therefore important to find the best possible consumption/precision compromise.

The precision level in datalogging mode is selected by configuring the parameter 0x0C.

7.6.3 Format of the temperature information

The format depend of the type of the module used, and is strictly identical to the format when reading the current value of the temperature (see chapter 5.1.1, and 5.2).

➢ **Example for a WaveTherm – DALLAS :**

MSB LSB MSB LSB

Most Significant Byte								Least Significant Byte							
b7	b6	b5	b4	b3	b2	b1	b0	b7	b6	b5	b4	b3	b2	b1	b0
S	S	S	S	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}

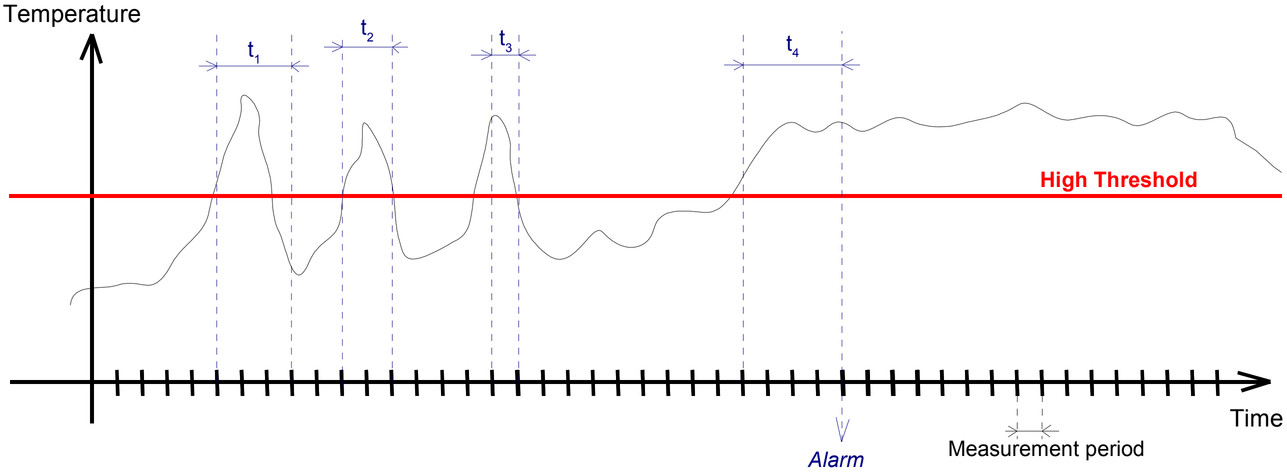
Bits [b7:b3] : sign bits.

Example : *The high threshold parameter is set to default value 0x01A0*

According to the format, High Threshold $= 2^4 + 2^3 + 2^1 = 26$ *°C*

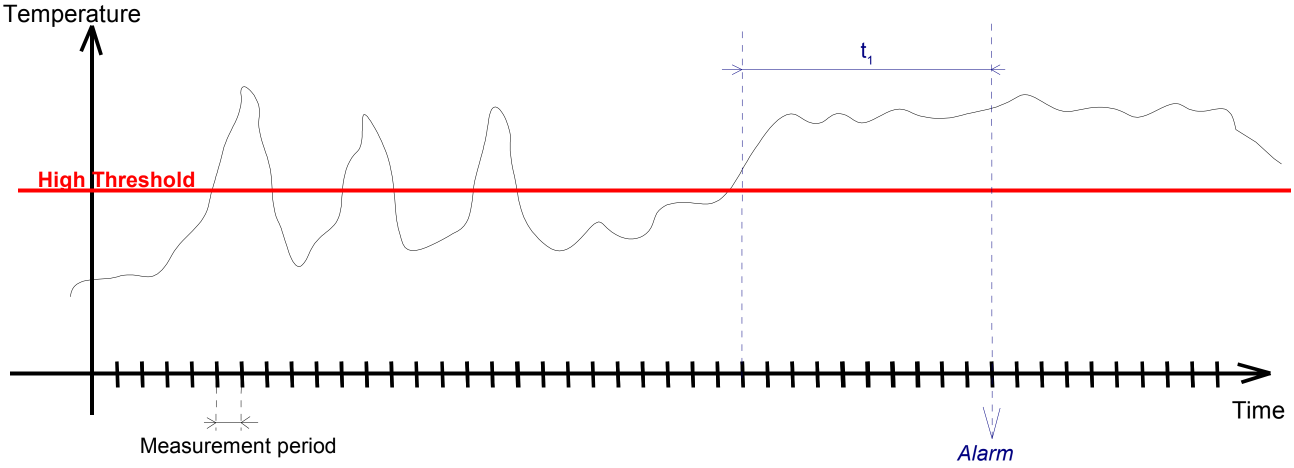
7.6.4 Principle of the detection modes

- **In cumulative mode,** an alarm is detected when the total temperature threshold alarm time is higher than the set duration parameter.



With a threshold excess duration, $t_{threshold}$ = 10 measurement periods, one gets $t_1 + t_2 + t_3 + t_4 > t_{threshold}$

- **In successive mode,** an alarm is detected when the continuous temperature threshold alarm time is higher than the set duration parameter.



With a threshold excess duration, $t_{threshold}$ = 10 measurement periods, one gets $t_1 > t_{threshold}$

Regardless of the mode selected, an alarm may be detected immediately if the threshold alarm duration is set to zero.

In addition, it is possible to reset the threshold detection, by deactivating and re-activating it.

7.6.5 Selection of the threshold detection modes, and activation of the detection

The threshold detection modes are selected by positionning the bit b6 of the *Operating Mode* byte. By default, the successive mode is selected.

The threshold detection is activated by positioning the bit b4, or b5 of the *Operating Mode* byte.

- ***Operating Mode* byte:**

MSB **LSB**

Operanting Mode							
Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
-	**Threshold Detection Mode** **0** : successive mode **1** : cumulative mode	**Low Threshold Detection** **0** : deactivated **1** : activated	**High Threshold Detection** **0** : deactivated **1** : activated	**Datalogging** **00** : deactivated **01** : time steps **10** : once a week **11** : once a month		**Stop Mode of the Datalogging** **0 :** permanent loop **1 :** stop memory full	-

The parameters relative to the threshold detection management must be configured before activating the detection.

7.6.6 Configuration of the measurement period of the threshold detection

Threshold alarm detection requires periodic measurement of the temperature for a predefined period. The value of this period enables establishment of the threshold alarm detection reactivity.

The measurement period is configured via a write command of the parameter 0x23 ; and its value is expressed in multiples of minutes.

After adjusting the measurement period, the WaveTherm module will measure the temperature, in order to compare it with the preset thresholds. This measurement is independent of the datalogging measurement.

for power saving reasons, it is recommendable to set the datalogging period as a multiple of the threshold alarm detection period (if the datalogging is set in time steps).

Attention, the threshold detection will be deactivated if the measurement period is set to 0.

7.6.7 Reading the threshold detection table

The module store in an internal table the information relative to the detection of a threshold alarm.

This table can store up to 5 events relative to high threshold detection, and up to 5 events relative to Low Threshold detection.

Applicative Command	Description
0x05	Request to read the threshold detection table
0x85	Response to the request to read the threshold detection table

- Contents of the request REQ_SEND_FRAME

Data Field (max : 152 bytes)
Applicative Command
1 byte
0x05

- Contents of the response RECEIVED_FRAME

Data Field (max : 152 bytes)								
Acknowledgement of the applicative command	**Events table relative to high threshold alarm**				**Events table relative to low threshold alarm**			
	Sensor number	**Date**	**Duration**	**Integrated value**	**Sensor number**	**Date**	**Duration**	**Integrated value**
1 byte	1 byte	6 bytes	2 bytes	**(*)**	1 byte	6 bytes	2 bytes	**(*)**
0x85								

Sensor number : *indicates which sensor is concerned.*

Date : *date of the threshold detection (format described in chapter 7.1.3).*

Duration : *duration of the threshold detection expressed in multiples of measurement period (parameter 0x23).*

(*) Integrated value : *average of all the values acquired since the first threshold detection, until its disappearance. The format of this value depend on the type of the module used, and is described in chapter 5.1.1, and 5.2.*
The size of this field depend on the type of the module used :

WaveTherm – DALLAS :	*size of 'Integrated value' = 2 bytes*
WaveTherm – PT100 :	*size of 'Integrated value' = 4 bytes*
WaveTherm – PT1000 :	*size of 'Integrated value' = 4 bytes*

> ***Remark :*** *this table is a circular buffer, i.e. the most recent event crush the oldest one. Thus, the table always store the five most recent events.*

Sensor number – Evt 0	Date – Evt 0	Duration – Evt 0	Integrated value – Evt 0
Sensor number – Evt 1	Date – Evt 1	Duration – Evt 1	Integrated value – Evt 1
Sensor number – Evt 2	Date – Evt 2	Duration – Evt 2	Integrated value – Evt 2
Sensor number – Evt 3	Date – Evt 3	Duration – Evt 3	Integrated value – Evt 3
Sensor number – Evt 4	Date – Evt 4	Duration – Evt 4	Integrated value – Evt 4

7.7 MANAGEMENT OF THE ALARM FRAMES

The WaveTherm module offers the possibility to automatically transmit radio frames when an occurrence is detected.

The following occurrences may provoke an automatic alarm:

- High threshold detection;
- Low threshold detection;
- End of battery life detection;
- Probe fault detection (only with WaveTherm – PT100, and WaveTherm – PT1000 modules).

It is possible to select for each type of occurrence whether or not an alarm frame is to be sent.

7.7.1 Description of the parameters used

Parameter number	Description	Size (in bytes)	Access Right	Default value
0x01	Operating Mode	1	R/W	Depending of the module used (see 6.1.5)
0x20	Application Status	1	R/W	0x80
0x21	Extended Application Status	1	R/W	0x00
0x22	Alarm Configuration byte	1	R/W	0x00
0xB0	Number of repeaters used to transmit an alarm frame	1	R/W	0x00
0xB1	Address of the 1st repeater used to transmit an alarm frame	6	R/W	0x00
0xB2	Address of the 2nd repeater used to transmit an alarm frame	6	R/W	0x00
0xB3	Address of the 3rd repeater used to transmit an alarm frame	6	R/W	0x00
0xB4	Address of the recipient of the alarm frame	6	R/W	0x010A030000BD

7.7.2 Configuration of the route to reach the alarm frames recipient

The route can be configured by a standard write command of the concerned parameters, or in an automatic way.

Indeed when a distant module (WaveCard, or WavePort type) send the Alarm Configuration command (0x23), the WaveTherm module stores the radio address of the transmitter, and the relay route (if used) as the recipient of alarm frames.

7.7.3 Configuration of the alarms to be sent

The alarms to be sent are configured by writing to the parameter 0x22, or by sending the following command :

Applicative Command	Description
0x23	Request to configure the alarms to be sent
0xA3	Acknowledgement of the request

- Contents of the request REQ_SEND_FRAME

Data Field (max : 152 bytes)								
Applicative command	**Alarms Configuration byte**							
1 byte	b7	b6	b5	b4	b3	b2	b1	b0
0x23	-	-	-	-	**Probe fault detection** **0 :** deactivated **1 :** activated	**End of battery life detection** **0 :** deactivated **1 :** activated	**High Threshold detection** **0 :** deactivated **1 :** activated	**Low threshold detection** **0 :** deactivated **1 :** activated

When sending this command, the internal parameter relative to the configuration of the alarm (0x22) will be automatically updated.

- Contents of the response RECEIVED_FRAME

Data Field (max : 152 bytes)	
Acknowledgement of the applicative command	**Status**
1 byte	1 byte
0xA3	0x00 : updating OK 0xFF : updating error

7.7.4 Triggering an alarm frame

After detection of a fault, if the configuration mode authorises transmission of alarms, the module transmits an alarm frame (applicative command 0x40).

- Structure of the alarm frame

Data Field (max : 152 bytes)										
Applicative Command	**Alarm Status**								**Date**	**Data field (optional)**
1 byte	1 byte								6 bytes	variable
	b7	b6	b5	b4	b3	b2	b1	b0		
0x40	-	**-**	**-**	**-**	**Probe Fault**	**End of battery life**	**High Threshold**	**Low Threshold**		**(1)**

Bits of the Alarm Status : ***0 :*** *not detected*
1 : *detected*

(1) The data field is used when a threshold alarm is detected, its format is as follow :

Data field		
Sensor number	**Duration (in multiples of measurement period)**	**Integrated value (*)**
1 byte	2 bytes	

(*) Integrated value : *average of all the values acquired since the first threshold detection, until its disappearance. The size of this field depend on the type of the module used :*

- WaveTherm – DALLAS :	*2 bytes*
- WaveTherm – PT100 :	*4 bytes*
- WaveTherm – PT1000 :	*4 bytes*

The remote device must send an acknowledgement frame (command 0xC0) to confirm reception of the alarm frame and end dialogue.

If the WaveTherm module does not receive this acknowledgment, it re-transmits the alarm frame according to the following parameters :

- a set number of times, according to the value of the parameter 0x19
- Between each re-transmission of a non-acknowledged alarm signal, the module waits for a predefined time (configured by parameter 0x1A)

Attention, an alarm frame only has one type of detection. When several alarms are detected, the WaveTherm module emits the frames one after the other.
An alarm frame will be transmitted after the previous frame has been acknowledged.

- The recipient equipment have to acknowledge the alarm, with the following command :

Data Field (max : 152 bytes)	
Acknowledgement of the applicative command	**Alarm status received in the alarm frame**
1 byte	1 byte
0xC0	

7.8 END OF BATTERY LIFE DETECTION

To detect the end of battery life, the **WaveTherm** module uses the power metering principle rather than measurement of the battery voltage. Lithium batteries are, in particular during passivation, unsuitable for the voltage measurement method to determine the remaining capacity.

The **WaveTherm** records and evaluates all events (measurements, transmissions) to decrement the power meter according to the battery used. When the meter passes below a predefined threshold, the "end of battery life" is signalled with the *Application Status* byte.

The initial value of the end-of-life meter is factory-set. It depends on the type and number of batteries used. *When the end of battery life is detected, the detection date is memorised and may be read with a radio command.*

7.8.1 Description of the parameters used

Parameter number	Description	Size (in bytes)	Access Right	Default value
0x20	Application Status	1	R/W	0x00
0x90	Date of detection of end of battery life	6	R/W	0x00
0xA2	Battery life duration counter	2	R	0xC15C

When the end of battery life is detected, the bit b0 of the *Application Status* is set to 1 ; and the detection date is stored. This date can be read by a standard read command of internal parameter (format of the date described in chapter 7.1.3).

MSB **LSB**

Application Status							
Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Reset detection **0:** not detected **1:** detected	**Low Threshold of sensor 2** **0:** not detected **1**: detected	**High Threshold of sensor 2** **0:** not detected **1**: detected	**Low Threshold of sensor 1** **0:** not detected **1**: detected	**High Threshold of sensor 1** **0:** not detected **1**: detected	**number of detected sensors** **0 :** 0 or 1 sensor detected **1 :** 2 sensors detected	**-**	**End of battery life** **0:** not detected **1**: detected

APPENDIX A : SET OF THE APPLICATIVE COMMANDS

Applicative Commands	Description
INTERNAL PARAMETERS SETTING	
0x10	Request of parameter(s) reading
0x90	Acknowledgement of the request of parameter(s) reading
0x11	Request of parameter(s) writing
0x91	Acknowledgement of the request of parameter(s) writing
MODULES INFORMATION	
0x20	Request to read the module type
0xA0	Response to the request to read the module type
0x28	Request of reading the firmware version (GET_FIRMWARE_VERSION)
0xA8	Response to the request of reading the firmware version
0x12	Request to read the date and time of the module
0x92	Response to request to read the date and time of the module
0x13	Request to set the date and time of the module
0x93	Response to request to set the date and time of the module
INFORMATION, CALIBRATION, AND INITIALIZATION OF THE SENSORS	
0x04	Request to initialize the sensors
0x84	Response to the request to initialize the sensors
0x08	Request to calibrate the radio module (WaveTherm - PT100 et PT1000 only)
0x88	Response to the request to calibrate the radio module (WaveTherm - PT100 et PT1000 only)
0x16	Request to read the user data area
0x96	Response to the request to read the user data area
0x17	Request to write the user data area
0x97	Response to the request to write the user data area
READING THE INDEXES AND TABLES	
0x01	Request to read the current temperature values
0x81	Response to the request to read the current temperature values
0x03	Request to read the datalogging storage table
0x83	Response to the request to read the datalogging storage table
0x05	Request to read the threshold detection table
0x85	Response to the request to read the threshold detection table
0x06	Request to read the storage table of the advanced datalogging
0x86	Response to the request to read the storage table of the advanced datalogging
0x07	Request to read the current ohmic value of the sensors
0x87	Response to request to read the current ohmic value of the sensors
ALARM FRAMES MANAGEMENT	
0x23	Request to configure the alarms to be sent
0xA3	Acknowledgement of the request