

# Star Network Protocol Stack User Guide

1w0300873 Rev.5 - 2012-08-29



## APPLICABILITY TABLE

PRODUCT
LE50-433
LE50-868

SW Version
GC.S00.01.03
GD.S00.01.03



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## 1. Introduction

### 1.1. Scope

The scope of the document is to present the features and the application of the Star Network embedded stack available on TELIT references LE50-433 and LE50-868.

### 1.2. Audience

This document is intended for Telit customers, who are integrators, about to implement their applications using TELIT LE50-433 and LE50-868 radio modules

### 1.3. Contact Information, Support

For general contact, technical support, to report documentation errors and to order manuals, contact Telit Technical Support Center (TTSC) at:

[TS-SRD@telit.com](mailto:TS-SRD@telit.com)  
[TS-NORTHAMERICA@telit.com](mailto:TS-NORTHAMERICA@telit.com)  
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Alternatively, use:

<http://www.telit.com/en/products/technical-support-center/contact.php>

For detailed information about where you can buy the Telit modules or for recommendations on accessories and components visit:

<http://www.telit.com>

To register for product news and announcements or for product questions contact Telit Technical Support Center (TTSC).

Our aim is to make this guide as helpful as possible. Keep us informed of your comments and suggestions for improvements.

Telit appreciates feedback from the users of our information.



## 1.4. Document Organization

This document contains the following chapters:

[“Chapter 1: “Introduction”](#) provides a scope for this document, target audience, contact and support information, and text conventions.

[“Chapter 2: “Description of Standard Functionality”](#) gives a detailed description of the standard functionalities and operation of the Star Network protocol stack.

[“Chapter 3: “Description of the Telemetry Functionality”](#) gives a description of telemetry functionalities and operation of the Star Network protocol stack.

## 1.5. Text Conventions



**Danger – This information MUST be followed or catastrophic equipment failure or bodily injury may occur.**



**Caution or Warning – Alerts the user to important points about integrating the module, if these points are not followed, the module and end user equipment may fail or malfunction.**



**Tip or Information – Provides advice and suggestions that may be useful when integrating the module.**

All dates are in ISO 8601 format, i.e. YYYY-MM-DD.

## 1.6. Related Documents

- [1] EN 300 220-2 v2.3.1 ETSI Standards for SRD , February 2010
- [2] ERC Rec 70-03 ERC Recommendation for SRD, June 2010
- [3] 2002/95/EC Directive of the European Parliament and of the Council, 27 January 2003
- [4] SR Manager Tool User Guide 1vv0300899
- [5] xE50-868/433 RF Module User Guide 1vv0300905
- [6] 2006/771/EC Harmonization of the radio spectrum for use by short-range devices
- [7] 2009/381/EC Amending Decision 2006/771/EC on harmonization of the radio spectrum for use by short-range devices





## 2. Description of the Standard Functionalities

This Chapter is dedicated to the standard functionality of the Star Network protocol stack.

There are 2 different modes available for Star Network protocol stack that are described in following paragraphs:

- The *configuration mode* which allows to parameter the module. It is set through the use of Hayes commands sent on the serial link.
- The *operating mode* which is the functional use for data transmission

### 2.1. Configuration mode

Hayes or 'AT' commands complies with Hayes protocol used in PSTN modem standards. This 'AT' protocol or Hayes mode is used to configure the modem parameters, based on the following principles:

- A data frame always begins with the two ASCII 'AT' characters, standing for 'ATtention'
- Commands are coded over one or several characters and may include additional data
- A given command always ends up with a <CR> Carriage Return

A	T	Command	Additional data	<CR>
---	---	---------	-----------------	------



***NOTE: The delay between 2 characters of the same command must be less than 10 seconds***

The only exception to this data-framing rule is the switching command from the operating mode to configuration mode. In this case only :

- the escape code ('+++') must be started and followed by a silent time at least equal to the serial time out.
- <AT> and <CR> shall not be used.



Below is the complete list of the ‘AT’ commands available on the module.

Command	Description
+++	<p><b>Hayes Mode Activation</b></p> <p>‘+++’ command gives an instant access to the modem’s parameters configuration mode (Hayes or AT mode), whatever the current operating mode in process might be.</p> <p>‘+++’ command should be entered as one string, i.e. it should not be preceded by ‘AT’ and followed by &lt;CR&gt; but two silent times which duration is configurable via S214 register (Serial time-out). The time between two ‘+’ must not exceed the time-out value.</p> <p>Hayes mode inactivates radio functions.</p>
ATO	<p><b>Communication mode activation</b></p> <p>‘ATO’ command gives an instant access to the modem’s operating mode, configured in S220 register.</p> <p>‘ATO’ command is used to get out of Hayes mode. It will also terminate all running carrier tests if any.</p> <p>Answer : <b>OK</b> or <b>ERROR</b> if the configuration is not complete</p>
AT/V	<p><b>Modem’s firmware version</b></p> <p>‘AT/V’ command displays the modem’s firmware version as follows: <b>pp.MCR.MM.mm&lt;CR&gt;</b></p> <p>With:</p> <p><b>pp</b> is the platform:</p> <ul style="list-style-type: none"> <li>GC: LE50-868</li> </ul> <p><b>XCR: X</b> is the stack (S for Star Network and B for Bootloader).</p> <p><b>C</b> is the casing:</p> <ul style="list-style-type: none"> <li>0: OEM boards</li> <li>1: USB dongle or IP67 box</li> </ul> <p><b>R</b> is reserved and always read as ‘0’</p> <p><b>MM</b>: Major version <b>mm</b>: minor version</p>
AT/S	<p><b>Modem’s registers status</b></p> <p>‘AT/S’ command displays status of all relevant registers of the modem</p>
ATSn?	<p><b>Register interrogation</b></p> <p>‘ATSn?’ command displays the content of Hayes register number n (Refer to the register description table).</p> <p>Some registers are standard for every Telit modems while others are specific to some products.</p> <p>Answer : <b>Sn=x&lt;CR&gt;</b></p>
ATSn=m	<p><b>Register modification</b></p> <p>‘ATSn=m’ command configures Hayes register number n with the value m, e.g. <b>ATS200=4&lt;CR&gt;</b> enters the value ‘4’ in the register S200.</p> <p>The value is automatically stored in the EEPROM memory.</p> <p>Answer : <b>OK</b> or <b>ERROR</b></p>
ATR	<p><b>Parameters reset</b></p> <p>‘ATR’ command resets all modem’s parameters to their default values.</p> <p>Answer : <b>OK</b></p>



ATP	<p><b>Stand By Activation</b> When serial stand by is set, the ‘ATP’ command put the module in stand by mode. To wake up the module, send a NULL (0x00) character.</p>
ATBL	<p><b>Switch to Bootloader</b> ‘ATBL’ command escape from the main program and run the bootloader. This command is useful to update the firmware by serial or radio link. See the dedicated part for details.</p>

Specific ‘AT’ commands has been integrated in order to make measurements and tests.

Command	Description
ATTO	<b>Pure carrier transmission</b> at center frequency
ATT1	<b>Modulated carrier transmission</b>
ATTO	<b>Exit carrier transmission</b>



**Note 1: After an AT command (ended by <CR>), the serial link gives back result code, which is "OK" or "ERROR".**



**Note 2: "+++" command gives back OK.**

These commands are effective after a maximum delay of 10 mS ; the back code OK indicates the good execution of the command, and another command can be sent right after the back code OK.



## 2.2. Operating mode

There are 2 communication protocols available on the module:

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



**Note : Transparent mode allows sending big data frames and also streaming when radio baud rate is equal or greater than serial one.**

- **Addressed Secured mode:** it is a kind of multipoint network protocol. Each module can communicate with every other module in the same network. All the frames are addressed, checked through a CRC and acknowledged. This mode also allows sending telemetry commands over the network to monitor inputs or change output state of a remote identified module. Finally, this mode allows broadcasting by sending to address 0. This mode can't support frame.

**Note : Addressed Secured mode doesn't allow sending big data frames. The whole serial frame needs to be stored in buffer before being treated and finally sent on the air. For this reason the maximum allowed size is 240 bytes.**

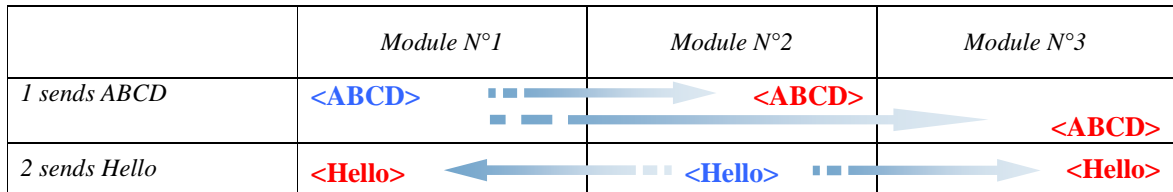


In addition to these two modes, a few optional functionalities can be enabled like LBT, Cyclic Wake Up, or AES encryption:

- **LBT (Listen Before Talk):** It means that the transmitting module will scan the radio link and verify it is free (no radio activity) before sending its data to avoid collision. LBT is available in both transparent and Addressed Secured modes. See register S226 for details.
- **Cyclic Wake Up:** A device running Cyclic Wake Up sleeps most of the time and periodically wakes up during a few milliseconds to listen to the radio channel. If an incoming radio frame is detected, the module wakes up completely and performs the message treatment. Otherwise, the module returns immediately to stand by until next radio scan. This option allows sending radio messages to a sleeping module. Cyclic Wake Up is available in both transparent and Addressed Secured modes. See registers S240, S243, S245 and S247 for details.
- **AES Encryption:** When enabled, this option performs an AES 128 bits encryption of data sent in Addressed Secured mode. The encryption key is customizable. AES Encryption is only available in Addressed Secured mode and has no effect in Transparent mode. Only the user data are encrypted allowing to mix encrypted and clear messages in the same network. See registers S255 and S280 for details.

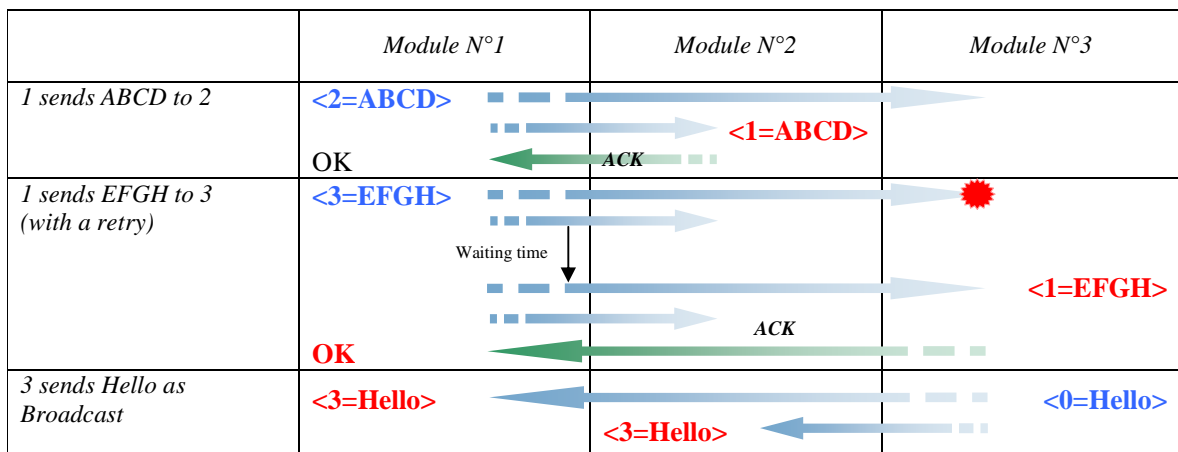



### 2.2.1. Basic Illustration of Transparent mode



<in blue> : data sent  
<in red> : data received

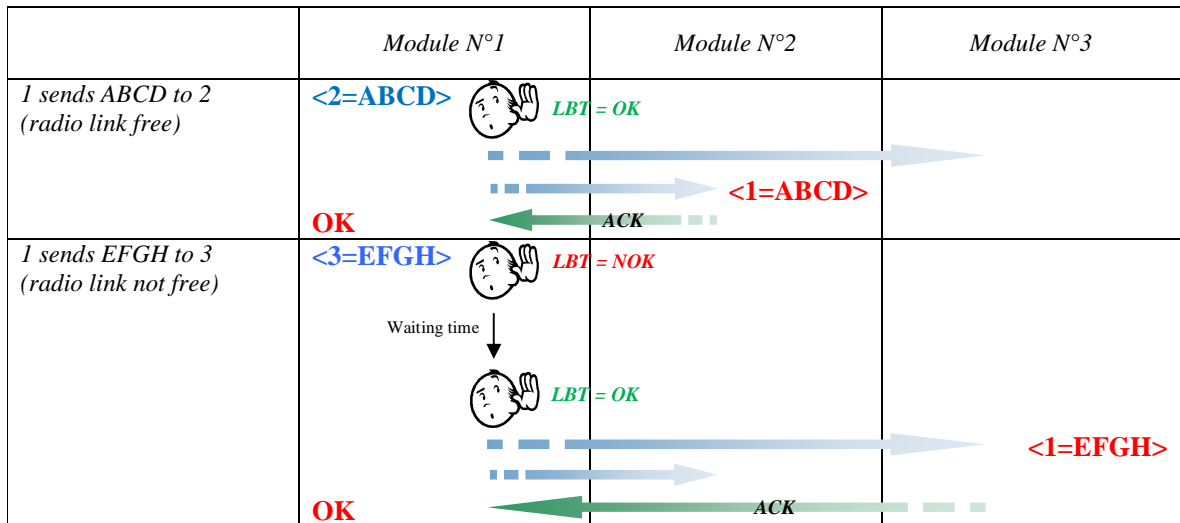
### 2.2.2. Basic Illustration of Addressed Secured mode



 Collision or error  
<in blue> : data sent  
<in red> : data received



### 2.2.3. Basic Illustration of Addressed Secured mode with LBT



## 2.3. Public Registers Detailed Use

The parameters to be configured via Hayes mode are stored in the module permanent memory, called S registers. Those registers are always listed as follow:

- S20x registers correspond to the radio parameters
- S21x registers correspond to the serial parameters
- S22x registers correspond to the operating parameters
- S24x registers correspond to low power parameters
- S25x registers correspond to the network parameters
- S26x registers correspond to the telemetry parameters

### 2.3.1. Radio Configuration

The Radio configuration is set via the S20x registers. Through them, you can:

- Change radio channel : S200,
- Change the radio baud rate : S201,
- Change the radio Output Power : S202,
- Modify the carrier length : S204,
- Change Radio Frequency Sub-Band : S206.
- Change Xor pattern applied on radio data: 209

The radio parameters are preferably set in the following order :

#### 1. Frequency Sub-band assignment : S206

This register sets the Frequency Sub-band used for the communication.

For LE50-868 :

S206 value	Band	Frequency Sub-Band
0 (default)	g1	868.0-868.6 MHz
1		n.a.
2	g2	868.7-869.2 MHz
3		n.a.
4		n.a.
5		n.a.
6	g3	869.4-869.65 MHz
7		n.a.
8	g4	869.7-870 MHz
9		
10	g	863.0-870 MHz



For LE50-433 :

S206 value	Band	Frequency Sub-Band
0 (default)	1f	433.050 – 434.79 MHz

The set of S206 register will automatically set S200, S201 and S202 registers with default value.

## 2. Radio baud rate : S201

This register sets the data rate on the RF link.

S201 value	Radio baud rate	
	LE50-868	LE50-433
0	4.8 kbps	n.a.
1	9.6 kbps	
2	19.2 kbps	n.a.
3 (default)	38.4 kbps	
4	115.2 kbps	



**NOTE:** When radio baud rate is very slow compared to serial data rate, all data are stored in a buffer of 255 bytes. To not risk a buffer overflow and data loss, it is advised to enable to serial flow control in register S216.

## 3. Radio channel : S200

The number of channels available on each sub-band depends on the radio baud rate chosen.

Sub-band	LE50-868					LE50-433
	Band g	Band g1	Band g2	Band g3	Band g4	Band 1f
Radio baud rate (S201)	(0): 4.8 kbps (1): 9.6 kbps (2): 19.2 kbps (3): 38.4 kbps (4): 115.2 kbps					(1): 9.6 kbps (3): 38.4 kbps (4): 115.2 kbps
Number of channels	(0): 60 (1): 60 (2): 20 (3): 10 (4): 0	(0): 12 (1): 12 (2): 6 (3): 3 (4): 1	(0): 10 (1): 10 (2): 5 (3): 2 (4): 1	(0): 1 (1): 1 (2): 1 (3): 1 (4): 0	(0): 6 (1): 6 (2): 3 (3): 2 (4): 0	(1): 8 (3): 8 (4): 4
S200	(0): from 0 to 59 (1): from 0 to 59 (2): from 0 to 19 (3): from 0 to 9 (4): n.a.	(0): from 0 to 11 (1): from 0 to 11 (2): from 0 to 5 (3): from 0 to 2 (4): only 0	(0): from 0 to 9 (1): from 0 to 9 (2): from 0 to 4 (3): from 0 to 1 (4): only 0	(0): only 0 (1): only 0 (2): only 0 (3): only 0 (4): n.a.	(0): from 0 to 5 (1): from 0 to 5 (2): from 0 to 2 (3): from 0 to 1 (4): n.a.	(1): from 0 to 7 (3): from 0 to 7 (4): from 0 to 3

The default value for this register is S200=0





#### 4. Radio Output power : S202

The default value (**in bold**) is set to the maximum output power authorized in each Sub-Band.

Sub-band	LE50-868					LE50-433
	Band g	Band g1	Band g2	Band g3	Band g4	Band 1f
S202	0 : -8dBm 1 : -5dBm 2 : -2dBm 3 : +1dBm 4 : +4dBm 5 : +7dBm 6 : +10dBm 7 : <b>+14dBm</b>	0 : -8dBm 1 : -5dBm 2 : -2dBm 3 : +1dBm 4 : +4dBm 5 : +7dBm 6 : +10dBm 7 : <b>+14dBm</b>	0 : -8dBm 1 : -5dBm 2 : -2dBm 3 : +1dBm 4 : +4dBm 5 : +7dBm 6 : +10dBm 7 : <b>+14dBm</b>	0 : -8dBm 1 : -5dBm 2 : -2dBm 3 : +1dBm 4 : +4dBm 5 : +7dBm 6 : +10dBm 7 : <b>+14dBm</b>	0 : -8dBm 1 : -5dBm 2 : -2dBm 3 : +1dBm 4 : +4dBm 5 : <b>+7dBm</b> 6 : +10dBm 7 : +14dBm	0 : -8dBm 1 : -5dBm 2 : -2dBm 3 : +1dBm 4 : +4dBm 5 : +7dBm 6 : <b>+10dBm</b> 7 : +14dBm

#### 5. Radio preamble length : S204

This register sets the length (in bytes) of the radio preamble sent before the data. It serves as synchronization frame for the receiver(s). The default value is 8 bytes (S204=8).

If the radio receiver is configured in low power with wake on radio activated, then the preamble length of the sender may be increased to have more chance to be detected by the remote sleeping module. See Wake On Radio chapter for more details.

Without low power consideration, this register hasn't to be modified. However, in some hostile environment (metallic parts, vibrations...) it can be increased to have a more reliable synchronization. This will lower the over air throughput as it increase the non-data use of the radio.

#### 6. Radio Whitening Character : S209

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

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



## 2.3.2. Serial link configuration

The serial link configuration is set via the S21x registers. Through them, you can:

- Set the serial baud rate : S210,
- Set the parity : S212,
- Set the number of stop bits: S213,
- Set the serial time-out : S214,
- Set the flow control type : S216,

After each modification in the serial settings, the module will answer 'OK' with the current configuration, and the changes will be effective immediately after.

The Serial parameters are preferably set in the following order:

### 1. Serial Baud rate : S210

This register selects the serial baud rate value. It is linked to the time-out register S214. They can be set with the following values :

S210 value	Serial baud rate	S214 minimum value
1	1 200 bps	17
2	2 400 bps	9
3	4 800 bps	5
4	9 600 bps	3
<b>5 (default)</b>	<b>19 200 bps</b>	<b>2</b>
6	38 400 bps	2
7	57 600 bps	2
8	115 200 bps	2



**NOTE:** When serial baud rate is very high compared to radio data rate, all data are stored in a buffer of 255 bytes. To not risk a buffer overflow and data loss, it is advised to enable to serial flow control in register S216.

### 2. Serial timeout : S214

The module is not able to know when a frame reception is finished on the serial link, but it needs this information to stop radio transmission in transparent mode, or to start sending data in the other modes.

This timeout is the indicator used to decide when the data frame is finished: if no character is received for a time equal to this timeout, the data frame is seen as finished and the modem acts accordingly.

The default value is 5 milliseconds.



The Timeout value is of course in accordance with the serial baud rate : it must be at least equal to the length of 2 characters. See the table in the baud rate (S210) part of this chapter. For example, for a 19200 bps baud rate, the time to send 1 character (1 start bit + 8 data bits + 1 stop bit) is 521  $\mu$ s, giving a squared up timeout value of 2 ms.

You can set a higher value to this timeout if you have some gaps in the sending of a frame.

### 3. Serial data format : S212 and S213

These registers set the format of the characters sent on the serial link :

- S212 : Parity. It can take three values : '1' for No Parity, '2' for Even Parity, or '3' for Odd Parity. The default value is **S212=1**.
- S213 : Number of Stop bits: 1 bit or 2 bits. Default value is **S213=1**.

The settings for the available configurations are :

Format type		Parity S212	Stop Bits S213
8/N/1	8 data bits, no parity, 1 stop bit	1	1
8/E/1	8 data bits, even parity, 1 stop bit	2	1
8/O/1	8 data bits, odd parity, 1 stop bit	3	1
8/N/2	8 data bits, no parity, 2 stop bits	1	2
8/E/2	8 data bits, even parity, 2 stop bits	2	2
8/O/2	8 data bits, odd parity, 2 stop bits	3	2
7/N/2	These configurations are only possible in transparent using the same settings as 8/N/1		
7/E/1			
7/O/1			



#### 4. Flow control management : S216

In all the modes, the data coming from the serial link are stored in a buffer and then sent. Thus, for long frame greater than 240 bytes it is necessary to have a flow control on the serial link to avoid a buffer overflow and the loss of data. If long frames are sent without flow control, some data may be lost. In transparent mode, if serial data rate is equal to radio one, the flow control can be disabled because in this case the buffer doesn't risk overflow.

The module manages three types of flow control :

- Hardware or CTS/RTS (S216=0) : the RTS signal from the module will authorize the host to transmit data.
- Software or Xon/Xoff (S216=1) : the module sends a Xoff character on the serial link to interrupt the transmission from the host, and a Xon character to resume. This control will only work from the module to the host.
- None (S216=2, default) :the host must manage its outgoing data frames in order not to overflow the buffer.

This flow control is available for our virtual RS232 serial link .



---

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

---



### 2.3.3. Operating Mode configuration

The Operating mode configuration is set via the S22x registers. Through them, you can:

- Set the operating mode : S220,
- Set the number of retries: S223,
- Set the LBT: S226
- Set the random waiting time : S227

The Operating Mode parameters are preferably set in the following order :

#### 1. Operating Mode : S220

This is the most significant register : it tells how the module must run. The available operating modes are:

Value	Mode
1	Transparent Mode (default)
9	Addressed Secured Mode

#### 2. LBT : S226

This register allows activating and setting up the LBT functionality. The LBT sensitivity refers to the detected RF level over which the RF link is considered as occupied.

Value	LBT	Comment
0	OFF (default)	no LBT
1	ON with high sensitivity	LBT with detection for RF >-90dBm
2	ON with medium sensitivity	LBT with detection for RF >-80dBm
3	ON with low sensitivity	LBT with detection for RF >-70dBm

#### 3. Number of repetitions : S223

This register is used in Addressed Secured mode. It is the number of times the message will be repeated in case of non acknowledgement, or the number of times the module will try to send the message in case of the radio link is not free (when LBT functionality is activated).

This register is set to 2 as default. It is enough in most of the configurations.

#### 4. Random waiting time : S227

This register activates a random waiting time before every radio transmission (except for acknowledge). When LBT functionality is ON, it is automatically activated. The random waiting time is comprised between 0 and 64mS.

S227 value	Random Waiting Time
0 (default)	OFF
1	ON



## 2.3.4. Network Configuration

The configuration to use the module in Addressed Secured mode is done with the S25x registers. Through them, you can:

- Set the Network ID : S250,
- Set the Client Address : S252,
- Set the Network options : S255,
- Set a default address for transmission : S256.
- Set a default address for telemetry : S258.

The parameters are preferably set in the following order:

### 1. Network ID : S250

When in Addressed Secured operation, modules can communicate only if they are parts of the same 'network'.

There can be up to 65535 networks defined, but only one can work in a given area in each radio channel. If you want to place more than one network in the same area, use different radio channels and not different network numbers.

The default value is 0.

### 2. Network Options : S255

When running in Addressed – Secured and Telemetry mode, this register contains the option flags used to configure the operation.

This register is a group of 4 flag bits :

Bits	7	6	5	4	3	2	1	0
Name	RSSI	ACK	2B	Ret	AES	NH	CR	N°

↪ *Header* (Bit 0, **default 1**): if set to 1, the frames sent on the serial link will be preceded with a header showing the sender address. This frame will be as follows, for each settings of the bit 2:

”1=data” if the header is ASCII

”<0x01>=data” if the header is numeric

If set to 0, the receiver will not know where the frame comes from

↪ *Carriage Return* (Bit 1, **default 0**) : if set to 1, the frame sent on the serial link will be followed by a CR character (<0x0D>).

↪ *Numeric Header* (Bit 2, **default 0**) : Used when bit 0 is set to 1, it selects the type of header for transmission or reception to ASCII (0) or numeric (1). It is also applied for the RSSI field if activated.



- ↪ **AES (Bit 3, default 0):** If set to 1, enable the AES encryption on data sent in addressed secured mode. The 128 bits encryption key is defined in register 280.
- ↪ **Status answer (Bit 4, default 0) :** defines if the module returns a transmission status after sending a frame. If set to 1 (no answer), the modem will give no information if the frame has been received on the remote side or not. If bit 4 “Status answer” is set to 0 (serial answer enable) while bit 6 “ACK” is 0 (Radio ACK enable), module returns OK if the radio acknowledge has been received, ERROR otherwise. Finally if bit 4 is set (serial answer enable) while bit 6 “ACK” is 1 (radio acknowledge disable), module returns OK in all cases.
- ↪ **2 bytes Numeric Header (Bit 5, default 0) :** Used when bit 2 is set to 1, it defines if the numeric header is on 1 byte (0) for less than 255 modems, or 2 bytes (1) for up to 65535 modems. This bit has no effect if the header is ASCII (Bit 2 = 0). The frames sent and received will be as follows :
  - "<0x01>=Data" if this bit is set to 0
  - "<0x00><0x01>=Data" if this bit 5 is set to 1
- ↪ **ACK (Bit 6, default 0) :** Radio Acknowledge disable: if ‘1’, the radio Ack is disable and any secured radio frames are not acknowledged. This is useful when several clients have the same ID in a network.
- ↪ **RSSI (Bit 7, default 0) :** if set to 1, the frame sent on the serial link will be followed by the RSSI value level. The format (hexa or ASCII) depends on the Bit 2

### 3. Client Address: S252

The user can set a Client number between 1 and 65535. The client numbers must all be different in a network.

The default value is 1. Value 0 is not permitted because reserved for broadcast transmission.

### 4. Default transmission Address: S256

If this register is different from 0, the frames received on the serial link will be sent to this address, without any header detection done.

This register is useful to set a Network-like system with up to 65534 clients and one server, and/or when the clients are not able to manage the frame header.

### 5. Default telemetry Address: S258

This register is used in telemetry I/O copy function to define a binding between 2 modules. When this I/O copy function is enabled (see register 260) the inputs of the local module are copied on the output of the module specified in register S258.

This register is also used in telemetry edge detection. If some inputs are defined as Edge IRQ Inputs (see registers 261 to 269) a frame relating IO state of local module is automatically sent to module specified in register 258 each time an edge occurs on such configured input.



## 2.3.5. Low Power Configuration

The configuration to use low power features is done with the S24x registers. Through them, you can:

- Choose the stand by mode : S240,
- Set the sleeping duration : S243
- Set the RX awake duration: S245
- Set the time out before returning to stand by: S247

### 1. Stand By Mode : S240

Three stand-by modes exist and can be activated individually or in combination. Stand by modes are represented by bits:

Bits	7-3	2	1	0
Name	Reserved	Cyclic Wake Up	Soft (Serial)	Hard (Std By Pin)

- ↩ Hardware: when bit 0 is set, the module stays in stand by while stand by pin is maintained to VCC. The module resume in operating mode as soon as a falling edge occurs on Stand By Pin.
- ↩ Software: when bit 1 is set, the module enters and escapes stand by through Hayes commands. In Hayes mode, send ATP<CR> to enter in sleep mode and send 0x00 to resume.
- ↩ Cyclic Wake Up: when bit 2 is set, the module runs a mode where it listens periodically to the radio channel. The sleep duration is defined by S243 register and the RX radio scan is defined in S245 register. This mode allows the module to be most of the time in stand-by while being able to receive radio frame. Typically, the listen slot is 10ms length every 1000ms leading in a ratio of 99% of time in stand by. Cyclic Wake Up is available in both Transparent and Addressed Secured mode.



**Note1: When a receiver runs Cyclic Wake Up, the sender must send radio frames with very long preamble in order to increase the probability of detection by the sleeping receiver. The higher probability is reached when the preamble of sender is equal to the sleep duration of the sleeping receiver. For example, if radio data rate is 38,4Kb/s, and if the sleeping device is set to wakeup every 1000ms, you should consider to set the preamble length (S204 register) to  $[38,4 \times 1000]/8 = 4800$  bytes of preamble on sender side**



**Note2: Due to some internal limitations, when Cyclic Wake Up is used, the maximum frame length is limited to 223 bytes in Transparent mode and 210 bytes in Addressed Secured mode.**







***Note3: Cyclic Wake Up can not be enabled alone; otherwise there is a risk to never take back control of the sleeping module. Cyclic Wake Up is enabled only in combination with Hard stand by mode insuring to always have a chance to awake the module by stand-by pin.***

The default value is 0, no stand by activated.

## **2. Sleep Duration : S243**

The role of this register is double.

When Cyclic Wake Up is activated (Register S240), the present register gives the sleep duration in milliseconds between two radio scans.

When Telemetry IO copy is set to “IO copy Client “(Register S260), the present register gives the IDLE duration between two IO copy refresh, in this case, value should be a multiple of 1000ms.

If both Cyclic Wake Up and IO copy Client are activated, this register gives the sleep duration between two IO copy refresh.

Default value is 1000ms.

## **3. RX Duration : S245**

When Cyclic Wake Up is activated (Register S240), the present register gives the RX scan duration in milliseconds. Typically a few milliseconds are enough in order to save the maximum of energy. We advice 15ms when radio data rate is set to 4800b/s and only 10ms for higher radio data rates.

Default value is 10ms.

## **4. Time Out before returning to sleep : S247**

When Cyclic Wake Up is activated (Register S240), this register gives the timeout duration in milliseconds without any activity before returning to sleep. Thanks to this register it is possible to continue exchanging messages after having awaked a remote sleeping device. The module waits for this timeout before returning in stand-by. If an activity (serial or radio) occurs before timeout is elapsed, the timeout is re launched for a new S247 ms duration. This register is used when the received radio message, forwarded to serial, will trig a serial response which can then being forwarded on radio immediately. When no response is envisaged, it is not needed to loss time and energy, in such situation, this register can be reduced to only a few milliseconds.

Default value is 100ms.



## 2.4. Public Registers List

Numbers in **bold** indicate the default value

Access	Register	Name	Description
<b>General</b>			
R	S192	Serial Number	Serial number of the module, the one present on the sticker. Read-only register.
<b>Radio</b>			
R/W	S200	Channel	Number of the radio channel in use, depend of the Frequency Sub-Band used, and the product <b>Default : 0.</b>
R/W	S201	Radio Baud-Rate	Indicates the radio link rate. <ul style="list-style-type: none"> <li>0 : 4.8 kbps</li> <li>1 : 9.6 kbps</li> <li>2 : 19.2 kbps</li> <li><b>3 : 38.4 kbps</b></li> <li>4 : 115.2 kbps</li> </ul> 0 and 2 are not available for LE50-433
R/W	S202	Output Power	Radio power output: <ul style="list-style-type: none"> <li>0 : -8dBm</li> <li>1 : -5dBm</li> <li>2 : -2dBm</li> <li>3 : +1dBm</li> <li>4 : +4dBm</li> <li>5 : +7dBm</li> <li>6 : +10dBm</li> <li>7 : +14dBm</li> </ul> Note: The maximum power authorized and the default value depend on the Frequency Sub-Band used, and the product. Check S202 table in §2.3.1.
R/W	S204	Radio Carrier Length	Indicates the radio carrier length. This carrier is sent before each data frame and is used to synchronize the receiver. Between 4 and 65535 <b>Default : 8</b>
R/W	S206	Frequency Sub-Band	Indicates the frequency Sub-Band in use. Between <b>0</b> and 10 for LE50-868 Only <b>0</b> for LE50-433
R/W	S209	Radio Whitening Character	Indicates the XOR value for radio data. Between <b>0</b> and 255.



Access	Register	Name	Description												
<b>Serial Link</b>															
R/W	S210	Serial Speed.	<p>Indicates the speed on the Serial Connection</p> <p>'1': 1200 bits/s      <b>'5': 19200 bits/s</b>            '2': 2400 bits/s    '6' : 38400 bits/s            '3': 4800 bits/s    '7' : 57600 bits/s            '4': 9600 bits/s    '8' : 115200 bits/s</p> <p>The time out value must be compatible with the serial speed:</p> <table border="1"> <thead> <tr> <th>Min. time-out (S214)</th> <th>Serial Speed (S210)</th> </tr> </thead> <tbody> <tr> <td>17 ms</td> <td>1200 bits/s</td> </tr> <tr> <td>9 ms</td> <td>2400 bits/s</td> </tr> <tr> <td>5 ms</td> <td>4800 bits/s</td> </tr> <tr> <td>3 ms</td> <td>9600 bits/s</td> </tr> <tr> <td>2 ms</td> <td>≥19200 bits/s</td> </tr> </tbody> </table>	Min. time-out (S214)	Serial Speed (S210)	17 ms	1200 bits/s	9 ms	2400 bits/s	5 ms	4800 bits/s	3 ms	9600 bits/s	2 ms	≥19200 bits/s
Min. time-out (S214)	Serial Speed (S210)														
17 ms	1200 bits/s														
9 ms	2400 bits/s														
5 ms	4800 bits/s														
3 ms	9600 bits/s														
2 ms	≥19200 bits/s														
R/W	S212	Parity	<p>Serial Link Parity Type:</p> <ul style="list-style-type: none"> <li>'1': <b>None (default)</b> ,</li> <li>'2': Even,</li> <li>'3': Odd.</li> </ul>												
R/W	S213	Number of Stop bits	<p>Serial Link Stop Bits :</p> <ul style="list-style-type: none"> <li><b>1 bit (default)</b>,</li> <li>2 bits.</li> </ul>												
R/W	S214	Serial Link Time Out	<p>Indicates the value of the time-out on the serial link. The time out value must be compatible with the serial speed: (see S210 register description).</p> <p>Between 2 and 100 milliseconds</p> <p><b>Default : 5.</b></p>												
R/W	S216	Flow Control	<p>Indicates flow control type:</p> <ul style="list-style-type: none"> <li>'0': Hardware: CTS/RTS</li> <li>'1': Software: Xon/Xoff</li> <li><b>'2': None (default)</b></li> </ul>												



Access	Register	Name	Description																		
<b>Operation</b>																					
R/W	S220	Function Mode	Operating mode of the Modem : <ul style="list-style-type: none"> <li>'1' : <b>Transparent</b></li> <li>'9' : Addressed Secured and telemetry</li> </ul>																		
R/W	S223	Number of Retries	Number of retries in case of non-Ack response to a message (addressed secured mode) mode, or in case of non free radio link (LBT). Included between 0 and 255 (255 means retry until success). <b>Default value: 2</b>																		
R/W	S226	LBT	LBT ON / OFF, and sensitivity <ul style="list-style-type: none"> <li>'0' : <b>OFF</b></li> <li>'1' : ON with high sensitivity</li> <li>'2' : ON with medium sensitivity</li> <li>'3' : ON with low sensitivity</li> </ul>																		
R/W	S227	Random Waiting Time	Random waiting Time ON / OFF <ul style="list-style-type: none"> <li>'0' : <b>OFF</b></li> <li>'1' : ON</li> </ul>																		
<b>Low Power</b>																					
R/W	S240	Type of Low-power	Low power behavior: <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Bits</th> <th>7</th> <th>6</th> <th>5</th> <th>4</th> <th>3</th> <th>2</th> <th>1</th> <th>0</th> </tr> </thead> <tbody> <tr> <td></td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>Wake On Radio</td> <td>Serial</td> <td>Hard Pin</td> </tr> </tbody> </table> <ul style="list-style-type: none"> <li>Bit 1: when set, Stand-By is activated by Hardware pin</li> <li>Bit 2: when set, Stand-By activated by Serial command</li> <li>Bit 3: when set and in combination with Hard or Serial stand by, the module performs a cyclic wake up to listen periodically to the radio link.</li> </ul> <b>Default : 0</b>	Bits	7	6	5	4	3	2	1	0		-	-	-	-	-	Wake On Radio	Serial	Hard Pin
Bits	7	6	5	4	3	2	1	0													
	-	-	-	-	-	Wake On Radio	Serial	Hard Pin													
R/W	S243	Cyclic wake up Period	Defines the time, in milliseconds, between two wakeup slots when wake on radio is activated.  Between 100 and 65535ms <b>Default: 1000ms</b>																		
R/W	S245	Cyclic wake up Rx Duration	Defines the time, in milliseconds, during which the module will listen to the radio when wake on radio is activated. If no radio activity is detected during this time, the module resume to stand by.  Between 1 and 255ms <b>Default: 10ms</b>																		
R/W	S247	Cyclic wake up Rx Timeout	Defines the timeout, in milliseconds, after which the module returns to stand by when a radio carrier is detected but no valid frame is received. This duration has to be set in accordance with the preamble length of the sender.  Between 10 and 65535ms <b>Default: 100ms</b>																		



Access	Register	Name	Description																		
<b>Network Control</b>																					
R/W	S250	Network ID	Network Number on 2 Bytes. Between 0 and 65535. <b>Default : 0</b>																		
R/W	S252	Client Number	Client Number on 2 Bytes. Between 1 and 65535. <b>Default : 1</b>																		
R/W	S255	Network Options	Indicates the Network options. 4 bits are used :  <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Bits</th> <th>7</th> <th>6</th> <th>5</th> <th>4</th> <th>3</th> <th>2</th> <th>1</th> <th>0</th> </tr> </thead> <tbody> <tr> <td></td> <td>RSSI</td> <td>ACK</td> <td>2B</td> <td>Ret</td> <td>AES</td> <td>NH</td> <td>CR</td> <td>N°</td> </tr> </tbody> </table> <p><b>Default value : 1</b></p> <ul style="list-style-type: none"> <li>➤ Bit 'N°': indicates whether the received frame begins with the Client ID (1) or not (0).</li> <li>➤ Bit 'CR': indicates whether the received frame ends with the 'Carriage Return' character (0x0D) (1) or not (0).</li> <li>➤ Bit 'NH': indicates whether the format in Transmission (and in reception, if the Bit 'N°' is activated) is ASCII (1=Data) (0) or Numeric (&lt;0x01&gt;=Data) (1).</li> <li>➤ Bit 'AES': enable (1) or not (0) the AES encryption on data sent in addressed secured mode.</li> <li>➤ Bit 'Ret': Indicates if the 'OK' should be returned after each radio transmission (0) or not (1).</li> <li>➤ Bit '2B': In case of a Numeric Header (bit 'NH'=1) indicates if the header is on 1 bytes (0) or 2 bytes (1). Used if you have more than 255 modems in your system.</li> <li>➤ Bit 'ACK' : Disable the radio acknowledgement (1) or enable (0).</li> <li>➤ Bit 'RSSI': Enable the value of received power at the end of the frame (1) or not (0).</li> </ul>	Bits	7	6	5	4	3	2	1	0		RSSI	ACK	2B	Ret	AES	NH	CR	N°
Bits	7	6	5	4	3	2	1	0													
	RSSI	ACK	2B	Ret	AES	NH	CR	N°													
R/W	S256	Default Address	Indicates the default address to which every radio frame will be sent. Between 0 and 65535. <b>Default : 0 (inactive)</b>																		
R/W	S258	Default Telemetry Address	Indicates the default address to which telemetry edge events and telemetry IO copy frames will be sent. Between 0 and 65535. <b>Default : 0 (no telemetry binding specified)</b>																		



<i>I/O control</i>			
R/W	S260	IO Copy	<ul style="list-style-type: none"> <li>• <b>'0': IO copy disabled (Default)</b></li> <li>• '1': IO copy Server</li> <li>• '2': IO copy client</li> </ul>
R/W	S261 S262 S263 S264 S265 S266 S267 S268 S269	I/O1 Config. I/O2 Config. I/O3 Config. I/O4 Config. I/O5 Config. I/O6 Config. I/O7 Config. I/O8 Config. I/O9 Config.	<p>For each S26X registers, the corresponding I/OX can be configured as:</p> <ul style="list-style-type: none"> <li>• <b>'0': Status dedicated<sup>(1)</sup> or pull down (Default)</b></li> <li>• '1': Digital output with GND at power up</li> <li>• '2': Digital output with VCC at power up</li> <li>• '3': Digital input</li> <li>• '4': Rising edge detector input</li> <li>• '5': Falling edge detector input</li> <li>• '6': Both edges detector input</li> <li>• '7': Analog Input<sup>(2)</sup></li> </ul> <p>(1) A few pins are shared between telemetry and status indicators like 'Status TX-RX or 'Frame Detect'. By default, all this pins are used for status indication and the others are fixed in GND output. (see <a href="#">§Dedicates IO description</a> for details)</p> <p>(2) Only J3 to J6 are analog capable. (see <a href="#">§Description of the telemetry functionality</a> for details)</p>

<i>AES Encryption Key</i>			
R/W	S280	AES Key	<p>Specify the 128 bits key used for AES encryption on data sent in addressed secured mode.</p> <p>Only used when bit 3 of register 255 is enabled.</p> <p>The encryption key must have 16 ASCII characters. All digits '0' to '9', letters 'a' to 'z' and 'A' to 'Z' can used. The following symbols can also be used: ! " # \$ % &amp; ' ( ) * + , - . / : ; &lt; = &gt; ? [ \ ] ^ _ {   } ~</p> <p><b>Default: 0000000000000000</b></p>



## 2.5. Dedicated IO description.

Four IOs of LE50-868 are dedicated to inform device status and happening events. These signals (output) are activated by default but the user can use these pins for other telemetry usage by configuring registers S261 to S269. Refer to [5] for detailed hardware description of IOs.

### 2.5.1. TX LED (I01)

When register S261=0, this output signal is set to VCC during radio transmission and stay to GND the rest of the time. It is switched for all kind of radio transmissions including ACK, repetitions and radio tests.

### 2.5.2. RX LED (I02)

When register S262=0, this output signal is set to VCC as soon as a radio frame is detected with correct synchronization word. The signal returns to GND as soon as the frame reception is finished. This signal is the equivalent of “Frame Detect” on old Telit products.

Note that this signal switches at low level before application layer treatment, that is to say that the signal goes to VCC even if a frame has not the correct network number or doesn't match the destination ID.

### 2.5.3. ACK TX (I08)

Activated when S268=0.

In Addressed Secured mode, this signal rises to VCC when an ACK hasn't been received after frame transmission and repetition. This is the hardware version of “ERROR” serial message. It stays at VCC until next success addressed secured transmission.

If IO copy is set to server (S260=1), ACK TX rise to VCC when an IO copy client loss has been detected. In this case, the signal stays at VCC during 1 second.

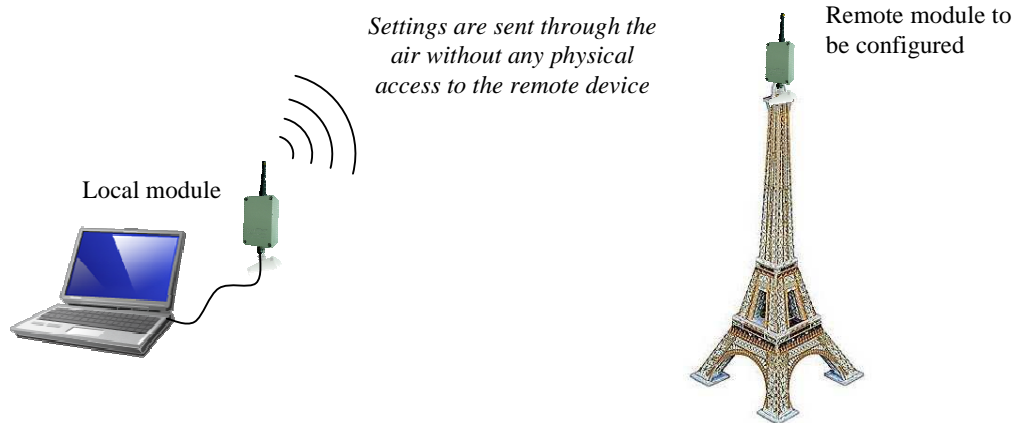
### 2.5.4. Status RX/TX (I09)

When register S269=0, this signal indicates the status of the serial port. When serial port is transmitting, Status RX/TX signal goes VCC until the end of serial transmission. The signal stays to GND the rest of the time. It is particularly useful to drive a RS232/485 converter.



## 2.6. Hayes over the air

It is possible to enter the configuration mode of a remote module using a local one to forward Hayes commands over the air and receive responses from the remote module.



### 2.6.1. Requirements

To send Hayes commands over the air, you have to know the 11 characters serial number of the remote module and also the current radio configuration of the remote module: band, channel and RF data rate.

### 2.6.2. How to start Hayes over the air

- First enter the configuration mode of the local module by sending normal ‘+++’ serial frame.
- Set up the local module in order to match the radio configuration of the remote one : band, channel and RF data rate must be the same as in the remote module.
- Set the local module in Transparent mode (ATS220=1)
- Escape the configuration mode of the local module by sending ATO.
- Use the local module to send on the air the following frame ‘+++xxxxxxxxxxx’ that is to say ‘+++’ concatenate with the 11 characters of the remote module serial number. The frame must be sent at once without any delay between characters.
- If you receive an “OK” back, this means that you have correctly entered the configuration mode of the remote module. If you don’t receive any response, make sure the serial number is correct and insure that you are in the range of the remote module.
- You can now send any classic Hayes command to the remote module. You can confirm this state by asking the serial number sending “ATS192?” the remote module should reply with its own serial number confirming that you are currently configuring the





desired module. Each command must be sent in on shot without delay between characters. Now, for example you can change the serial data rate by sending `ATS210=4`; this will turn the com port of the remote module to 9600bds. All Hayes commands sent over the air are replied normally like in local mode.

- When you have completed the remote configuration, simply send `ATO` to escape the remote configuration mode. The remote module send `OK` back and resume the operating mode using the new configuration.

### 2.6.3. Particular case

Hayes over the air also allows acting on the radio configuration of the remote module. But in this case, each parameter modified on the remote module must also be applied locally.

For example, to change the radio channel from 0 to 1, send `+++xxxxxxxxxx` to enter the configuration mode of the remote module, send `ATS200=1` to change the radio channel of the remote module, remote module sends `OK` on channel 0 and then immediately apply the new channel. At this step, remote module is already on channel 1 while local module is still on channel 0. Send `+++` to enter the local configuration mode, send `ATS200=1` to change the local channel (`OK` back), send `ATO` to escape the configuration mode of the local module. Now both modules share the same channel and you can continue the remote configuration or close it by sending `ATO`.

This procedure is the same for each parameter affecting the radio link (band, channel, data rate).

Finally, it is also possible to trig remotely some radio test by sending `ATT0` or `ATT1`. In this case, the radio test automatically stops after 30 seconds on the remote module in order to recover the communication with the local module.



## 3. Description of the Telemetry Functionalities

This Chapter is dedicated to the telemetry functionality of the Star Network protocol stack. It allows functional use of I/Os of the module.

### 3.1. General Features

- Telemetry protocol is based on the addressed secured operating mode. Each module is able to execute telemetry orders while exchanging serial data.
  - 9 pins of the module are dedicated for I/O use, with different capability :
    - Standard digital In / Out
    - IRQ Input to automatically send a frame on edge event
    - 12 bits analog inputs capable, readable either locally or remotely
- I/O copy is available between 2 modules or more in star architecture to update digital output according to digital input from another module.
- Independent I/O and data binding is possible to route data and I/O frame to different target.
- 9 pins are available for user telemetry application. All pins are digital I/O capable and some pin has specific functionalities shown in the following table.



Pin	Name	Dedicate usage	Digital Output	Digital Input	Rising Edge IRQ Input	Falling Edge IRQ Input	Analog input
J1	I/O1	TX LED	✓	✓	✓	✓	
J2	I/O2	RX LED	✓	✓	✓	✓	
J3	I/O3	-	✓	✓	✓ <sup>(1)</sup>	✓	✓
J4	I/O4	-	✓	✓	✓	✓ <sup>(1)</sup>	✓
J5	I/O5	-	✓	✓	✓	✓	✓
J6	I/O6	-	✓	✓	✓	✓	✓
J7	I/O7	-	✓	✓	✓	✓	
J8	I/O8	ACK TX	✓	✓	✓	✓	
J9	I/O9	Status TX/RX	✓	✓	✓	✓	

(1) These pins are also able to wake up module from stand-by in order to send a frame on edge event. To do so, IO3 must be configured in rising edge detector and IO4 in falling edge. The both edge detection configuration can't awake the module from standby.

Refer to [5] for detailed hardware description of IOs.



## 3.2. Telemetry Frames Description

Telemetry protocol is able to execute telemetry orders while exchanging serial data. It uses an addressed secured mode to insure reliability and network capabilities. Data and Telemetry commands are differentiated using '=' and 'T' characters respectively. Thanks to addressed secured mode, broadcasting is possible by sending telemetry command or data to address '0'.

⇒ A data frame is sent as following:

With ASCII header<sup>(1)</sup>:

*[ASCCI Address][“=”][Data]*

*(example: “2=hello” sends “hello” on the serial link of module N°2.)*

With Numeric header<sup>(1)</sup>:

*[HEX Address][“=”][Data]*

*(example: “<0x02>=hello” sends “hello” on the serial link of module N°2.)*

⇒ While telemetry orders are sent as following:

With ASCII header<sup>(1)</sup>:

*[ASCCI Address][“T”][Telemetry\_order]*

*(example: “3TDG<CR>” request to Get the digital inputs values of module N°3)*

With Numeric header<sup>(1)</sup>:

*[HEX Address][“T”][Telemetry\_order]*

*(example: “<0x03>TDG<CR>” request to Get the digital inputs values of module N°3)*

(1) See bit 2 of S255 register for details.



### 3.2.1. General Syntax

The telemetry frames are described in the following tables :

↳ General request syntax :

<i>Field</i>	<i>Size (byte)</i>	<i>Description</i>
<i>Address</i>	1 to 5	ASCII ID of the addressed module
<i>T (0x54)</i>	1	Separator indicating the end of address field and the telemetry frame type
<i>Technology</i>	1	Specifies if the request is analogic 'A' or digital 'D'
<i>Access</i>	1	Specifies if operation is Get 'G' or Set 'S' IO values
<i>Specific fields (depending on the command)</i>	variable	For set request, a few information is needed in this field
<i>&lt;CR&gt;</i>	1	All telemetry frames ends by carriage return

↳ General reply syntax :

<i>Field</i>	<i>Size (byte)</i>	<i>Description</i>
<i>Address</i>	1 to 5	ASCII ID of the addressed module
<i>T (0x54)</i>	1	Separator indicating the end of address field and the telemetry frame type
<i>Technology</i>	1	Specifies if the reply is analogic 'A' or digital 'D'
<i>R (0x52) or E (0x45)</i>	1	Indicate a <b>R</b> eply or <b>E</b> rror from module
<i>Values</i>	variable	This field gives all the inputs state after a get request execution. The values are given in digital bit field or analog value depending of 'technology' indicator field. This field is empty for Error replies.
<i>&lt;CR&gt;</i>	1	All telemetry frames ends by carriage return



### 3.2.2. Detailed description of Telemetry orders

↪ Digital Get request :

Field	Size (byte)	Description
Address	1 to 5	ID of the addressed module (in ASCII or in hexa depending of S255 options)
T (0x54)	1	Separator indicating the end of address field and the telemetry frame type
D (0x44)	1	'D' indicates that a digital access is desired
G (0x47)	1	'G' indicates that a Get (read) operation is asked.
<CR>	1	All telemetry frames ends by carriage return

Example 1 (with numeric header disable, S255-bit2 = 0):

User request (ASCII):           **15TDG<CR>**           ask digital inputs values of module 15  
 Module return (ASCII):       **15TDR259<CR>**       reply that IO1, IO2 and IO9 are '1' (others are '0')

Example 2 (with numeric header enable, S255-bit2 = 1):

User request (Hex):           **0F 54 44 47 0D**           ask digital inputs values of module 15  
 Module return (Hex):       **0F 54 44 52 01 03 0D**       reply that IO1, IO2 and IO9 are '1' (others are '0')

↪ Analog Get request :

Field	Size (byte)	Description
Address	1 to 5	ID of the addressed module (in ASCII or in hexa depending of S255 options)
T (0x54)	1	Separator indicating the end of address field and the telemetry frame type
A (0x41)	1	'A' indicates that an analog access is desired
G (0x47)	1	'G' indicates that a get (read) operation is asked.
<CR>	1	All telemetry frames ends by carriage return

Example 1 (with numeric header disable, S255-bit2 = 0):

User request (ASCII):       **7TAG<CR>**           ask analog inputs values of module 7  
 Module return (ASCII):   **7TAR273,0,1020,89<CR>**   reply that IO3=273mV, IO4=0mV, IO5=1020mV and IO6=89mV



Example 2 (with numeric header enable, S255-bit2 = 1):

User request (Hex): **07 54 41 47 0D** ask analog inputs values of module 7

Module return (Hex): **07 54 41 52 01 11 00 00 03 FC 00 59 0D** IO3:273mV, IO4:0mV, IO5:1020mV, IO6:89mV

↩ Digital Set Command:

Field	Size (byte)	Description
Address	1 to 5	ID of the addressed module (in ASCII or in hexa depending of S255 options)
T (0x54)	1	Separator indicating the end of address field and the telemetry frame type
D (0x44)	1	'D' indicates that a digital access is desired
S (0x53)	1	'S' indicates that a Set (write) operation is asked.
Mask	2 or 3	Indicates which output will be set, others will be let unchanged. (in ASCII or in hexa depending of S255 options)
, (0x2C)	0 or 1	Separator between Mask and Value, only in case of ASCII format
Value	2 or 3	Specifies the value to set on output selected by the mask. (in ASCII or in hexa depending of S255 options)
<CR>	1	All telemetry frames ends by carriage return

Example 1 (with numeric header disable, S255-bit2 = 0):

User request (ASCII): **28TDS136,8<CR>**Set IO4 to 1, reset IO8 to 0 and let other IOs unchanged on module 28

Module return (ASCII): **28TDR264<CR>** reply IO state after request execution IO4 and IO9 are '1' (others are '0')

Example 2 (with numeric header enable, S255-bit2 = 1):

User request (Hex): **1C 54 44 53 00 88 00 08 0D** Set IO4 to 1, reset IO8 to 0 and let other IOs unchanged on module 28

Module return (Hex): **1C 54 44 52 01 08 0D** reply IO state after request execution IO4 and IO9 are '1' (others are '0')



**Note: If user attempts to write a non existent output (Mask > 256) a digital error is returned, example: '1TDE<CR>'.**



### 3.2.3. Interruptible Inputs

All inputs are interruptible capable. That is to say, they are able to detect a rising edge or a falling one or both depending of the configuration. To use this function, the input should be declared as 'Rising edge detector input', 'Falling edge detector input' or 'Both edges detector input' in register 261 to 269.

When enabled, an edge event on those pins automatically sends a telemetry frame to the default client chosen in S258 register. The frame sent is the same as the one returned after a digital read request. Of course the address set in S258 register can be the address of the local module (S258=S252) in this case, all edge events are reported on the serial link of the local module.

In addition, IO3 and IO4 are also able to detect edge even if module is in stand by mode. In this case, when an edge occurs, the module first wake up and then sends the telemetry frame to the default telemetry address specified in register 258.

### 3.3. IO Copy

“Telemetry” is the action to read or set I/O of a remote module by sending orders from an intelligent part like PC or automate. “IO Copy” is the capacity to automatically set the outputs of a module according to the inputs of a remote module and vice versa. In this case, the modules are autonomous without the need of a controller.

#### 3.3.1. General Usage

The IO Copy can be used either in point to point architecture or in a star network. In all cases, IO copy requires the use of one IO server (S260=1) and one or more IO client (S260=2).

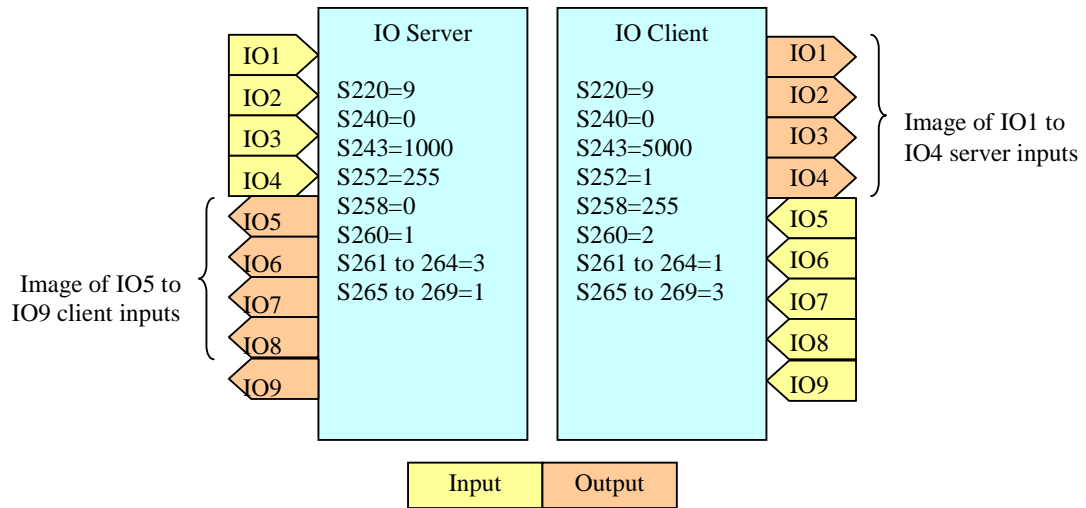
Each client sends periodically its input values to the server (specified in S258 register) and wait for server input values coming back to update its local outputs.

The update period is chosen by S243 register from 100 to 65000 ms and can be different for each client. Between 2 updates, a client may go in stand-by mode to save power if asked by S240 register.

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

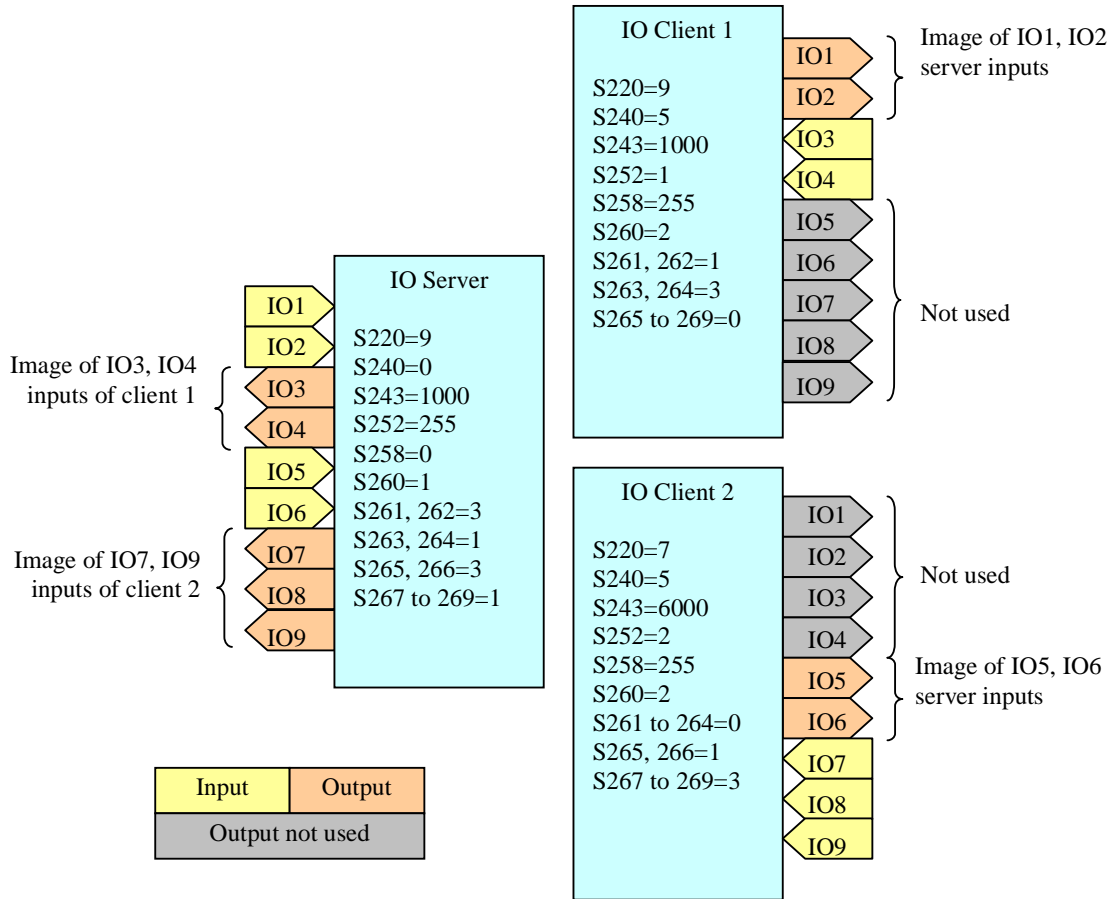






***Example 1:***  
***IO copy in point to point architecture with 4 ports copied from server to client and 5 ports copied from client to server with one refresh every 5 seconds.***

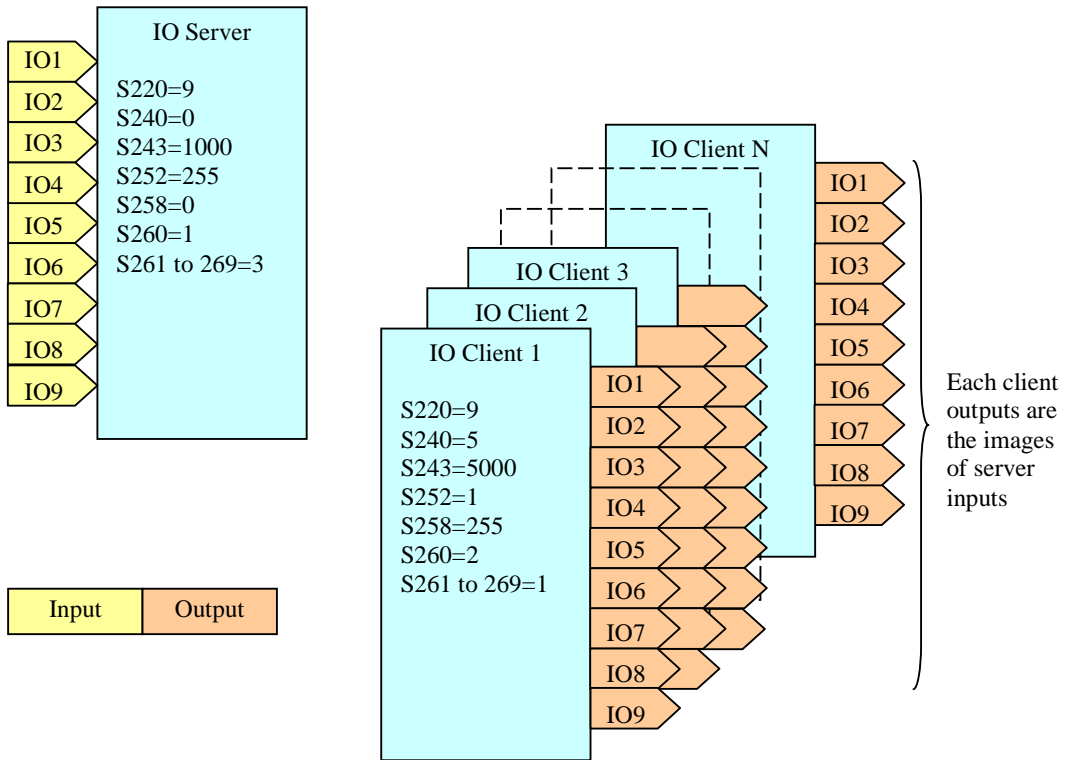




**Example 2:**

*IO copy with Star architecture with 2 ports copied from server to each client, 2 ports copied from client 1 to server and 3 ports copied from client 2 to server. Low power is activated on both clients with one refresh each second on Client 1 and every 6 seconds on Client 2.*





**Example 3:**  
*IO copy with Star architecture with server inputs copied to N clients outputs.*



### 3.3.2. Optimized Usage

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

Finally, it is possible to detect a link failure in small network up to 9 clients. When a client sends its inputs values, the frame also contain the timer period in second. The server records this period for each of the first 9 clients. When message is no more received from a client during twice the specified period + 1 second, the master indicates the failure writing '255TDE<CR>' on its serial link and rising edge on ACK\_TX signal.

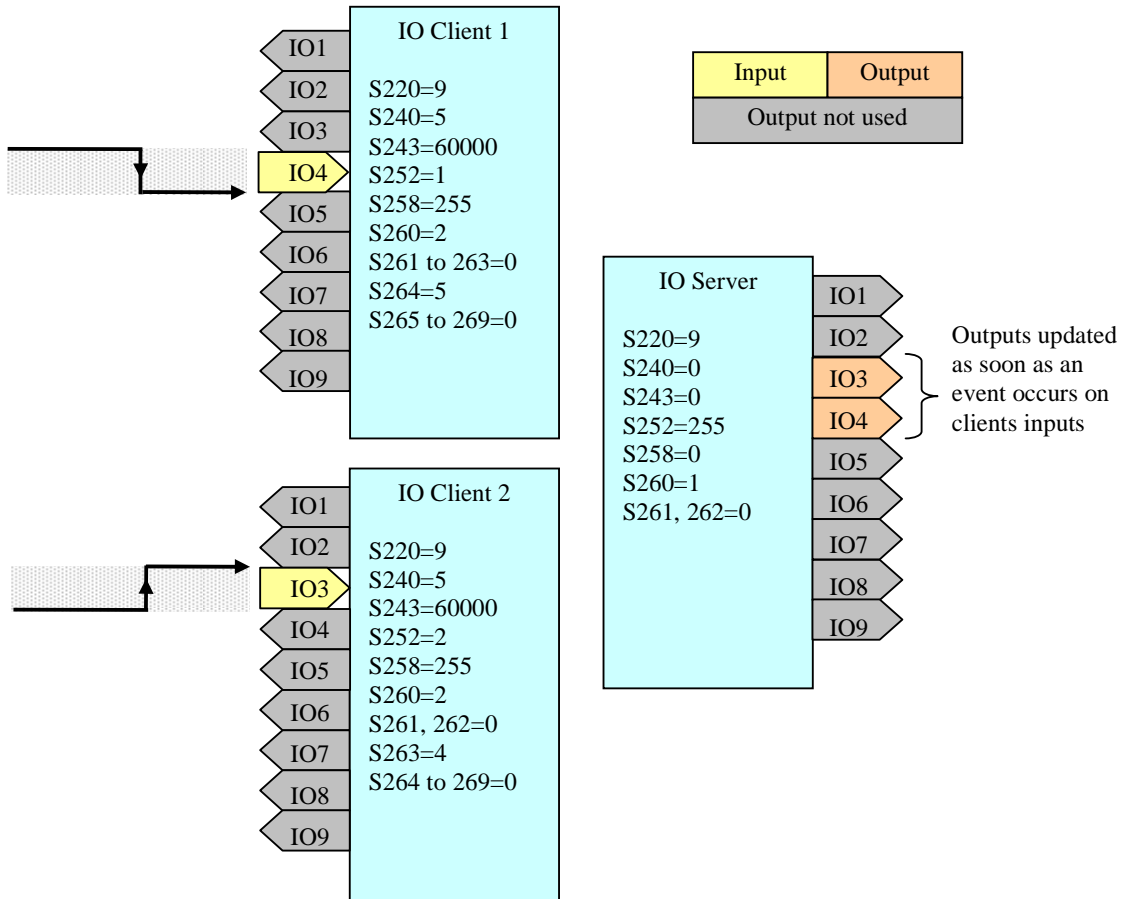
Combining the two previous functionalities:

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

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

More over, if it is not necessary to know on which client the edge occurred, it is possible to install up to 9 clients, all with IO4 as interrupt input activated. In this case, the IO4 server output will fall down as soon as an event occurs on one of the 9 clients.





**Example 4:**

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

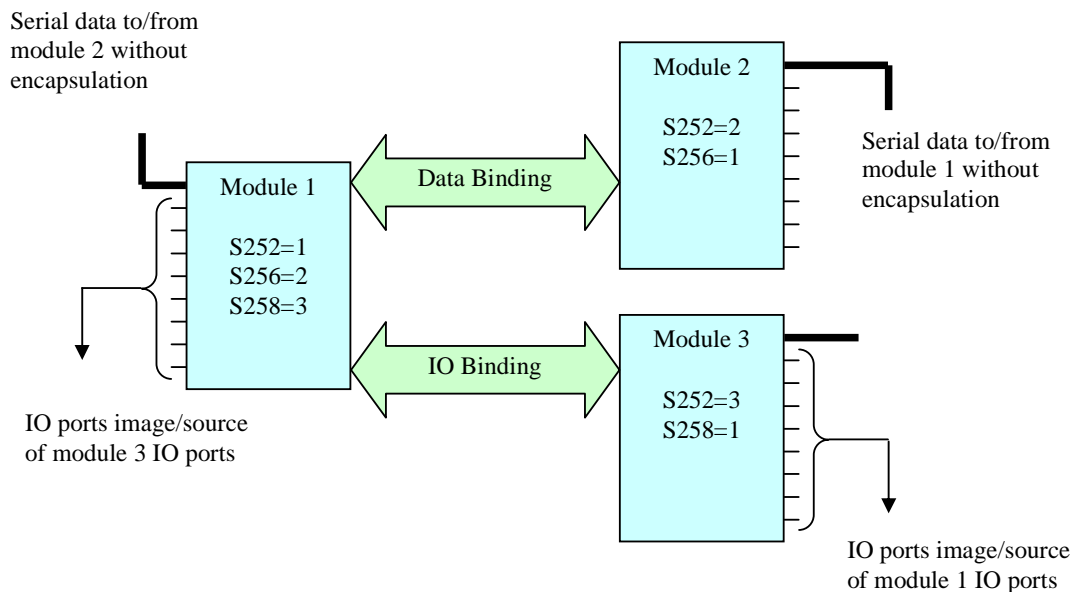


### 3.3.3. Bindings

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

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

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



**Example:**  
*Independent data and telemetry bindings*



## 4. Document History

Revision	Date	Changes
0	2011-02-23	First issue
1	2011-05-17	<ul style="list-style-type: none"> <li>• §II.2 - Operating Modes: complete rewrite to be clearer.</li> <li>• §II.3 - Network Configuration : addition of AES bit and explanation of this bit in 255 register</li> <li>• §II.3 - Default telemetry Address: S258, new register coming with new telemetry functions now available</li> <li>• §II.3 - Low Power Configuration: this chapter is completely new and describe all low power modes and associate registers.</li> <li>• §II.4 : Note about Cyclic wake up limitation now removed because Cyclic wake up is now operational in all modes.</li> <li>• §II.4 : in registers table, add AES bit in reg 255 and add reg 258.</li> <li>• §II.4 : in registers table, S260 appeared with new telemetry features, and some precisions for reg S261 to 269.</li> <li>• §II.4 : in registers table, new register for AES Encryption Key</li> <li>• §II.5. Dedicated IO description : this chapter is completely new and describes all pins which have specific functions</li> <li>• §III.1 : add IRQ feature, add I/O copy features.</li> <li>• §III.1 : new version of the IO table, clearer and more exhaustive.</li> <li>• §III.2 - Analog Get request : this paragraph is new.</li> <li>• §III.2 - Interruptible inputs, IO copy and Binding : new paragraphs coming with new telemetry functionalities.</li> </ul>
2	2011-10-25	<ul style="list-style-type: none"> <li>• §3.1 – better description of I/O3 and I/O4 features</li> <li>• §2.2 – Information regarding buffer size</li> <li>• §2.3 - Information regarding buffer capacity for serial flow control</li> </ul>
3	2011-11-17	<ul style="list-style-type: none"> <li>• Template modification</li> </ul>
4	2012-07-02	<ul style="list-style-type: none"> <li>• §2.3 : registers modifications including LE50-433</li> <li>• §2.4 : registers modifications including LE50-433</li> </ul>
5	2012-08-29	<ul style="list-style-type: none"> <li>• §2.6 – Hayes over the air : this paragraph is new</li> </ul>

