



WaveTherm module technical specifications

Version 1

LIST OF UPDATES

Update #	Description	Author	Date	Comments
1	First edition	RCS	22/11/04	Version 1
2	Add-on FCC text	RCS	17/02/05	Version 2

REFERENCE DOCUMENTS

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



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.

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1 PRESENTATION OF THE WAVETHERM MODULE

WaveTherm refers to a range of wireless remote temperature measuring devices, based on **Wavenis® Ultra Low Power radio technology** of CORONIS offering several years of autonomous battery operation.

The industrial design of the WaveTherm module guarantees exceptional communication reliability in harsh working environments and has been optimised to enable large-scale production.

1.1 CHARACTERISTICS

➤ Technical characteristics

- LOS radio range up to 1 km.
- ISM bandwidth 433 / 868 / 915 Mhz with fixed frequency or frequency hopping.
- Digital frequency modulation (GFSK)
- Communication speed: up to 9.6 Kbits/ sec.
- Receiver sensitivity : -110dBm (BER = 1%, 9.6 kps)
- Transmission power +14 dBm with internal aerial.
- Uses the secure communication protocol  **WAVENIS®**
- CE approval : EN 300-683
- ART certification : EN 300-220-1



Attention: WaveTherm modules do not interfere with other electronic (fixed or wireless) systems installed close by.
Furthermore, based on our present knowledge, it represents no health risk whatsoever for persons working occasionally or regularly within the operating radius.



➤ Physical characteristics

- Protection index :
IP65 : totally protected against dust and water spray and splashing from all directions.
or **IP68** : totally protected against dust and prolonged immersion under certain conditions.
- Operating temperature range : [-20°C ; +70°C]
- Storage temperature: [0 ; +50°C] (*)
- Probe connection cable: 2 m.
- Dimensions (H/W/D) : 12 x 4 x 3 cm
- Weight : 110g to 160g
- A diagram indicating the physical size of the unit is provided in appendix A.

(*) High storage temperatures may result in battery passivation problems.
The ideal storage temperature is between 10°C and 30°C.

➤ Electrical characteristics

Caractéristique	Valeur / Norme
Alimentation	Par 1 Pile lithium chlorure de thionyle 3,6V
Consommation en standby	< 5µA avec 2 capteurs de température
Consommation en émission	< 40 mA
Consommation en réception	< 17 mA
Norme radiofréquence	EN 300-220-1

➤ **Radio frequency characteristics at 433 Mhz – fixed frequency**

The characteristics indicated below are given for a temperature range of -20°C to 70°C

Characteristics	Min	Typical
Operating frequency		433.92 MHz
Frequency drift		75 KHz ±5%
Transmission speed		2400 Bauds
Passband reception		200 KHz
Receiver sensitivity(1) for a BER= 1%	-104dbm	-108 dbm
Transmission power ^[1]	8 dbm	10 dbm

[1] : The sensitivity and radio power characteristics are given in conduit (load 50 Ohms).

➤ **Radio frequency characteristics at 868 Mhz – frequency hopping**

Characteristics	Min	Typ.	Max
Operating frequency			Bands 868 – 868.600 Mhz 868.700 – 869.200 Mhz
Channel width			50 KHz
Frequency drift			9 KHz
Transmission speed			9600 Baud in NRZ mode
Type of modulation			GFSK
Receiver sensitivity(1) for a BER = 1%	-108dbm	-110 dbm	
Transmission power ^[1]	12 dbm	14 dbm	
Line of sight range			800 m

[1] : The sensitivity and radio power characteristics are given in conduit (load 50 Ohms).

➤ **Radio frequency characteristics at 915 Mhz – frequency hopping (for US version)**

Characteristics	Min	Typ.	Max
Operating frequency			Bands 902 – 928 Mhz
Channel width			50 KHz
Frequency drift			9 KHz
Transmission speed			9600 Baud in NRZ mode
Type of modulation			GFSK
Receiver sensitivity(1) for a BER = 1%	-108dbm	-110dbm	
Transmission power ^[1]	12 dbm	14 dbm	
Line of sight range			800 m

[1] : The sensitivity and radio power characteristics are given in conduit (load 50 Ohms).

1.2 SENSOR INTERFACE

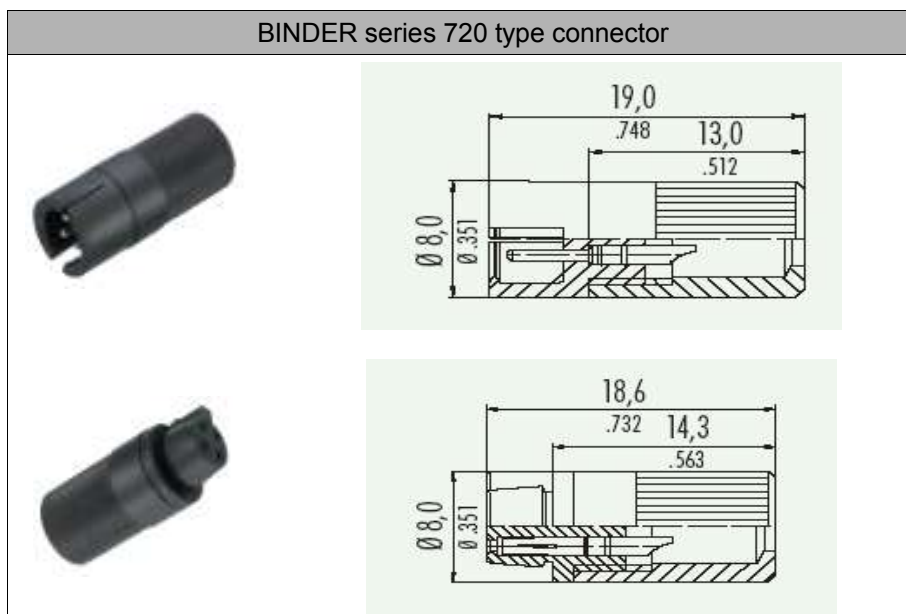
The WaveTherm modules are designed for use in a varied environment. They are therefore available with several types of temperature sensors offering performance characteristics enabling maximum coverage of the module's scope of application.

- ◆ WaveTherm – DALLAS: turnkey module supplied prewired to the probe via a connector.
- ◆ WaveTherm – PT1000: turnkey module offering better performance than the WaveTherm – DALLAS option. As standard, the WaveTherm modules are supplied with a PT1000 probe directly connected to the module (no connectors). However, when requested by the customer, it is possible to supply these modules with a BINDER series 720 type connector.
- ◆ WaveTherm – PT100: module intended for use by assemblers. Supplied without probe, with socket connector on the module side and a plug-in connector on the probe side.

1.2.1 WAVETHERM – DALLAS

This module is designed for a maximum of two temperature probes type DS18B20 (or DS18S20) from DALLAS. The DALLAS 1-wire type probe contains an internal 12-bit convertor.

Each external probe is connected to a cable outside the casing. This cable is equipped with a 3-pin connector type BINDER (series 719).



Automatic identification of the temperature probes enables memorisation of the probe's ID. This phase is completed automatically when the module is switched on and may also be enabled with a specific radio request.

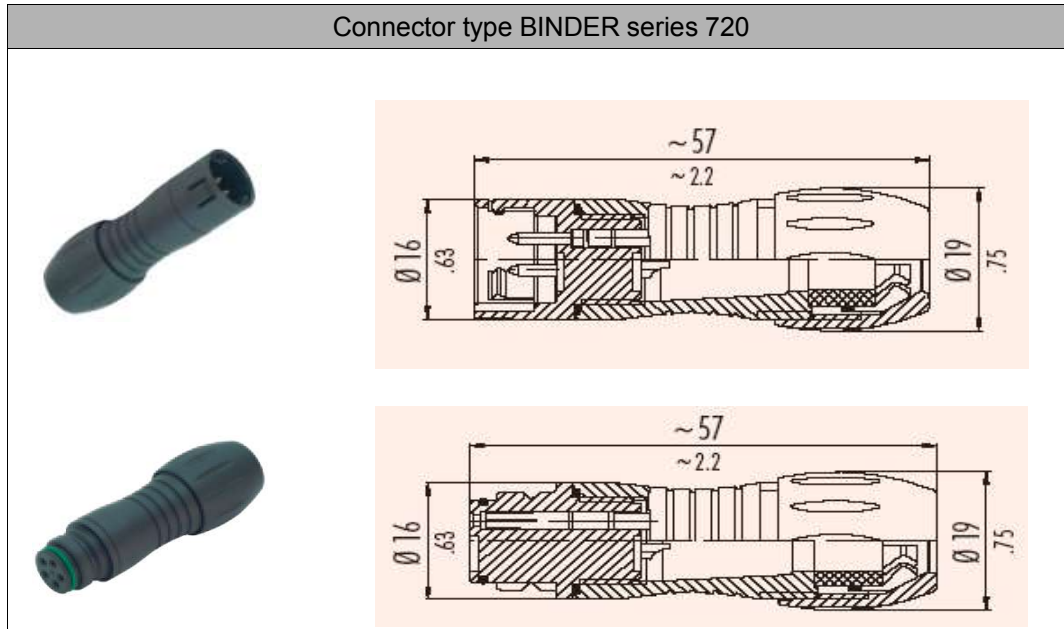
The module returns a radio signal with the probe's ID (see chapter 2.1.2)

➤ Precision of modules with DALLAS (18B20) probes:

Parameter	Condition	Min	Nom	Max	Unit
Measurement range		-55		+125	°C
Resolution		0.0625		0.5	°C
Measurement error	-55°C < t _{amb} < +125°C			± 2	°C
	-10°C < t _{amb} < +85°C			± 0.5	
Aging effect	1'000 h, t _{amb} = 125°C, Vdd = 5.5V			± 0.2	°C

1.2.2 WAVETHERM – PT1000

The WaveTherm PT1000 module is able to manage 1 or 2 PT1000 temperature probes.
The probes are connected to the module with sealed plug-in connectors for connection to 2, 3 or 4-wire probes (type BINDER series 720).



➤ Precision of modules with PT1000 probe

Parameter	Condition	Min	Nom	Max	Unit
Measurement range		590		1620	Ω
Resolution			0,4		Ω
Measurement error	$T_{amb} = 25^{\circ}\text{C} \pm 1^{\circ}\text{C}$			$\pm 1,28$	Ω
	$15^{\circ}\text{C} < t_{amb} < 35^{\circ}\text{C}$			$\pm 1,44$	
	$0^{\circ}\text{C} < t_{amb} < 50^{\circ}\text{C}$			$\pm 1,68$	
Aging effect	8'000 h, $15^{\circ}\text{C} < t_{amb} < 35^{\circ}\text{C}$			$\pm 0,32$	Ω
	20'000 h, $0^{\circ}\text{C} < t_{amb} < 50^{\circ}\text{C}$			$\pm 0,64$	
Grouping of probes	$0^{\circ}\text{C} < t_{mesure} < 100^{\circ}\text{C}$		$\pm 0,32$	$\pm 0,40$	Ω

Parameter	Condition	Min	Nom	Max	Unit
Measurement range		- 100		160	°C
Resolution			0,1		°C
Measurement error	$T_{amb} = 25^{\circ}\text{C} \pm 1^{\circ}\text{C}$			$\pm 0,35$	°C
	$15^{\circ}\text{C} < t_{amb} < 35^{\circ}\text{C}$			$\pm 0,40$	
	$0^{\circ}\text{C} < t_{amb} < 50^{\circ}\text{C}$			$\pm 0,45$	
Aging effect	8'000 h, $15^{\circ}\text{C} < t_{amb} < 35^{\circ}\text{C}$			$\pm 0,10$	°C
	20'000 h, $0^{\circ}\text{C} < t_{amb} < 50^{\circ}\text{C}$			$\pm 0,20$	
Grouping of probes	$0^{\circ}\text{C} < t_{mesure} < 100^{\circ}\text{C}$		$\pm 0,08$	$\pm 0,10$	°C

1.2.3 WAVETHERM – PT100

The WaveTherm PT100 module is able to manage 1 or 2 PT100 temperature probes.

The probes are connected to the module with sealed plug-in connectors for connection, via a shielded cable, to 2, 3 or 4-wire probes (type BINDER series 720, see 1.2.2).

➤ Precision of modules with PT100 probe :

Parameter	Condition	Min	Nom	Max	Unit
Measurement range		59		162	Ω
Resolution			2		mΩ
Measurement error	$T_{amb} = 25^{\circ}\text{C} \pm 1^{\circ}\text{C}$			± 19	mΩ
	$15^{\circ}\text{C} < t_{amb} < 35^{\circ}\text{C}$			± 27	
	$0^{\circ}\text{C} < t_{amb} < 50^{\circ}\text{C}$			± 39	
Aging effect	10'000 h, $15^{\circ}\text{C} < t_{amb} < 35^{\circ}\text{C}$		± 4	± 8	mΩ

Parameter	Condition	Min	Nom	Max	Unit
Measurement range		-100		160	°C
Resolution			0,01		°C
Measurement error	$T_{amb} = 25^{\circ}\text{C} \pm 1^{\circ}\text{C}$			$\pm 0,05$	°C
	$15^{\circ}\text{C} < t_{amb} < 35^{\circ}\text{C}$			$\pm 0,07$	
	$0^{\circ}\text{C} < t_{amb} < 50^{\circ}\text{C}$			$\pm 0,10$	
Aging effect	10'000 h, $15^{\circ}\text{C} < t_{amb} < 35^{\circ}\text{C}$		$\pm 0,01$	$\pm 0,02$	°C

1.3 WAVETHERM MODULE OPERATING LIFE

The aim of this chapter is to describe the power consumption profiles of the WaveTherm radio frequency module used for temperature measurement in order to estimate the working life of the battery according to the various operating conditions.

The Wavenis protocol used in all Coronis Systems products includes several dialogue modes (peer-to-peer, polling, broadcast). Depending on the operating conditions, the choice of one or the other of these modes may be recommended. This chapter defines the impact of the mode used on the module operating life.



This chapter does not take into account WaveTherm module application power-saving features such as system wake-up management (day/night system). Consult Coronis Systems for specific configurations.

The operating life of a module is based on the average current under various operating conditions. The operating life of the module depends on the following parameters :

- ◆ Average consumption,
- ◆ Operating climatic conditions,
- ◆ Electronic cut-out voltage,
- ◆ Battery capacity.

1.3.1 PARAMETERS WITH AN INFLUENCE ON AVERAGE POWER CONSUMPTION

The average consumption is the sum of the currents drawn for module operation (average stand-by current) and application parameters. These application parameters are:

- ◆ Module wake-up period,
- ◆ The population of modules in the network in which this module is incorporated,
- ◆ The radio polling frequency of the module,
- ◆ The type of data read (instantaneous temperature, internally logged temperatures),
- ◆ The Datalogging mode configuration (periodic reading of internally logged data),
- ◆ The operating configuration of a repeater module.

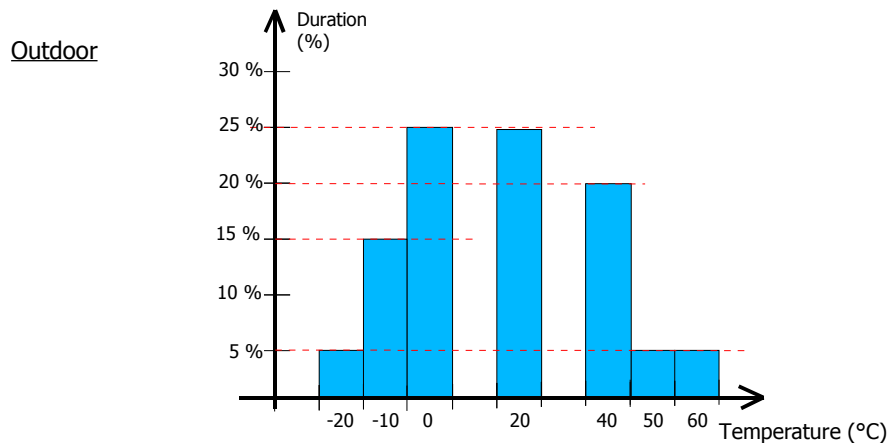
Some data used for calculation of the module operating life may not be modified. This is the case for the electronic cut-out voltage, wake-up period and battery capacity.

The wake-up period is consciously set to 1s. Increasing this wake-up period may help save current in relation with period reception but also has the effect of increasing the reception frame duration when reading.

➤ Auto-adaptation of the detection threshold

The WaveTherm modules constantly adjust the detection levels for wake up periods according to the environment. This helps guarantee the operating life-span even in the presence of disturbances and interference.

➤ Climate diagram



The climate diagram illustrated above represents the amount of time spent by the module at a given temperature. It is used for calculation of the module operating life.

1.3.2 ESTIMATION OF OPERATING LIFE

The initial parameters are the radio polling frequency, population of modules in the area and the datalogging mode parameter settings.

The population of modules corresponds to the number of modules within range of one another. Each module monitors all frames even those not directed at it which consequently has an impact on power consumption.

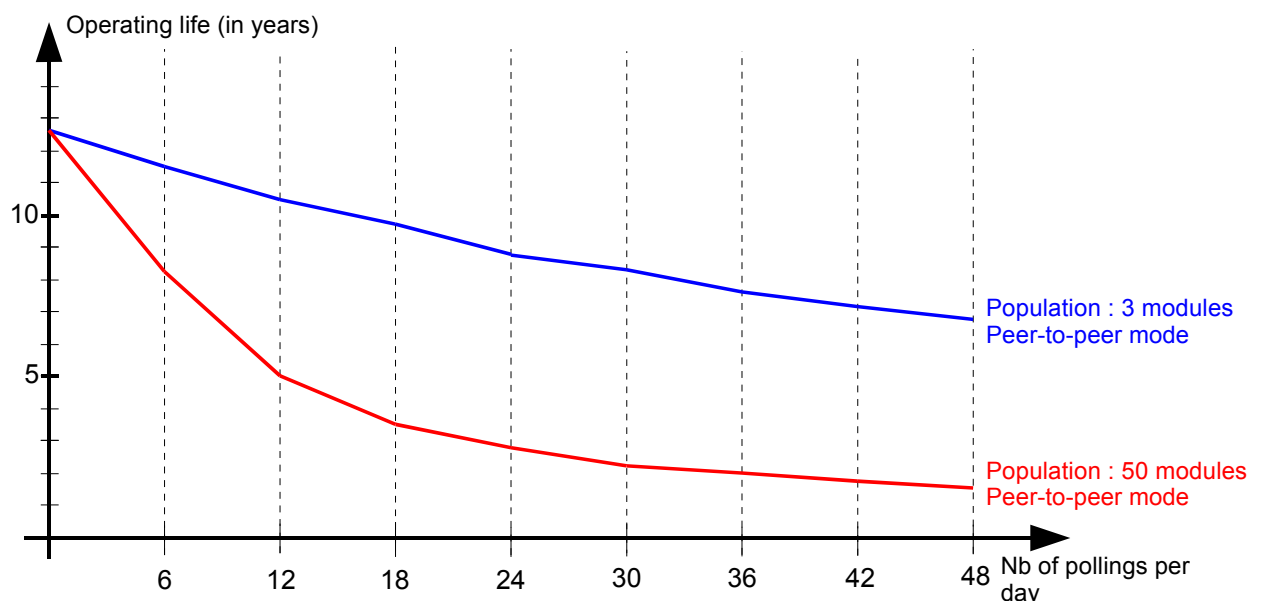
The following estimations are based on the assumption that all modules are read at the same polling frequency.

The theoretic operating life calculation taking into account the various parameters is relatively complex. In this document we have therefore chosen various graphs illustrating the influence of these parameters on the product operating life.

➤ Operating life = f (Nb of radio pollings)

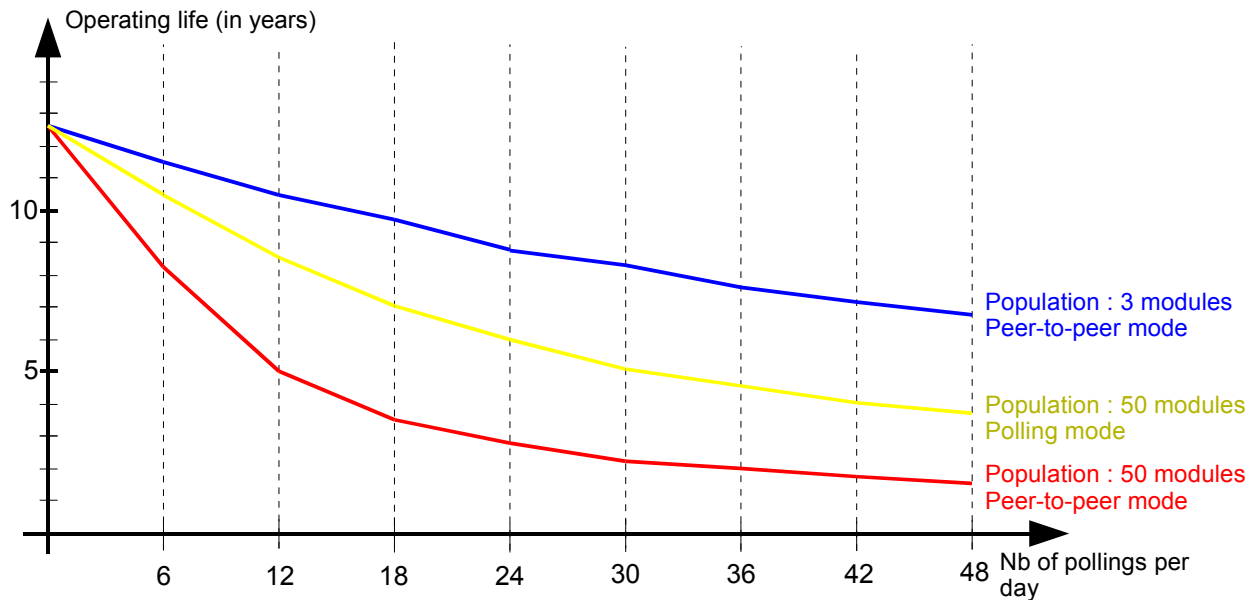
The datalogging period is set at 15 minutes
The standard peer-to-peer read mode is used

The blue line corresponds to a module population of 3
The red line corresponds to a module population of 50.



The solution recommended by Coronis Systems to counter reduction of the operating life in the case of a high module population is to use the polling mode which offers the advantage of transmitting only one frame to read a group of modules.

The yellow line below indicates the approximate operating life for a population of 50 modules by polling them in groups of 25 modules. (YELLOW)

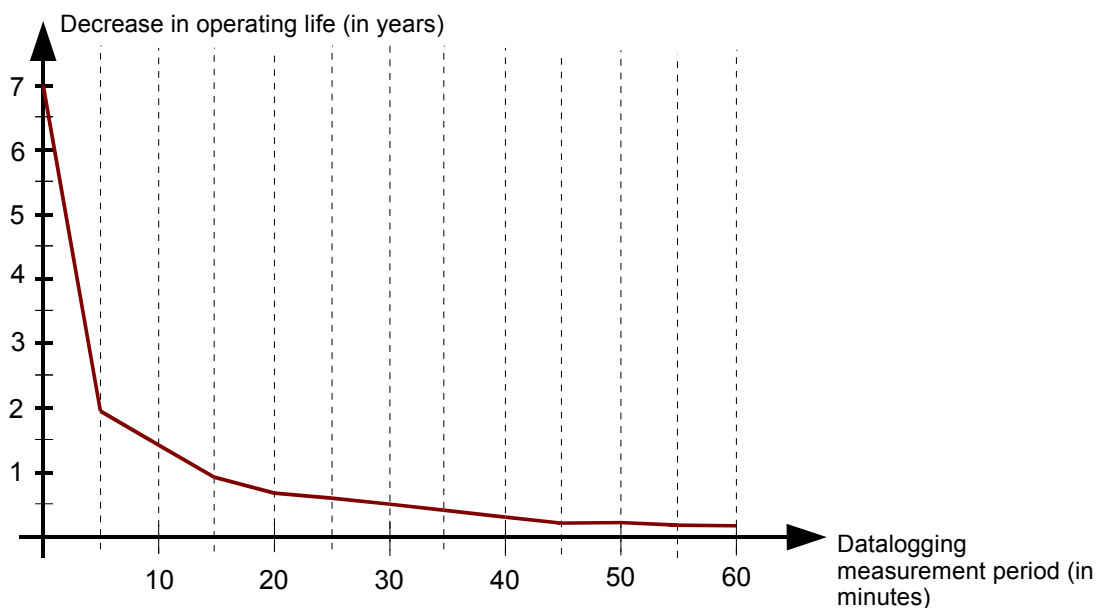


1.3.3 INFLUENCE OF DATALOGGING MODE MEASUREMENT PERIOD

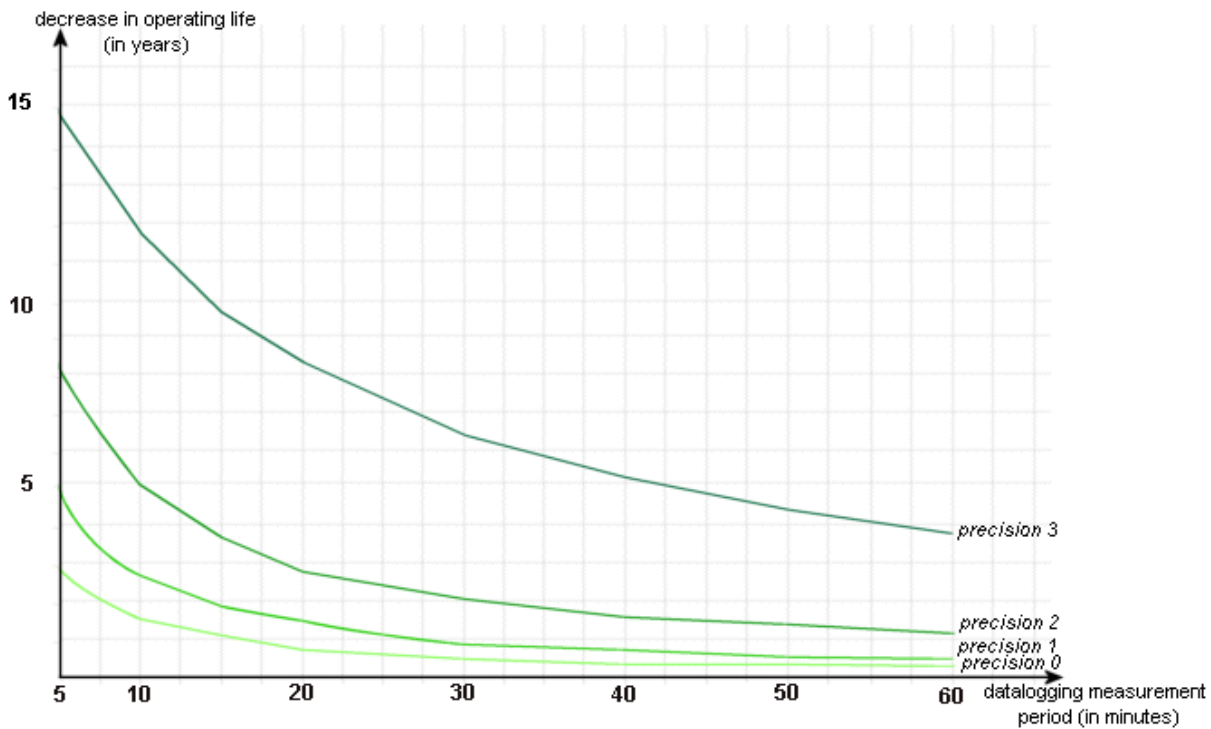
As a reminder, the internal memory of a standard WaveTherm module may save up to 48 temperature readings.

The graph below illustrates the reduction in product operating life according to the datalogging mode measurement period.

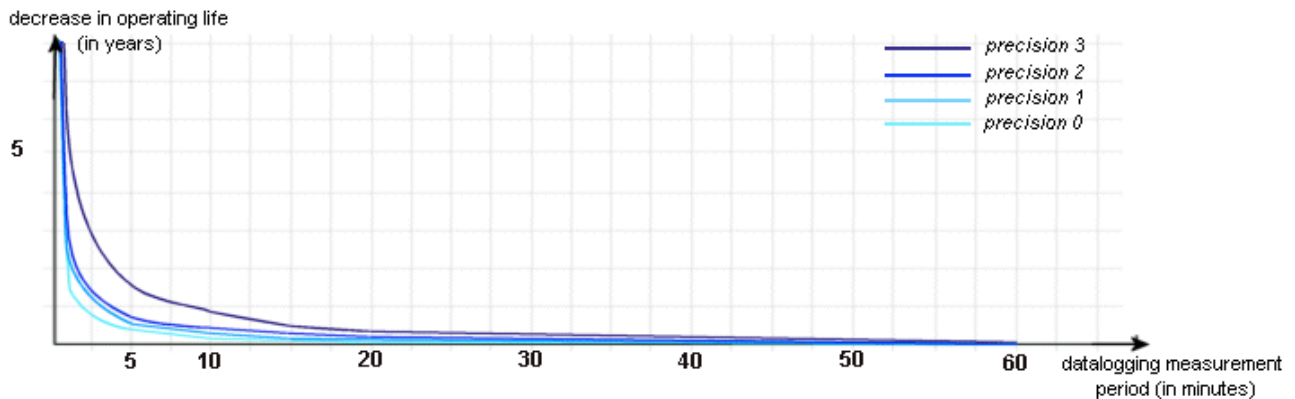
➤ Wavetherm - DALLAS



➤ WaveTherm - PT100



➤ Wavetherm - PT1000



These estimates are naturally taken into consideration in the choice of applications and systems.

It is recommendable to use the 'Polling' mode when a high product population within range of each other is noted.

The influence of the datalogging mode wake-up period on the module operating life is relatively low. When temperature measurement is to be carried out, it is recommendable to use the datalogging mode and poll the module at a lower frequency to reduce battery consumption.

2 INFORMATION RELATIVE TO THE PROBES ASSOCIATED WITH THE WAVETHERM MODULES

2.1 DALLAS PROBES

2.1.1 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.



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

2.1.2 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

2.1.3 SETTING OF THE PROBE COEFFICIENT PARAMETERS

The precision of DALLAS probes is indicated by the manufacturer as $\pm 0.5^{\circ}\text{C}$ (-10°C to $+85^{\circ}\text{C}$) 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. Management of this memory zone is described further in chapter 5.2.

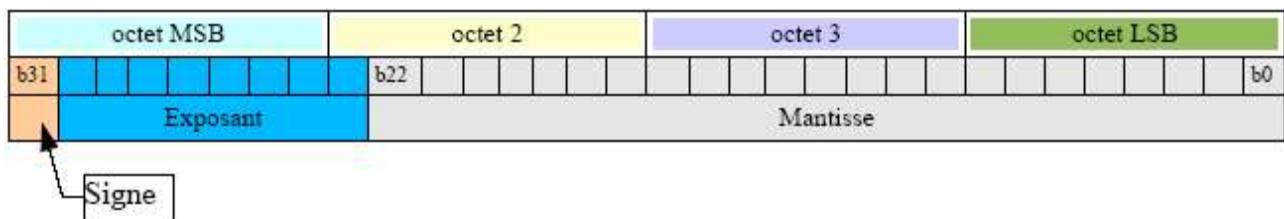
2.2 PT100 AND PT1000 PROBES

2.2.1 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.

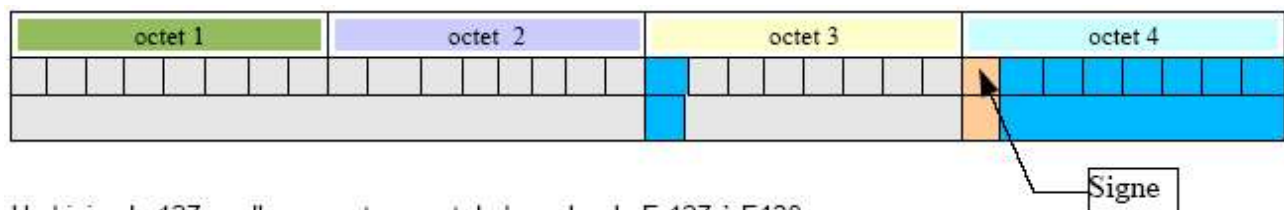
The format used is the standard IEEE format with precision coded on 32 bits (+/-5.8774e-39 to +/-170,14e36)

➤ 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.



Un biais de 127 sur l'exposant permet de le coder de E-127 à E128.

2.2.2 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.

2.2.3 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 :* $R = R0[1 + At + Bt^2 + C(t - 100^\circ\text{C})t^3]$
- ◆ *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:

and not $\text{temperature} = f(\text{resistance})$
 $\text{resistance} = f(\text{temperature}).$

The relationship $T = f(R)$ must therefore be calculated according to the relationship provided in standard EN60751.

The following polynomial is used:

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

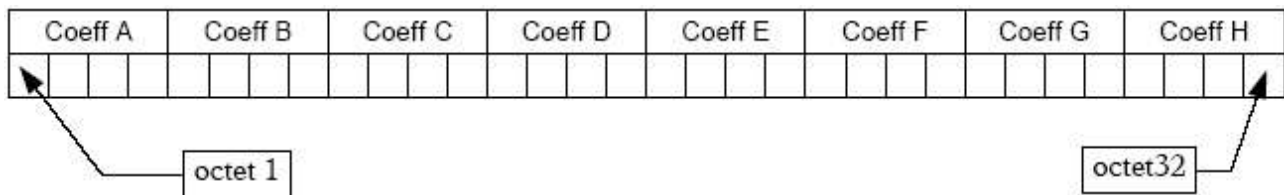
where $C_7, C_6, C_5, C_4, C_3, C_2, C_1$, and C_0 are the parameters to be transferred to the radio module

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. 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

3 INSTALLATION OF A WAVETHERM MODULE

WaveTherm module installation is carried out by connecting the temperature measurement probes to the module. (in general, the modules are supplied with the probes pre-wired)

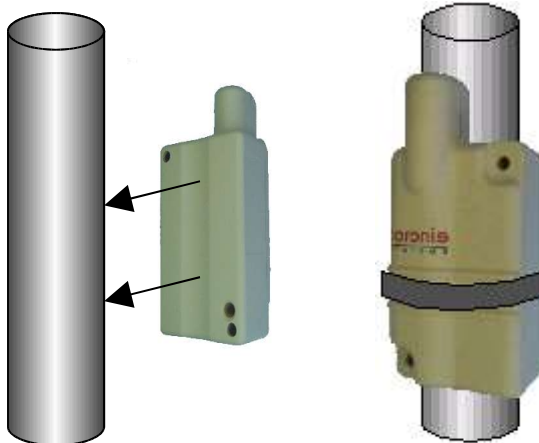
3.1 MODULE FASTENING

Two diagonally opposed holes enable easy screw fastening of the module to a flat surface.



Two diagonally opposed holes enable easy screw fastening of the module to a flat surface.

The specially designed casing of the WaveTherm module may be fastened to a pipe (the rear surface of the module is vertically curved) and secured with clamping or fastening straps (a horizontal guide is incorporated in the front surface for this purpose).



3.2 INSTALLATION PRECAUTIONS

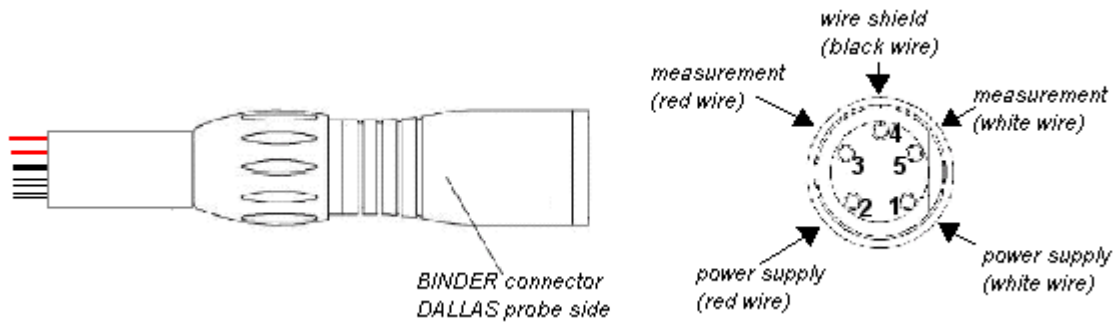
To ensure optimum operation, both from a battery as well as a radio frequency emission point of view, it is recommendable to fasten the WaveTherm module vertically with the aerial pointing up and to ensure a minimum distance of 20 cm between two modules.

It is also recommendable to install the modules, whenever possible, far away from metal surfaces and electrical cables.

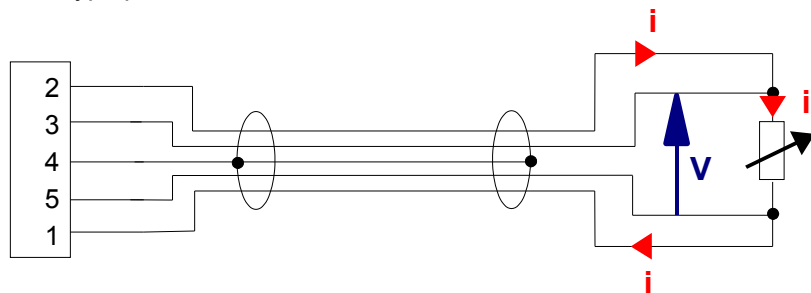
3.3 REPLACEMENT OF A MEASUREMENT PROBE

In the case where a new probe must be installed, the diagram for connection to the module is as follows.

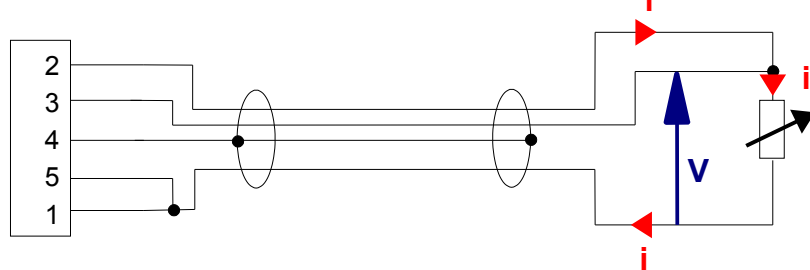
- **PT100 or PT1000 probes:** connectors BINDER series 720, 2, 3, or 4-wire versions are used.



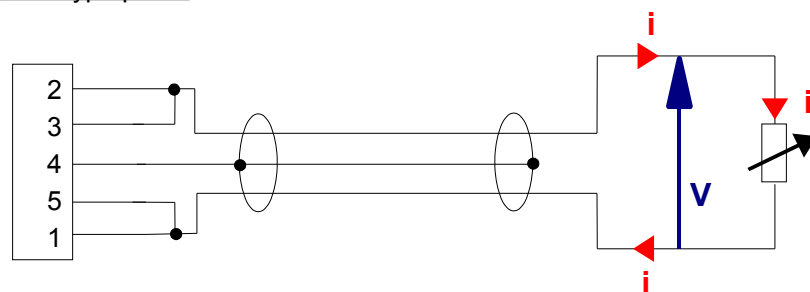
Wiring of a 4-wire type probe



Wiring of a 3-wire type probe

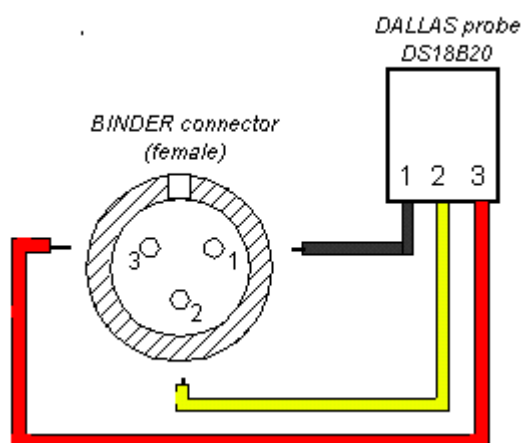
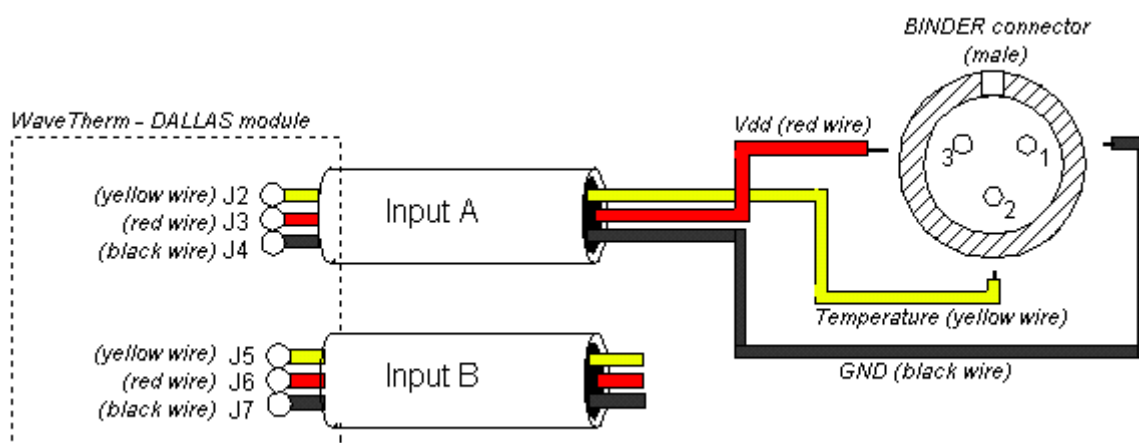


Wiring of a 2-wire type probe



➤ **DALLAS probe:** the connector BINDER series 719, 3-wire version is used.

	WaveTherm PCB side	Description	Wire colour	Binder Connector	DALLAS probe (DS18B20)
Input A	J2	Temperature	Yellow	2	2
	J3	Vdd Dallas probe	Red	3	3
	J4	GND	Black	1	1
Input B	J5	Temperature	Yellow	2	2
	J6	Vdd Dallas probe	Red	3	3
	J7	GND	Black	1	1



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 1 st 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 peer-to-peer 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.

5 WAVETHERM MODULE FUNCTIONS

The WaveTherm modules offer the following functions :

- ◆ Read temperatures immediately,
- ◆ Read temperatures logged,
- ◆ Log and automatically transmit alarm or occurrence signals :
 - threshold detection
 - end of battery life
 - probe fault detection (only used with WaveTherm – PT100)
- ◆ Operating mode management (including clock synchronisation)
- ◆ Read internal parameters (firmware version, radio communication mode,...)

5.1 READ TEMPERATURES

As standard, the WaveTherm module offers the possibility to read temperatures (in degrees Celsius and in an ohmic value) by setting a precision index value.

5.1.1 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.

5.1.2 READ OHMIC VALUE OF PROBES IMMEDIATELY



Compatibility : - WaveTherm – PT100
- WaveTherm – PT1000

In the case of the WaveTherm – PT100 and WaveTherm - PT1000 modules, it is possible to read the probe temperature data in the form of an ohmic value.

This read command may be carried out with a preset precision level. In general, precision level 0 is sufficient. The other precision levels are used in difficult environments.

5.2 STORAGE OF CALIBRATION PARAMETERS

The WaveTherm module manages the radio accessible non-volatile memory zone and enables storage of up to 32 bytes.

This zone enables storage of calibration parameters for the temperature module(s).
This zone is accessible in read and write by specifying the start address and data size.

Access to the read function is achieved by specifying the address of the first element to be attained, then the total number of elements to be read (the size of one element is one byte).



Remark: Even if the memory zone size is 32 bytes, the address of the first element to be read is coded on two bytes as this zone is larger on other products.

Access to the write function is achieved by specifying the address of the first element to be attained, then the total number of elements to be written (the size of one element is one byte) and finally the read bytes.

5.3 PERIODIC TEMPERATURE READING (DATALOGGING)

The Datalogging mode enables periodic logging of temperatures at each input (by selecting the precision index for PT100 and PT1000 probes) (see chapter 5.1.1).

The frequency of these readings may be set in three modes:

◆ **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.

◆ **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.

◆ **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 system does not manage changes in the number of days in a month.*

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.

5.4 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 5.6)
- ◆ End of battery life detection (see 5.8)
- ◆ Probe fault (*WaveTherm – PT100 only*) (see 5.7)

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.

5.4.1 ALARM MANAGEMENT PARAMETER SETTING

The alarm frame transmission parameters are set in two steps,

- ◆ **Configuration of the alarm frames receiver module** (as well as the repeater path if applicable).

This setting is carried out by accessing the parameters concerned, but may also be carried out automatically.

Therefore, when a remote module of the type WaveCard/WavePort transmits an alarm configuration command; the WaveTherm module retrieves the address of the remote module and repeater path (if used) and memorises them as receiver of alarm frames.

- ◆ **Enable alarms with the alarm management parameter**

Alarm frame management configuration is achieved with specific radio commands. Following an alarm configuration command, the WaveTherm module returns an acknowledgement of reception. In the case of an error, or a non-conform request, the acknowledgement frame contains a write status byte. Otherwise it returns control, index and input bytes.

5.4.2 TRIGGERING AN ALARM FRAME

After detection of a fault, if the configuration mode authorises transmission of alarms, the module transmits an alarm frame.



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 remote device must send an acknowledgement frame 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 a set number of times.

Between each re-transmission of a non-acknowledged alarm signal, the module waits for a predefined time.

5.5 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)

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

5.5.1 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 mode
Case n°1 : Periodic wake-up, without distinction of day of the week
Case n°2 : Periodic wake-up in specific time windows for certain days of the week, periodic wake-up for the other days
Case n°3 : Periodic wake-up for certain days of the week, periodic wake-up disabled for the other days
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.

➤ Example of different wake-up modes:



Time window n°1 : wakeup every 3 seconds



Default wake-up period, every second.

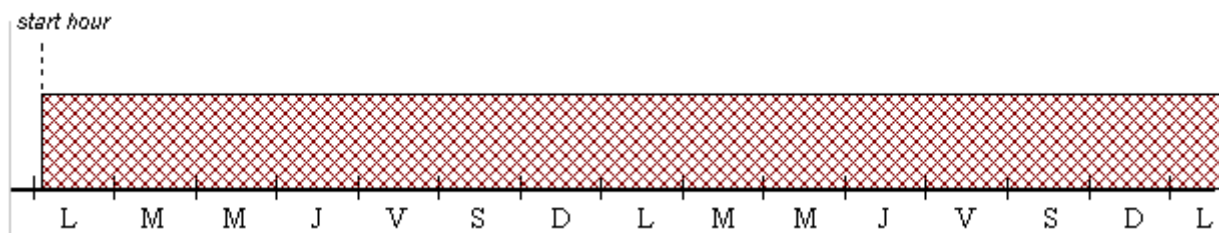


Time window n°2 : wakeup every 6 seconds

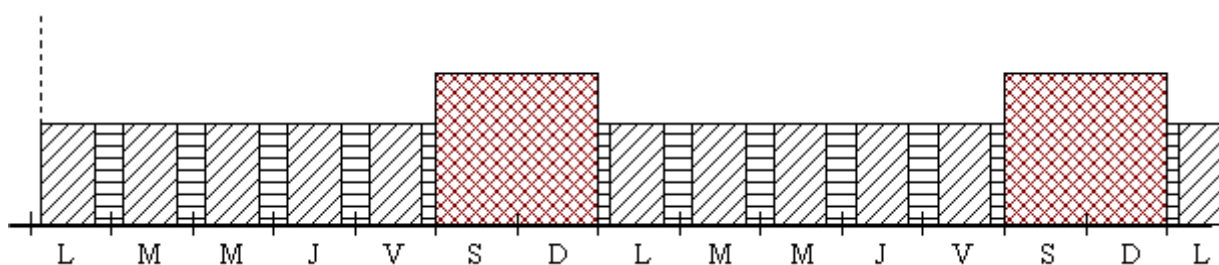


no wake-up period (in fact, wakeup every 10 seconds)

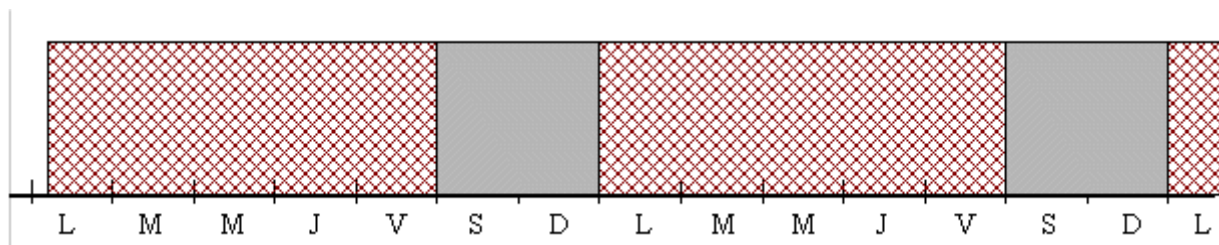
Case n°1 : *Periodic wake-up, without distinction of day of the week*



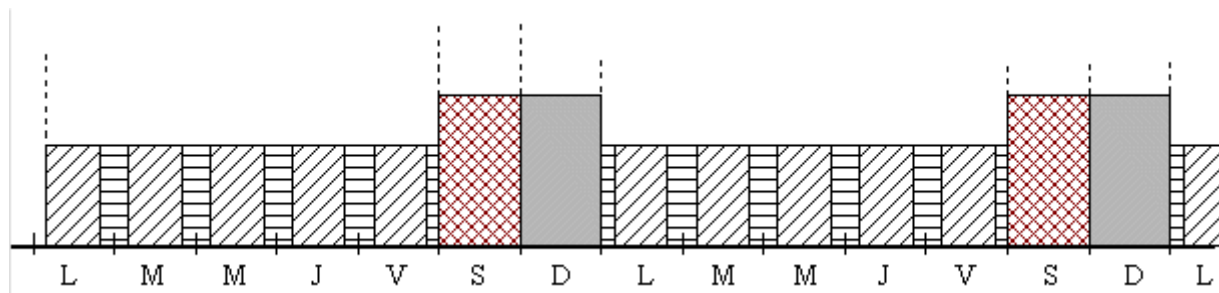
Case n°2 : *Periodic wake-up in time windows from Monday to Friday.
Standard periodic wake-up for the other days.*



Case n°3 : *Periodic wake-up from Monday to Friday.
Wake-up disabled the other days.*



Case n°4 : *Periodic wake-up in time windows from Monday to Friday.
Standard periodic wake-up on Saturday.
Wake-up disabled on Sunday.*



5.5.2 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.

5.5.3 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 WaveTherm 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.

5.5.4 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

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 ;*
- ◆ *Validate the time window mode with the 'wake-up system status word'.*

5.5.5 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' :*

- ◆ *the rest of the week, the module uses the default wake-up period.*
- ◆ *periodic wake-up disabled (polling every 10 sec.)*

5.6 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 5.1.1).

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)

5.6.1 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.

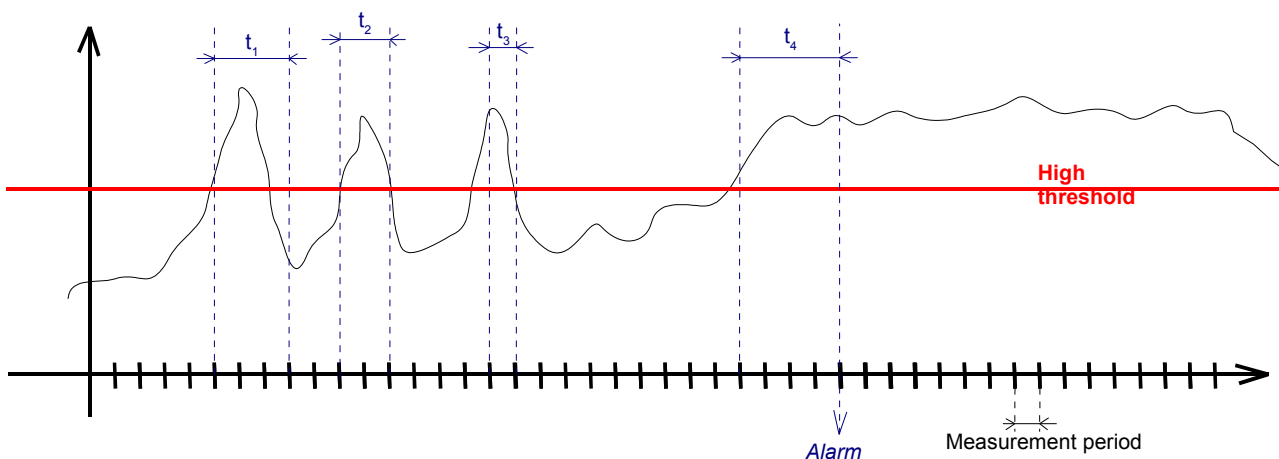


This period is set independent of the datalogging period. However, for power saving reasons, it is recommendable to set the datalogging period as a multiple of the threshold alarm detection period.

The following parameters apply to this function:

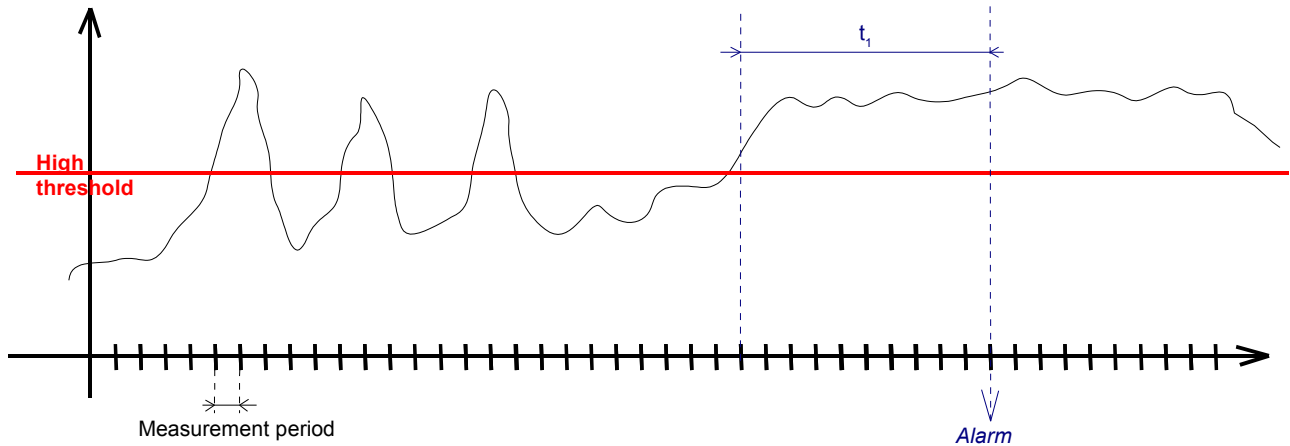
- ◆ High threshold alarm,
- ◆ Low threshold alarm,
- ◆ Threshold excess time (used in cumulative and successive mode),
- ◆ Mode parameter setting byte (high threshold enabled, low threshold enabled, immediate, successive or cumulative mode).

➤ **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, $t_{seuil} = 10$ measurement periods, one gets $t_1 + t_2 + t_3 + t_4 > t_{seuil}$

- 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, $t_{seuil} = 10$ measurement periods, one gets $t_1 > t_{seuil}$



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

5.6.2 STORAGE OF THRESHOLD ALARM OCCURRENCES

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.

5.6.3 TRANSMISSION OF A THRESHOLD ALARM FRAME

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

5.7 SENSOR FAULT DETECTION (IF ACCEPTED 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 module only**, after detection of a probe fault, the module carries out the following operations:

- ◆ records the detection date in an internal parameter.
- ◆ If required, transmits an immediate probe fault detection radio frame.

5.8 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 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.*

APPENDIX – A : CASING DIMENSIONS

