TG-ETRX-R212-AT-Commands

ETRX1 AND ETRX2 WIRELESS MESH

NETWORKING MODULES

AT-Command Dictionary
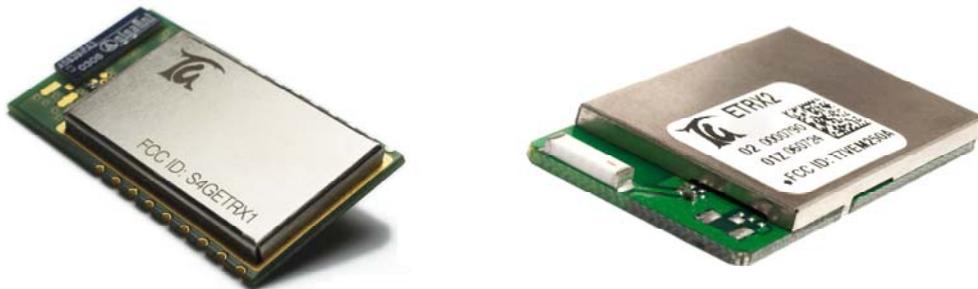
Current Firmware R212

Telegesis

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1 Introduction

This document describes the AT-Command interface of the ETRX1 and ETRX2, IEEE 802.15.4 wireless meshing modules.

The Telegesis ETRX1 and ETRX2 modules have been designed to be built into any device and provide a low cost, low power IEEE802.15.4 wireless mesh networking solution based on the EmberZNet2.xx meshing stack. Integration into a wide range of applications is made easy using a simple AT-style software interface and advanced hardware design.

No RF experience or expertise is required to add this powerful wireless networking capability to your products. The ETRX1 and ETRX2 offer fast integration opportunities and the shortest possible time to market for your product.

1.1 Document Overview

This document is meant as an AT-Command and S-Register reference for R2xx revisions of the firmware based on EmberZNet2.x. In order to learn how your products can profit from wireless mesh networking please also refer to the following documents:

- ETRX1 or ETRX2 Product Manual
- ETRX1 or ETRX2 Development Kit User Guide
- ETRX1 or ETRX2 R2xx Firmware User Guide

The ETRXn Product Manuals concentrate on the hardware specification of the respective modules. The Development Kit User Guide contains all of the information required to set up your development kit and run firmware upgrades where necessary. The Firmware User Guide gives you an overview of how to use the ETRXn wireless meshing modules.

For a command overview of the R1xx series of firmware based on EmberNet3.x please refer to the R1xx AT-Command Dictionary and Application Notes. Please note that R1xx series firmware and R2xx series firmware are not over-the-air compatible.

1.2 A Note on ZigBee® Compliance (updated)

The firmware revisions R2xx are based on the EmberZNet2.x mesh stack, which overcomes many of the limitations of the ZigBee® 2006 Home Controls profile, which is the only profile ratified by the ZigBee® Alliance at this time. As a result, an end product containing an ETRX1 or ETRX2 based on firmware revisions R2xx <u>cannot</u> yet be certified to be tested for ZigBee® compliance.

EmberNet 2.x already contains many of the features that are expected to find its way into the upcoming release of the ZigBee® specification.

If you require your product to be tested for ZigBee® compliance, you can talk to us about supplying a custom version of our firmware tailored for this requirement, once you have become a member of the ZigBee® Alliance, which is a prerequisite for offering products with ZigBee® certification.

The ETRX1 and ETRX2 run a private application profile, as the functionality of the module cannot be pressed into any of the existing application profiles (like lighting). The profile ID used is 0xC090. This also means that interoperation with 3rd party ZigBee® nodes is unlikely.

Both Ember, as a promoting member, and Telegesis, as a participating member of the ZigBee® Alliance, are working to evolve the firmware with the ZigBee® standard and any future stack and application profiles to offer our customers the best wireless mesh networking solution.

With the capability of in-field upgrading of firmware over the air, you will be able to react quickly and easily to changes in both the ZigBee® standard as well as your own requirements.

1.3 Important notes

The new Ember Bootloader which runs on the ETRX2 can be triggered using the command AT+BLOAD as described in Section 2, but it can also be triggered in hardware. If the A/D2 pin is pulled low during the boot-up of the module, the module will also enter the bootloader, so exercise caution when doing hardware design and ensure that this pin is not grounded during start-up and reset. If unused the pad can be left floating and a pull-up is not required.

<u>**Important Note for the ETRX1:**</u> From Revision R1005 of the Ember bootloader it is possible to enter the bootloader by pulling I/O5 low after a reset or during bootup. Make sure that I/O5 does not get pulled low externally to prevent entering the bootloader unintentionally!

2   AT Style Command Conventions

To simplify the communication with the ETRXn modules, an AT-style command set, similar to the industry standard Hayes modem control language, is used.

Each command must be preceded by the "AT" or "at" prefix. To terminate a command enter <CR>. Any data not following this pattern is either not accepted by the module or will cause an error message in response.

Commands are followed by an optional response that includes <CR><LF><Response> and a prompt <CR><LF><Prompt><CR><LF> where the prompt could also be an error message.

Example:

ATS00?<CR>
<CR><LF>S00:FFFF
<CR><LF>OK<CR><LF>

It is recommended to wait for an "OK" or "ERROR:xx" prompt before issuing the next command.

Any data which is prompted to the user is delivered in the format <CR><LF><prompt><CR><LF>. Unless disabled in S07 or S08 prompts may appear whenever the corresponding event occurs.

Example:

<CR><LF><BCAST:000D6F000005A666=test><CR><LF>

A prompt intersecting a command being entered will not affect the command itself.

Throughout this document, only the responses and prompts are presented, <CR><LF> are omitted intentionally. Sequences of AT commands in a single line are not supported.

The ETRXn features a 128-byte FIFO to buffer incoming characters which is sufficient to hold even the longest possible command. To prevent a buffer overflow in channel mode XON/XOFF handshaking is used. Optional hardware handshaking can be enabled as described in the register description of S0B in section 4.

Read Command **ATXXX?**	Commands ending with a '?' return the currently set value of the parameter or parameters
Write Command **ATXXX=<…>**	This command sets user-definable parameters as indicated by the '=' sign.
Execution Command **ATXXX**	This command executes routines of the module and returns parameters

Table 1: Types of AT commands

2.1 Parameters

Usually there are no optional parameter sets, so each parameter must be entered in the correct format.

XX	8-bit hexadecimal number. Valid characters are 0-9, a-f and A-F
n	Number from 0-9
s	Sign
b	Bit (0 or 1)
c	character
PPPP	16-bit hexadecimal PAN ID (0x0000 to 0x3FFF)
CC	decimal channel (802.15.4 channel 11-26)
<EUI64>	64-bit IEEE802.15.4 address in hexadecimal

Table 2: **Different formats of parameters**

2.2 Prompt Overview

The following prompts can show up during the operation of the ETRX1 and ETRX2 modules. Most of the prompts can be disabled using register S07 and S08.

Prompt Overview	
JPAN: CC,PPPP	The Node has joined a PAN on channel CC with PAN ID PPPP
LeftPAN	The node has left the PAN
UCAST:<EUI64>=<data>[,<length>]	Reception of a Unicast
BCAST:<EUI64>=<data>[,<length>]	Reception of a Broadcast
RAW:<data>	Reception of raw data
SCAST:<EUI64>=<data>[,<length>]	Reception of a Scast (Data sent to the sink)
ACK:nn	Receipt for successful acknowledgement of a message
NACK:nn	Notification of missing acknowledgement
CHAN:<EUI64>	A request to open a channel
OPEN	A channel has been opened
CLOSE	A channel has been closed
NEWNODE:<EUI64>	A new node has joined the network
SINK:<EUI64>	A new sink was found and stored
[REM]SED:<EUI64>	A sleepy end device has been found
[REM]MED:<EUI64>	A mobile sleepy end device has been found
[REM]FFD:<EUI64>	A router has been found
[REM]COO:<EUI64>	A coordinator has been found
COUNT:<EUI64>,XX,<ioread>,<A/D1>,<A/D2>	Triggered by action 2000 (see section 5)
NDATA:<EUI4>,XX,<ioread>,<A/D1>,<A/D2>	Triggered by actions 0110 - 0113 (see section 5)
SDATA:<EUI64>,<ioread>,<A/D1>,<A/D2>	Triggered by actions 0100 - 0103 (see section 5)
<plaintext>	Message prompted on the sink (see section 5, functionality 0108 – 010B)
Snn[x]:<data>:<EUI64>	Remote S-Register reading
NAK:<EUI64>	A request to a remote node with EUI64 was not acknowledged.
PWRCHANGE:nn	Indicates a change of power mode caused by an action

Table 3: Prompt Overview

2.3 Device Overview

Table 4 gives an overview of the device types mentioned in this document and elsewhere.

Device Types		Also known as
COO	Coordinator	ZigBee Coordinator (ZC)
FFD	Router	ZigBee Router
SED	Sleepy End Device	ZigBee End Device (ZED)
MED	Mobile Sleepy end Device	

Table 4: Device Overview

The terms Full Function device (FFD) and Reduced Function Device (RFD) are obsolete, but the abbreviations are retained in the R212X firmware to avoid problems with users' legacy application software.

2.4 AT Command Overview

The following table gives a quick reference of all commands available.

Command Overview	
ATI	Display product identification information
ATZ	Software reset
AT&F	Restore factory settings
AT+BLOAD	Enter the bootloader menu
AT+CLONE	Clone the local node's firmware to a remote node
AT+RECOVER	Recover from a failed clone attempt (ETRX2 only)
AT+PASSTHROUGH	Enter pass-through bootloading mode (ETRX1 only)
ATS	S-Register access
ATSALL	Write all remote S-Registers
AT+TOKDUMP	Display all local S-registers
ATSREM	Remote S-register access
AT+ESCAN	Scan the energy of all channels
AT+EN	Establish PAN
AT+JN	Join next best network
AT+PANSCAN	Scan for active PANs
AT+JPAN	Join specific PAN
AT+DASSL	Disassociate local device from PAN
AT+DASSR	Disassociate remote device from PAN
AT+NTABLE	Show the neighbour table
AT+N	Display network parameters
AT+CTABLE	Display list of local children
AT+PARENT	Display Parent's ID
AT+POLL	Poll Parent for data
AT+SN	Scan network for other nodes
AT+REMSN	Scan for remote device's direct neighbours
AT+LINKCHECK	Check link parameters with a neighbour
AT+PING	Indicate presence in the network
AT+BCAST	Transmit a broadcast
AT+BCASTB	Transmit a broadcast of binary data
AT+UCAST	Transmit a unicast
AT+UCASTB	Transmit a unicast of binary data
AT+SCAST	Transmit data to the Sink
AT+SCASTB	Transmit binary data to the sink
AT+SSINK	Search for a sink
AT+SINK	Display the local Node's sink
AT+OPCHAN	Opens a channel to a remote node
+++	Close channel
AT+OPLCHAN	Opens a limited channel to a remote node
AT+ACKCHAN	Accept channel
AT+RDATAB	Send binary raw data
AT+IDENT	Play a tune on remote devboard

Table 5: Command Overview

2.4.1 Module Control & Configuration Commands

I – Display Product Identification Information	
Execute Command **ATI**	Response **Telegesis ZigBee** **Rnnn[X|A]** **<EUI64>** **OK** Where nnn is the firmware revision and <EUI64> is the Device's IEEE 802.15.4 identifier In addition to announcing itself as either an ETRX1 or ETRX2 the firmware revision is also clearly marked to be for either the AVR platform of the ETRX1 (A prefix), or the XAP16B platform of the ETRX2 (X prefix).
SW release	R208 - added ETRX1 and ETRX2 differentiator

Z – Software Reset	
Execute Command **ATZ**	Response Module Performs a software reset All non-volatile S Registers keep the user defined values, if the module was part of a PAN it will remain part of it.
SW release	R200

&F – Restore Factory Defaults	
Execute Command **AT&F**	Response Module Performs a factory reset All non-volatile S Registers are updated with their factory defaults. In order to leave the network as well use the AT+DASSL command after executing AT&F
SW release	Modified in R206

+BLOAD – Enter The Bootloader Menu	
Execute Command **AT+BLOAD**	Response **<entering bootloader>** The device leaves the AT command line and enters the Ember bootloader menu for downloading new firmware. A description of the bootloading process can be found in the devkit manuals. Please note that the bootloader menu will run at a data rate of 38k4 (ETRX1) or 115k2 (ETRX2), no parity, 8 data bits regardless of the current data rate and the S0B register setting.
SW release	R200

+PASSTHROUGH – Bootload Remote Node In Passthrough Mode (ETRX1 only)

Execute Command	Response
AT+PASSTHROUGH:<EUI64>,cccccccc	**Press Enter for BL menu…**
	or
Note	**ERROR<errorcode>**
This command is available on the ETRX1 only.	
The default password on both ETRX1 and ETRX2 is "TG-ETRX1".	Where <errorcode> represents the error code explained in section 3.
	Allows you to bootload a remote node which address is given by <EUI64> as described in the ETRX1 Devkit manual.
	cccccccc represents the remote nodes 8 character password. After completion a soft reset is performed on the remote end.
SW release	R200

+CLONE – Clone Local Node To Remote Node

Execute Command	Response
AT+CLONE:<EUI64>,cccccccc	**Cloning…**
	or
Use on:	
All devices	**ERROR<errorcode>**
Note	
On the ETRX1 cloning is only supported if the local Ember bootloader has revision >1005. Error 30 will be displayed if this is not the case.	Where <errorcode> represents the error code explained in section 3.
	Clones the firmware of the local node to a remote node which address is given by <EUI64>.
On the ETRX1 the local node will reset after successful bootloading, on the ETRX2 the node will continue operation without a reset.	cccccccc represents the remote nodes 8 digit password. After completion a soft reset is caused on the remote end.
The default password on both the ETRX1 and ETRX2 is "TG-ETRX1".	
SW release	R208 added to the ETRX2

+RECOVER – Recover From A Failed Clone Attempt (ETRX2 only)

Execute Command	Response
AT+RECOVER	**Recovering…**
Use on:	or
All devices	
	ERROR<errorcode>
Note	
Use this command in cases where the cloning operation was interrupted and the remote device therefore remains in the bootloader.	Where <errorcode> represents the error code explained in section 3.
	Clones the firmware of the local node to a remote node which is already in the bootloader.
For more information on over-the-air firmware upgrading please refer to the respective Development Kit Manual.	
SW release	R208

S – S-Register Access

Read Command ATSnn[x]?	Response Snn:<data> OK or ERROR<errorcode> The module displays the contents of S-register nn or an error message, where <errorcode> represents the error code explained in section 3. All 16-bit registers can also be accessed bit by bit. In order to do this [x] may specify the bit which is to be read. The result when reading a single bit will always be 0 or 1.
Write Command ATSnn[x]=<data> Note Some S-Registers require a password for write access. See S-Register description for details. **The default password on both ETRX1 and ETRX2 is "TG-ETRX1".** Some S-Registers are read-only and will return an error if you are trying to write to them	Response OK or ERROR<errorcode> The data is written to S-register number nn and if applicable stored in non-volatile EEPROM. The data format for each individual S Register is given in the S-Register description. <errorcode> represents the error code explained in section 3. For all 16-bit registers individual bits can also be set or cleared by specifying the bit using [x] and setting it to either 0 or 1.
SW release	R200

SALLnn – Write All Remote S-Registers

Write Command ATSALLnn[x]=<data> Use on: All Devices Note Use this command carefully to prevent setting registers of units you do not want to alter. Also be aware that there are no guarantees that each and every node in the network is reached.	Response OK Or ERROR<errorcode> The module broadcasts a write command to all remote nodes on the PAN. Every remote module receiving this request will perform the command. nn specifies the register number which is written. For all 16-bit registers individual bits can also be set or cleared by specifying the bit using [x] and setting it to either 0 or 1.
SW release	R208 – Individual bits can now be set

SREMn – Remote S-Register Access

Read Command **ATSREMnn[x]:<EUI64>?** Use on: All Devices	Response **Snn:<data>** **OK** or **ERROR<errorcode>** The module displays the contents of S-Register nn or an error message, where <errorcode> represents the error code explained in section 3. The data format of each individual S-Register is given in the S-Register description. All 16-bit registers can also be accessed bit by bit. In order to do this [x] may specify the bit which is to be read. The result when reading a single bit will always be 0 or 1. In case bit 14 of S06 is set the response will be **OK** In this case the OK prompt only shows successful transmission of the read request. The actual reading of the S-Register will be prompted later in the following format: **Snn:<Data>:<EUI64>** This allows up to 10 requests to 4 different nodes to be in flight at any one time. In case the target node could not be reached the following prompt will be displayed: **NAK:<EUI64>**
Write Command **ATSREMnn[x]:<EUI64>=<data>** Note Some S-Registers are read only and will return an error if you are trying to write to them Some S-Registers require a password for write access. See S-Register description for details. **The default password on both ETRX1 and ETRX2 is "TG-ETRX1".**	<data> is written to remote S-register number nn and if applicable stored in non-volatile memory. Response **OK** Or if any problems occur **ERROR<errorcode>** Where <errorcode> represents the error code explained in section 3. For all 16-bit registers individual bits can also be set or cleared by specifying the bit using [x] and setting it to either 0 or 1.
SW release	R200

TOKDUMP – Display All S-Registers

Execute Command **AT+TOKDUMP**	Response **+TOKDUMP:** **<data>** **OK** Or **ERROR<errorcode>** The module displays the contents of all local S-registers or an error message, where <errorcode> represents the error code explained in section 3. The data format for each individual S Register is given in the S-Register description in section 4.
SW release	R200

2.4.2 Network Control & Configuration Commands

+ESCAN – Scan The Energy Of All Channels

Execute Command **AT+ESCAN**	Response **+ESCAN:** **11:XX** **12:XX** **…** **26:XX** **OK**
Use on: All nodes which are not part of a PAN	or **ERROR<errorcode>**
Note Scanning all channels can take up to 16 seconds. This command can only be executed if the local node is not part of a PAN. Use **AT+DASSL** to leave a PAN before executing this command.	<errorcode> represents the error code explained in section 3. XX represents the average energy on the respective channel (see description in Section 8). Channels masked out in S00 are not scanned.
SW release	R200

+EN – Establish PANetwork

Execute Command **AT+EN**	Response **JPAN:CC,PPPP** **OK** or **ERROR<errorcode>**
Use on: All nodes which are not part of a PAN	<errorcode> represents the error code explained in section 3. The local node becomes a coordinator and performs an energy scan on all channels selected in S00. It then starts a PAN with a random unused PAN ID (PPPP) on the quietest channel (CC). It is possible to force the coordinator to a specific PAN ID and channel by selecting a single channel in S00 and setting S01 to a PAN ID other than FFFF. By default S00 and S01 are set to both FFFF, which causes the coordinator to pick a channel and PAN ID as described above.
Note When issuing this command the local device becomes a Coordinator. Establishing a PAN can take up to 16 seconds. This command can only be executed if the local node is not part of a PAN already.	If S01 is not set to FFFF the content of S01 is used instead of a random PAN ID, given that the preferred PAN ID is not used by a different PAN. In case the PAN ID specified in S01 is already in use a randomly generated PAN ID will be used. The new network's encryption key is defined in S03. If S03 is set to all 0's (default) a random key will be generated.
SW release	R200

+JN – Join Network

Execute Command **AT+JN**	Response **JPAN:CC,PPPP** **OK** or **ERROR<errorcode>**
Use on: All nodes which are not part of a PAN Note Joining a PAN can take up to 8 seconds, depending on the number of channels which need scanning. This command can only be executed if the local node is not part of a PAN already.	<errorcode> represents the error code explained in section 3. The local node scans all channels selected in register S00 for the existence of a PAN. When finding a PAN which allows joining it will automatically join in via the remote node with the highest RSSI. In case register S01 differs from the default value of 0xFFFF the node will only join a PAN with the PAN ID specified in S01.
Remote Action Depending on settings in S06 the new node will be announced either at the coordinator or parent device. (See the User Guide for a more detailed description of network establishment)	Prompt **NEWNODE:<EUI64>**
SW release	R200

+PANSCAN – Scan For Active PANs

Execute Command **AT+PANSCAN**	Response **+PANSCAN:CC,PPPP,b** **OK** or **ERROR<errorcode>**
Use on: All nodes which are not part of a PAN Note Scanning for active PANs can take up to 8 seconds. This command can only be executed if the local node is not part of a PAN already.	<errorcode> represents the error code explained in section 3. The node gives a list of all available PANs found. CC represents the channel, PPPP the PAN ID and b indicates whether the network is allowing additional nodes to join (0=joining not permitted, 1=joining allowed). The node does not join any of the PANs found.
SW release	R200

+JPAN – Join Specific PAN

Execute Command **AT+JPAN:CC,PPPP** Where CC is the channel and PPPP is the PAN ID of the network which is to be joined.	Response **JPAN:CC,PPPP** **OK** or **ERROR<errorcode>**
Use on All nodes which are not part of a PAN	
Note This command can only be executed if the local node is not part of a PAN already. The JPAN command is not affected by the channel mask in register S00.	<errorcode> represents the error code explained in section 3. The local node joins a particular PAN on channel CC with PAN ID PPPP via the remote node with the highest RSSI.
SW release	R200

+DASSL – Disassociate Local Device From PAN

Execute Command **AT+DASSL**	Response **OK** or **ERROR<errorcode>**
Use on All Devices which are part of a PAN	Prompt **LeftPAN** <errorcode> represents the error code explained in section 3. Instruct local device to leave the PAN.
SW release	R200

+DASSR – Disassociate Remote Device From PAN

Execute Command **AT+DASSR:<EUI64>** Use on All Devices which are part of a PAN	Response **OK** or **ERROR<errorcode>** <errorcode> represents the error code explained in section 3. Instruct remote device to leave the PAN.
Remote action	Prompt **LeftPAN**
SW release	R200

+NTABLE – Display the Neighbour Table

Read Command **AT+NTABLE?** Displays the local device's neighbour table. The neighbour table contains devices within a single hop of the local node. Use on All Devices	Response ShortID | LQI | inCost | outCost | age | EUI … **OK** The short ID is the 16-bit network ID of the neighbouring device, inCost and outCost are an indicator of the link quality between the local node and the remote node, age is the number of intervals during which the local node has not heard from that particular neighbour (in 16 second increments) and EUI is the neighbour's EUI64.
SW release	R200

+N – Display Network Information

Read Command **AT+N?** Use on All Devices	Response **+N:XXX,CC,PPPP,sZZ** or **NoPAN** followed by **OK** or **ERROR<errorcode>** <errorcode> represents the error code explained in section 3. XXX represents the nodes functionality in the PAN (FFD,COO,SED,MED), YY represents the IEEE802.15.4 radio channel (11-26), PPPP represents the node's PAN ID and ZZ represents the radio output power in dBm.
SW release	R200

+POLL – Poll The Parent Device

Execute Command **AT+POLL** Poll the parent device for new data. Note: Action 0011 is recommended for periodic polling. Use on SEDs MEDs	Response **OK** or **ERROR<errorcode>** <errorcode> represents the error code explained in section 3.
SW release	R207

+PARENT – Display Parent's ID

Read Command **AT+PARENT?** Display the Device's Parent EUI64. Use on SEDs MEDs	Response **+PARENT:<EUI64>** **OK** or **ERROR<errorcode>** <errorcode> represents the error code explained in section 3.
SW release	R207

+CTABLE – Display List Of Local Children

Read Command **AT+CTABLE?** Display the Device's children's EUI64 and the type (MED or SED). Use on Routers Coordinator	Response **+CTABLE** **index eui type** **<list of children>** **OK** or **noChilds** **OK** or **ERROR<errorcode>** <errorcode> represents the error code explained in section 3.
SW release	R207

+SN – Scan Network

Execute Command **AT+SN[:nn]** Use on All Devices Note In case no parameter is specified 07 is used by default.	Response **OK** or **ERROR<errorcode>** Prompt **FFD:<EUI64>[,syy,zz]** **SED:<EUI64>[,syy,zz]** **MED:<EUI64>[,syy,zz]** **COO:<EUI64>[,syy,zz]** Parameters **nn ranging from 00 to 07** <errorcode> represents the error code explained in section 3. In case bit 6 of register S06 is set the RSSI level (syy in dBm) and LQI (zz in hexadecimal) of the last hop are displayed. For a description of the LQI reading please see section 8. Only neighbours which are up to nn hops away are listed. If nn = 01 only direct neighbours will reply and nn = 00 will search the entire network.
SW release	R200

+REMSN – Scan For Remote Devices Direct Neighbours

Execute Command **AT+REMSN:<EUI64>**	Response **OK** or **ERROR<errorcode>**
	Prompt **REMFFD:<EUI64>[,syy,zz]** **REMZED:<EUI64>[,syy,zz]** **REMSED:<EUI64>[,syy,zz]** **REMMED:<EUI64>[,syy,zz]** **REMCOO:<EUI64>[,syy,zz]**
Use on All Devices	
Note If the target device of this command is an end device the results will reflect its parent, therefore it is recommended to target this command at routers only.	<errorcode> represents the error code explained in section 3. In case bit 6 of register S06 is set the RSSI level (syy in dBm) and the LQI (zz in hexadecimal) read at the remote device are displayed. For a description of the LQI reading please see section 8. After execution of this command all direct neighbours of the node with id <EIU64> will report within 8 seconds.
SW release	R200

+LINKCHECK – Check Link Parameters For Link With Neighbouring Device

Execute Command **AT+LINKCHECK:<EUI64>** Use on All Devices	Response **+LINKCHECK=syy,zz** **OK** or **ERROR<errorcode>** <errorcode> represents the error code explained in section 3. The command will only be successful if the node with the identifier <EUI64> is a direct neighbour, parent or child of the local node. The RSSI level (syy in dBm) and LQI (zz in hexadecimal) of the last hop are displayed. For a description of the LQI reading please see section 8.
SW release	R200

+PING – Indicate Presence In The Network

Execute Command **AT+PING** Use on All Devices	Response **OK** or **ERROR<errorcode>** <errorcode> represents the error code explained in section 3.
Remote Action	Prompt **FFD:<EUI64>[,syy,zz]** **SED:<EUI64>[,syy,zz]** **MED:<EUI64>[,syy,zz]** **COO:<EUI64>[,syy,zz]** The prompt above will be displayed on all nodes which can hear the ping. In case bit 6 of register S06 is set the RSSI level (syy dBm) and LQI (zz in hexadecimal) of the last hop are displayed. For a description of the LQI reading please see section 8. <EUI64> is the identifier of the sending device
SW release	R200

+BCAST – Transmit A Broadcast

Execute Command **AT+BCAST:nn,<data>** Use on: All devices	Response **OK** or **ERROR<errorcode>** Where <errorcode> represents the error code explained in section 3. Parameters **nn ranging from 00 to 10** Up to 65 bytes are sent. The response OK shows successful transmission. Successful transmission does not guarantee successful reception. To make sure data has been received by a specific node use a unicast message. Only neighbours which are up to nn hops away will receive the broadcast. If nn = 01 only direct neighbours will receive the broadcast and if n = 00 the entire network will.
Remote action	Prompt **BCAST:<EUI64>=<data>** Every node in the PAN which has received the broadcast message will prompt the above message where <EUI64> is the address of the sender and <data> is the data which was attached to the broadcast
SW release	R200

+BCASTB – Transmit A Broadcast Of Binary Data

Execute Command **AT+BCASTB:xx,nn** Where xx is the number (in hexadecimal) of data bytes to be sent and nn is the number of hops the message will travel. Use on All Devices Note: This command is particularly useful if the data may contain <CR> and <Backspace> characters.	Response **> <data being entered>** **OK** or **ERROR<errorcode>** After the '>' prompt a number of xx characters are expected to be entered. <errorcode> represents the error code explained in section 3. In case bit D of S08 is set a timeout error is generated if no character is received for 1 second. Parameters **xx ranging from 00 to 41 (hex)** **nn ranging from 00 to 10** Up to 65 bytes are sent to devices up to nn hops away. The response OK shows successful transmission. Successful transmission does not guarantee successful reception. To make sure data has been received by a specific node use a unicast message. Only neighbours which are up to nn hops away will receive the broadcast. If nn=01 only direct neighbours will receive the broadcast and if n = 00 the entire network will.
Remote action	Prompt **BCAST:<EUI64>,xx=<data>** Every node in the PAN which has received the broadcast message will prompt the above message where <EUI64> is the address of the sender and xx is the length of the message in hexadecimal.
SW release	R200

+UCAST – Transmit A Unicast

Execute Command **AT+UCAST:\<EUI64>,\<DATA>**	Response **+UCAST:nn** **OK** or **ERROR\<errorcode>** Where \<errorcode> represents the error code explained in section 4.
Use on All Devices Note - It is possible to have up to 10 transmissions to 4 different nodes in flight (i.e. pending for an ACK or NACK). - The ACK and/or NACK prompt can be disabled in S08	Prompt **ACK:nn** or **NACK:nn** Up to 65 bytes are sent to the node up to 6 hops away with address \<EUI64>. On successful transmission the user is given a transmission number followed by "OK". The user is then prompted "ACK" on receipt of an acknowledgement or "NACK" in case the message was not acknowledged. A NACK does not guarantee that the message has not reached its destination. Alternatively if bit 13 of S06 is set the response will be: **OK** or **ERROR\<errorcode>** In this case no transmission number is issued as only a single message can be in flight. An "OK" indicates successful acknowledgement.
Remote action	Prompt **UCAST:\<EUI64>=\<data>** Where \<EUI64> is the address of the sender.
SW release	R200

+UCASTB – Transmit A Unicast Of Binary Data

Execute Command
AT+UCASTB:xx,<EUI64>
 	
Where xx is the number (in hexadecimal) of data bytes to be sent.
 	
Use on
All Devices
 	
Note
   -   This command is particularly useful if the data may contain <CR> and <Backspace> characters.
   -   It is possible to have up to 10 transmissions to 4 different nodes in flight (i.e. pending for an ACK or NACK).
   -   The ACK and/or NACK prompt can be disabled in S08
	Response
	> <data being entered>
	+UCAST:nn
	OK
	
	or **ERROR<errorcode>**
	
	Prompt
	ACK:nn
	
	or **NACK:nn**
	
	Parameters
	xx ranging from 00 to 41 (hex)
	
	After the '>' prompt a number of xx characters are expected to be entered. Up to 65 bytes are sent to the node with address <EUI64>.
	In case bit D of S08 is set a timeout error is generated if no character is received for 1 second.
	On successful transmission the user is given a transmission number followed by "OK". After that the user is prompted "ACK" on receipt of an acknowledgement or "NACK" in case the message was not acknowledged. A NACK does not guarantee that the message has not reached its destination.
	
	Alternatively if bit 13 of S06 is set the response will be:
	OK
	
	or **ERROR<errorcode>**
	
	In this case no transmission number is issued as only a single message can be in flight. An "OK" indicates successful acknowledgement.

Remote action	Prompt **UCAST:<EUI64>,xx=<data>** Where <EUI64> is the address of the sender and xx is the length of the message in hexadecimal
SW release	R200

+SCAST – Transmit Data To The Sink

Execute Command **AT+SCAST:<data>** Use on All Devices Note - If a sink cannot be reached for three consecutive transmissions the sink is assumed unavailable and a new one is searched. - The ACK and/or NACK prompt can be disabled in S08 - It is possible to have up to 10 transmissions in flight (i.e. pending for an ACK or NACK).	Response **+UCAST:nn** **OK** or **ERROR<errorcode>** Where <errorcode> represents the error code explained in section 3. Prompt **ACK:nn** or **NACK:nn** Parameters Up to 65 bytes are sent to the network's sink given it is no more than 6 hops away. On successful transmission the user is given a transmission number followed by "OK". After that the user is prompted "ACK" on receipt of an acknowledgement or "NACK" in case the message was not acknowledged. A NACK does not guarantee that the message has not reached its destination. Alternatively if bit 13 of S06 is set the response will be: **OK** or **ERROR<errorcode>** In this case no transmission number is issued as only a single message can be in flight. An "OK" indicates successful acknowledgement
Remote action	Prompt **SCAST:<EUI64>=<data>** Where <EUI64> is the address of the sender.
SW release	R200

+SCASTB – Transmit Binary Data To A Sink

Execute Command **AT+SCASTB:xx** Where xx is the number (in hexadecimal) of data bytes to be sent. Use on All Devices	Response **> <data being entered>** **+SCAST:nn** **OK** or **ERROR<errorcode>**
Note - If a sink cannot be reached for three consecutive transmissions the sink is assumed unavailable and a new one is searched. - The ACK and/or NACK prompt can be disabled in S08 - It is possible to have up to 10 transmissions in flight (i.e. pending for an ACK or NACK).	Parameters **xx ranging from 00 to 41 (hex)** After the '>' prompt a number of xx characters are expected to be entered. Up to 65 bytes are sent to the networks' sink. In case bit D of S08 is set a timeout error is generated if no character is received for 1 second. On successful transmission the user is given a transmission number followed by "OK". After that the user is prompted "ACK" on receipt of an acknowledgement or "NACK" in case the message was not acknowledged. A NACK does not guarantee that the message has not reached its destination. Alternatively if bit 13 of S06 is set the response will be: **OK** or **ERROR<errorcode>** In this case no transmission number is issued as only a single message can be in flight. An "OK" indicates successful acknowledgement.
Remote action	Prompt **SCAST:<EUI64>,xx=<data>** Where <EUI64> is the address of the sender and xx is the length of the message in hexadecimal
SW release	R200

+SSINK – Search For A Sink

Read Command **AT+SSINK** Search for a sink on the network If a sink is already known and the known sink is reporting in as a reply to this request, no prompt will be displayed. Use on All Devices	Response **OK** or **ERROR<errorcode>** Prompt **SINK:<EUI64>** <errorcode> represents the error code explained in section 3.
SW release	R200

+SINK – Display The Local Node's Sink

Read Command **AT+SINK?** Displays the locally stored ID of the network's sink. In order to search for a sink use AT+SSINK.	Response **+SINK:Local** **OK** or **+SINK:None** **OK** or **+SINK:<EUI64>** **OK** or **ERROR<errorcode>**
Use on All Devices	Where <EUI64> is the address of the sink and <errorcode> represents the error code explained in section 3.
SW release	R207

+OPCHAN – Opens A Channel To A Remote Node

Execute Command **AT+OPCHAN:<EUI64>** Use on All devices Note Opening a channel to end devices will result in a limited data rate which depends on the polling interval of the child. When in sleep mode 02 a device will stay awake until the channel is closed	Response **OK** or **ERROR<errorcode>** <errorcode> represents the error code explained in section 3. Once the channel is established it acts like a virtual wire and transmits any data entered bi-directionally. There is no local echo of the data entered. To close the channel enter +++ on any end of the virtual wire. Parameters The remote module's address <EUI64>. Examples **AT+OPCHAN:000D6F0000012345** **OK** **OPEN** **>Hello world** **My second data line+++** **CLOSED** In case the channel breaks down an error message is displayed on both ends, where <errorcode> represents the error code explained in section 3.
Remote Action Note The "CHAN" prompt can be disabled in register S07	Prompt Depending on the setting of bit 12 in the remote S06 If unset the node will automatically accept the channel. **CHAN:<EUI64>** **OPEN** if set the node will display the request in the format **CHAN:<EUI64>** The remote device has to acknowledge the request using the command AT+ACKCHAN command.
SW release	R200

+++ – Close Channel

Execute Command **+++**	Response **CLOSED**
Remote Action	Prompt **CLOSED**
SW release	R200

+OPLCHAN – Opens A Limited Channel To A Remote Node

Execute Command **AT+OPLCHAN:XXXX,<EUI64>** Use on All Devices	Response **OK** or **ERROR<errorcode>** Same as AT+OPCHAN, but the connection will automatically close after a number of XXXX characters (in hexadecimal) have been sent by the device which opened the connection. +++ doesn't close the connection any more. In case Bit D of S08 is set the channel is also closed in case no character has been received via the serial port for more than a second.
Remote Action	Prompt Depending on the setting of bit 12 in the remote S06 If unset the node will automatically accept the channel. **LCHAN:XXXX,<EUI64>** **OPEN** if set the node will display the request in the format **LCHAN:XXXX,<EUI64>** The remote device has to acknowledge the request using the command AT+ACKCHAN command.
SW release	R200

+ACKCHAN – Accept Channel

Execute Command **AT+ACKCHAN:<EUI64>**	Response **OK** **OPEN** or **ERROR<errorcode>** <errorcode> represents the error code explained in section 3.
Example Prompt **[L]CHAN:<EUI64>** Reply **AT+ACKCHAN:<EUI64>**	The unit gets prompted that a remote unit is trying to establish a channel to this unit. If required the channel can be acknowledged which will cause the channel to open. In S06 the unit can be configured to automatically accept every incoming channel if not connected to another active channel.
SW release	R200

+RDATAB – Send Binary Raw Data

Execute Command **AT+RDATAB:xx** Use on All Devices Note Can be useful to quickly exchange bulk data with neighbouring node. The application needs to handle addressing, error checking, retries and acknowledgements.	Response **> <data being entered>** **OK** or **ERROR<errorcode>** Parameters **xx ranging from 00 to 72 (hex)** After the '>' prompt a number of xx characters are expected to be entered. Up to 114 bytes of data can be send to all nodes within reach (direct neighbours) The data is neither encrypted nor error checked. No retries are made and no acknowledgement is received. <errorcode> represents the error code explained in section 3.
Remote action	Prompt **RAW:<data>** or **<data>** in case bit B of S08 is set. Also this prompt can be disabled entirely by setting bit A of S08.
SW release	R208

+IDENT – Play A Tune On Remote Devboard

Execute Command **AT+IDENT:<EUI64>** Use on All Devices	Response **OK** or **ERROR<errorcode>** <errorcode> represents the error code explained in section 3. Plays a tune on a remote devboard if the Beeper is connected. Useful to identify remote nodes. See devkit manual for details about connecting a beeper to the ETRX1 and ETRX2. Setting bit 0 in S08 disables the remote response to the AT+IDENT command. The tune played on the remote device will differ depending on whether the device is an ETRX1 or ETRX2.
SW release	R200

3   List of Error codes

01	Too many characters have been entered on the command line
02	Unknown command
04	Invalid S-Register
05	Invalid parameter
06	Unicast could not be sent
07	Message was not acknowledged
08	No sink known
0E	Channel is unavailable
0F	Fatal error initialising the network
10	Error bootloading
12	Fatal error initialising the stack
14	Binding problem
15	Channel failed
16	Error trying to acknowledge a channel, which has not been requested recently
17	Only allowed on end devices
18	Out of buffers
19	Trying to write read-only register
20	Invalid password
23	PWM not in use (ETRX1 only)
24	Error Polling from Parent
25	Cannot form network
26	Cannot join network
27	No network found
28	Operation cannot be completed if node is part of a PAN
29	Local device is sink
2A	Error during energy scan
2B	No free Bindings
2C	Error leaving the PAN
2D	Error scanning for PANs
2F	Polling parent unsuccessful
30	Trying to clone or passthrough to an incompatible hardware platform
33	No response from the remote bootloader (ETRX2)
34	Target did not respond during cloning (ETRX2)
35	Timeout occurred during xCASTB
40	UART RX Frame error
41	UART RX Parity error
42	UART TX software buffer overflow
43	UART RX software buffer overflow
44	UART RX hardware buffer overflow
6C	Invalid binding table index
72	the maximum number of in flight messages has been exceeded
74	Payload too long
91	Operation only possible if joined to a PAN
A1	Network overload

4 S-Registers

Most S-Registers of the ETRX1 and ETRX2 can be read and written locally as well as remotely. The S-Registers are summarised in the table below.

S-Register Overview		Local R/W	Remote R/W
S00	Channel Mask	(•/•)	(•/•)
S01	Preferred PAN ID	(•/•)	(•/•)
S02	Transmit Power Level	(•/•)	(•/•)
S03	Encryption key[1]	(-/•)	(-/•)
S04	User Definable name	(•/•)	(•/•)
S05	OEM Word[1]	(•/•)	(•/•)
S06	Main Function[1]	(•/•)	(•/•)
S07	Extended Function1	(•/•)	(•/•)
S08	Extended Function2	(•/•)	(•/•)
S09	Password[1]	(-/•)	(-/•)
S0A	Revision Number	(•/•)	(•/•)
S0B	UART Setup	(•/•)	(•/•)
S0C	ETRX2: Pull-up enable ETRX1: Reserved	(•/•)	(•/•)
S0D	Data Direction of I/O Port (DDR) **(volatile)**	(•/•)	(•/•)
S0E	Initial value of S0D	(•/•)	(•/•)
S0F	Output Buffer of I/O Port (PORT) **(volatile)**	(•/•)	(•/•)
S10	Initial value of S0F	(•/•)	(•/•)
S11	Input Buffer of I/O Port (PIN) **(volatile)**	(•/-)	(•/-)
S12	A/D1	(•/-)	(•/-)
S13	A/D2	(•/-)	(•/-)
S14	ETRX2: A/D3 (Reserved) ETRX1: Reserved	(•/-)	(•/-)
S15	Immediate functionality at IRQ0	(•/•)	(•/•)
S16	Immediate functionality at IRQ1	(•/•)	(•/•)
S17	Timer/Counter 0	(•/•)	(•/•)
S18	Functionality for Timer/Counter 0	(•/•)	(•/•)
S19	Timer/Counter 1	(•/•)	(•/•)
S1A	Functionality for Timer/Counter 1	(•/•)	(•/•)
S1B	Timer/Counter 2	(•/•)	(•/•)
S1C	Functionality for Timer/Counter 2	(•/•)	(•/•)
S1D	Timer/Counter 3	(•/•)	(•/•)
S1E	Functionality for Timer/Counter 3	(•/•)	(•/•)
S1F	Timer/Counter 4	(•/•)	(•/•)
S20	Functionality for Timer/Counter 4	(•/•)	(•/•)
S21	Timer/Counter 5	(•/•)	(•/•)
S22	Functionality for Timer/Counter 5	(•/•)	(•/•)
S23	Timer/Counter 6	(•/•)	(•/•)
S24	Functionality for Timer/Counter 6 **(volatile)**	(•/•)	(•/•)

[1] Access to these registers is password protected

S-Register Overview (continued)		Local R/W	Remote R/W
S25	Initial Functionality for Timer/Counter 6	(•/•)	(•/•)
S26	Timer/Counter 7	(•/•)	(•/•)
S27	Functionality for Timer/Counter 7 **(volatile)**	(•/•)	(•/•)
S28	Initial Functionality for Timer/Counter 7	(•/•)	(•/•)
S29	Power mode **(volatile)**	(•/•)	(•/•)
S2A	Initial Power Mode	(•/•)	(•/•)
S2B	Start-up Functionality Plaintext A	(•/•)	(•/•)
S2C	Start-up Functionality Plaintext B	(•/•)	(•/•)
S2D	Parent's EUI	(•/-)	(•/-)
S2E	Device Specific	(•/•)	(•/•)
S2F	Special Function Pin 1 **(volatile)**	(•/•)	(•/•)
S30	Initial value of S2F	(•/•)	(•/•)
S31	Special Function Pin 2 **(volatile)** (ETRX2 only)	(•/•)	(•/•)
S32	Initial value of S31 (ETRX2 only)	(•/•)	(•/•)
S33	Supply Voltage (ETRX2 only)	(•/-)	(•/-)

Table 6: S-Register Overview

With a few exceptions the S-registers are stored in non-volatile memory and will keep their user defined settings unless reset to the factory defaults using the "AT&F" command. S0D, S0F, S27, S29, S2F and S31 are directly accessing volatile I/O registers to prevent memory corruption due to constant I/O access. Registers S0E, S10, S28, S2A, S30 and S32 represent the non-volatile registers which define the contents of S0D, S0F, S27, S29, S2F and S31 respectively after booting up.

4.1 Recovery of the Factory Default Settings

If the unit seems to be unresponsive to commands on the serial port this is most often due to the unit having been set into a power-down mode or the set-up for the serial connection having been altered. With revisions R200 of the firmware upwards, a feature has been added which performs a factory reset on any module which seems unresponsive. To factory reset a module, connect it to the PC's serial port and execute the Factory Reset Tool (downloadable from www.telegesis.com). When pressing the Reset button on the Reset Tool you are prompted to cause a hardware reset to the module by pulling the modules' reset line low for more than 100ms (done by pressing the reset button on the Development Board). Once completed, the factory default settings of the ETRXn module are restored.

4.2   S-Registers for Radio Setup

S00 – Channel Mask

Description The 802.15.4 channel mask.	Parameters **XXXX** Where XXXX represents a 16-bit decimal number enabling IEEE802.15.4 channel numbers 11 to 26. Writing a bit to 1 enables a channel and subsequently writing a bit to 0 disables a channel for scanning, joining and establishing networks. e.g. when setting S00 to 0001, only channel 11 will be used for all following operations.
Operations **R/W LOCAL** **R/W REMOTE**	
Becomes effective When Joining, Scanning or establishing a PAN	
Note The channel mask does not affect the AT+JPAN command	Range **0001 - FFFF**
Storage **Non-Volatile**	Factory Default **FFF0**
SW release	Default changed in R210

S01 – Preferred PAN ID

Description The 802.15.4 PAN ID.	Parameters **XXXX** Where XXXX represents a 16-bit decimal number
Operations **R/W LOCAL** **R/W REMOTE**	Range **0000 – 3FFF** or **FFFF**
Becomes effective When Joining or establishing a PAN	When establishing a PAN the coordinator will pick a random PAN ID if S01 is set to FFFF. If set to any value between 0000 and 3FFF this number will be used as PAN ID instead, unless trying to establish a PAN which already exists on the same channel. In this case a random PAN ID will be used instead. When joining only PANs with the ID stored in S01 will be joined unless S01 is set to FFFF. In this case the next best PAN which allows joining is joined.
Storage **Non-Volatile**	Factory Default **FFFF**
SW release	R200

S02 – Transmit Power Level

Description The devices transmit power level in dBm.	Parameters **snn** Where snn represents a signed 8-bit decimal number.
Operations **R/W LOCAL** **R/W REMOTE**	Range **-1 to -32** (on ETRX1) **4 to -43** (on ETRX2)
Becomes effective When Joining or establishing a PAN	Setting S02 to 4 on the ETRX2 enables the radio boost mode increasing both output power as well as sensitivity. Actual values for the ETRX2 are {3, 2, 1, -1, -2, -3, -4, -5, -6, -7, -8, -9, -11, -12, -14, -17, -20, -26, -43} Entering a value not on this list (such as –19) will resulted in the next lowest output power.
Storage **Non-Volatile**	Factory Default **-1** (on ETRX1) **3** (on ETRX2)
SW release	R208

S03 – Encryption Key

Description The encryption key which can be written using the password. The default password on both ETRX1 and ETRX2 is "TG-ETRX1".	Range **From 0 to 2^{128}-1** The 128-bit AES encryption key in hexadecimal representation (32 characters).
Operations **W LOCAL** **W REMOTE** Write operation **ATS03=<key>:<password>** **ATSREM03:<EUI64>=<key>:<password>**	For an in depth description of the network establishment and maintenance please refer to the user guide.
Becomes effective When Joining or establishing a PAN	When set to all 0s (default) a random security key is generated when establishing a PAN.
Storage **Non Volatile**	Factory Default **00000000000000000000000000000000**
SW release	R208 added random key generation

4.3 S-Registers for Module Setup

S04 – User Readable Name

Description	Parameters
A Used defined name which can be used to identify the node	**ccccccccccccccccccccc**
	Name with up to 20 characters.
Operations	
R/W LOCAL	
R/W REMOTE	
Becomes effective	
Instantly	
Storage	**Factory Default**
Non-Volatile	**<none>**
SW release	R208 – removed default setting

S05 – OEM Word

Description	Parameters
Password protected 16 bits which can be written by the OEM for device identification. The default password on both ETRX1 and ETRX2 is "TG-ETRX1".	**XXXX**
	Where XXXX represents a 16-bit hexadecimal number.
Operations	**Range**
R/W LOCAL	**0000 to FFFF**
R/W REMOTE	
	Bit 15 (MSB) – Bit 0:
Write operation	OEM Defined
ATS05=XXXX:<password>	
ATSREM55:<EUI64>=XXXX:<password>	
Becomes effective	
Instantly	
Storage	**Factory Default**
Non-Volatile	**0000**
SW release	R200

S06 – Main Function

Description Defines the behaviour of the Device.	**Parameters** **XXXX** Where XXXX represents a 16-bit hexadecimal number.
Operations **R/W LOCAL** **R/W REMOTE**	**Range** **0000 to FFFF**
Becomes effective **Instantly**	**Bit F:** Read only. Set: Brownout Fuse is not set. (ETRX1 only, reserved on ETRX2) **Bit E:** Set: Remote S-Register Reads don't wait for ACK
Write operation **ATS06=XXXX:<Password>** **ATSREM06:<EUI64>=xxxx: <Password>**	**Bit D:** Set: UCASTs and SCASTs wait for ACK **Bit C:** Set: Prompt user if a channel has been requested. <u>Unset: Automatically accept channel</u> **Bit B:** Set: Joining not permitted (overrides bits 0-3) **Bit A:** Set: Moving End Device (MED). <u>Unset: Sleepy End Device (SED)</u> (note: bit 9 must also be set)
Note - Default settings are underlined - For security reasons this register is password protected. The default password on both ETRX1 and ETRX2 is "TG-ETRX1". - Changes to Bits 9 and 10 require leaving and joining the network again to take effect. - An end device cannot be a sink	**Bit 9:** Set: Device is an End Device (bit A specifies Sleepy or Moving End Device) **Bit 8:** Device is Data Sink **Bit 7:** Set: Writing to S03 takes effect immediately (device will do a quick leave/re-init) **Bit 6:** Set: Display RSSI and LQI when devices report to AT+SN and AT+REMSN or AT+PING in **Bit 5:** Set: Attach Vcc reading to transmissions for functionalities 0100-0103, 0110-0113 and 2000 **Bit 4:** Set: When trying to join a network use network key in S03 (secured joining) **Bit 3:** <u>Set</u>: Allow unsecured joining via local node **Bit 2:** Set: Allow secured joining via local node **Bit 1:** <u>Set</u>: Allow unsecured joining via Trust Centre **Bit 0:** Set: Allow secured joining via Trust Centre
Storage **Non-Volatile**	
	Factory Default **000C**
SW release	R200

S07 – Extended Function1	
Description Defines the behaviour of the Device.	Parameters **XXXX** Where XXXX represents a 16-bit hexadecimal number.
Operations **R/W LOCAL** **R/W REMOTE**	Range **0000 to FFFF** **Bit F:** Set: Disable \<plaintext\> prompt **Bit E:** Set: Disable SDATA / NDATA prompts
Becomes effective **Instantly**	**Bit D:** Set: Disable COUNT: prompt **Bit C:** Set: Disable xED:, FFD: and COO: prompts **Bit B:** Set: Disable UCAST:\<EUI64\> prefix **Bit A:** Set: Disable BCAST:\<EUI64\> prefix **Bit 9:** Set: Disable SCAST:\<EUI64\> prefix **Bit 8:** Set: Disable '>' prompt when sending BCASTB, SCASTB, RDATAB, UCASTB. **Bit 7:** Set: Disable SCAST prompt **Bit 6:** Set: Disable BCAST prompt **Bit 5:** Set: Disable UCAST prompt **Bit 4:** Set: Disable JPAN prompt **Bit 3:** Set: Disable LeftPAN prompt **Bit 2:** Set: Disable CHAN prompt **Bit 1:** Set: Disable NEWNODE prompt **Bit 0:** Set: Disable SINK prompt
Storage **Non-Volatile**	Factory Default **0000**
SW release	R200

S08 – Extended Function2

Description	Parameters
Defines the behaviour of the Device.	**XXXX**
	Where XXXX represents a 16-bit hexadecimal number.
Operations	
R/W LOCAL	**Range**
R/W REMOTE	**0000 to FFFF**
Becomes effective	**Bit F:** Set: Changes to S02 take effect immediately
Instantly	**Bit E:** Set: I/O7 is driven high if awake and driven low otherwise (must be set as output)
	Bit D: Set: Enable 1s character timeout when entering data for xCASTB and limited channel.
	Bit C: Set: Don't discard and search for new sink when unreachable for three consecutive times
	Bit B: Set: Do not encapsulate raw data on rec.
	Bit A: Set: Disable displaying RAW: prompts
	Bit 9: Set: Disable ERROR:xx prompt
	Bit 8: Set: Disable OK prompt
	Bit 7: Set: Disable UCAST[B]:xx prompt
	Bit 6: Set: Disable SCAST[B]:xx prompt
	Bit 5: Set: Disable CLOSED prompt
	Bit 4: Set: Disable OPEN prompt
	Bit 3: Set: Enable PWRCHANGE:nn prompt
	Bit 2: Set: Disable NACK:nn prompt
	Bit 1: Set: Disable ACK:nn prompt
	Bit 0: Set: Disable AT+IDENT tune
Storage	**Factory Default**
Non-Volatile	**0000**
SW release	Last modified in R205

S09 – Password

Description	Parameters
The local nodes password.	**cccccccc**
	8 case sensitive characters (8 bytes).
Operations	Note that the password **must** have exactly 8 characters.
W LOCAL	
W REMOTE	
Write operation	
ATS09=<NEW>:<OLD>	
ATSREM09:<EUI64>=<NEW>:<OLD>	
Becomes effective	
Instantly	
Storage	**Factory Default**
Non-Volatile	**TG-ETRX1**
SW release	R200

S0A – Revision number

Description	Parameters
The firmware revision number.	The firmware revision number
Operations **R LOCAL** **R REMOTE**	
Becomes effective **Instantly**	
Storage **Non-Volatile**	
SW release	R200

4.4 I/O related S-Registers

S0B – UART Setup

Description	Parameters
The device's RS232 Baudrate and mode. The default setting of 0500 results in: 19200bps, no parity, 1 stop bit, 8 data bits.	**XXXX** Where XXXX represents a 16-bit hexadecimal number.

Operations
R/W LOCAL
R/W REMOTE

Becomes effective
Instantly

Note

For the ETRXn Ember only guarantees proper operation of the stack up to 19200 baud. It is not recommended to use continuous data rates above 38400, even using hardware flow control as using higher data rates does not increase the actual throughput.
If bit 5 is set, bi-directional Hardware Flow Control is used instead of XON/XOFF flow control. If using Hardware flow control I/O4 becomes the RTS output and the CTS input is assigned to either

I/O3 (ETRX1)
I/O2 (ETRX2)

On the ETRX1 the CTS input can be moved to I/O2 for compatibility reasons by setting bit 7 of this register.

Access to these I/Os via S0D,S0F is blocked whilst Hardware Flow control is active. Note that in case the 128-byte output buffer of the ETRXn is full data will be dropped.

Range of the most significant byte
00 to 0C
```
00: 1200   baud
01: 2400   baud
02: 4800   baud
03: 9600   baud
04: 14400  baud
05: 19200  baud
06: 28800  baud
07: 38400  baud
08: 50000  baud
09: 57600  baud
0A: 76800  baud
0B: 100000 baud
0C: 115200 baud (ETRX2 only)
```

Range of the least significant byte
00 to FF
   bit 7 set: CTS is on I/O2 (ETRX1 only, ETRX2: reserved)
   bit 6 set: enable error prompts for parity error, rx-frame-error and rx-buffer overflow
   bit 5 set: H/W flow control enable
   bit 4 set: no command echo
   bit 3 set: 7 data bits instead of 8
   bit 2 set: 2 stop bits instead of one
   bit 1 set: odd parity enabled
   bit 0 set: even parity enabled

Storage	Factory Default
Non-Volatile	**0500**
SW release	Modified in R208

S0C – ETRX2: Pull-up enable ETRX1: Reserved

Description	Parameters
Allows to enable the built in pull-ups for each individual I/O pin of the ETRX2.	**XXXX** Where XXXX represents a 16-bit hexadecimal number.
Operations **R/W LOCAL** **R/W REMOTE**	**Range** **0000 to FFFF**
Becomes effective Instantly	representing I/O pins `xxxx BA98 7654 3210` (ETRX2)
Note To achieve ultra low current consumption it is recommended not to use the built in pull-ups and leave this register in its default state.	e.g. setting bit 7 to 1 will enable the pull-up for I/O pin 7
Storage **Non-Volatile**	**Factory Default** **0000**
SW release	Added in R209

S0D – Data Direction of I/O Port

Description	Parameters
The data direction of the module's I/O port	**XXXX** Where XXXX represents a 16-bit hexadecimal number.
Operations **R/W LOCAL** **R/W REMOTE**	**Range** **0000 to FFFF**
Becomes effective Instantly	representing I/O pins `xxxx xxxx 7654 3210` (ETRX1) `xxxx BA98 7654 3210` (ETRX2) e.g. setting bit 7 to 1 will turn I/O pin 7 into an output, setting it to 0 will make it an input respectively.
Storage **Volatile**	**Factory Default** **Defined in S0E**
SW release	R200

S0E – Initial Setting of S0D

Description	Parameters
The initial setting of S0D stored in non volatile memory	**XXXX**
Operations **R/W LOCAL** **R/W REMOTE**	Where XXXX represents the initial value of S0D which is loaded after boot-up, soft or hard reset.
Becomes effective After Soft or Hard Reset	
Storage **Non-Volatile**	Factory Default **00F8**
SW release	R200

S0F – Output Buffer Of I/O Port

Description	Parameters
The output buffer of the module's I/O port	**XXXX**
Operations **R/W LOCAL** **R/W REMOTE**	Where XXXX represents a 16-bit hexadecimal number.
Becomes effective **Instantly**	Range **0000 to FFFF** representing I/O pins `xxxx xxxx 7654 3210` (ETRX1) `xxxx BA98 7654 3210` (ETRX2) If the I/O pin has been defined as an output in S0D the pin will drive the logic level defined by S0F. On the ETRX1 if defined as an input setting the output buffer to 1 activates the internal pull-up, which should be avoided if power consumption is critical.
Storage **Volatile**	Factory Default **Defined in S10**
SW release	R200

S10 – Initial Setting of S0F

Description	Parameters
The initial setting of S0F stored in non volatile memory	**XXXX**
Operations **R/W LOCAL** **R/W REMOTE**	Where XXXX represents the initial value of S0F which is loaded after boot-up, soft or hard reset.
Becomes effective **After Soft or Hard Reset**	
Storage **Non-Volatile**	Factory Default **00F0**
SW release	R200

S11 – Input Buffer of I/O Port

Description The Logical Levels at the I/O Pins	Range **0000 to FFFF**
Operations **R LOCAL** **R REMOTE**	representing I/O pins `xxxx xxxx 7654 3210` (ETRX1) `xxxx BA98 7654 3210` (ETRX2)
Becomes effective **Instantly**	S11 represents the logic level at each pin of the I/O port.
Storage **Instant Reading of Port Status**	
SW release	R200

S12 – A/D1 Reading

Description The analogue reading of A/D1	Parameters **XXXX**
Operations **R LOCAL** **R REMOTE**	Representation The hexadecimal reading of the analogue input in mV with respect to ground.
Becomes effective **Instantly**	Range ETRX1: 0000 – 09F6 (0 – 2550) ETRX2: 0000 – 04B0 (0 – 1200)
Storage **Instant Reading of analogue input**	If bit E of S2E is set on the ETRX1 the reading represents the contents of the 10-bit ADC register.
SW release	R209

S13 – A/D2 Reading

Description The analogue reading of A/D2	Parameters **XXXX**
Operations **R LOCAL** **R REMOTE**	Representation The hexadecimal reading of the analogue input in mV with respect to ground.
Becomes effective **Instantly**	Range ETRX1: 0000 – 09F6 (0 – 2550) ETRX2: 0000 – 04B0 (0 – 1200)
Storage **Instant Reading of analogue input**	If bit E of S2E is set on the ETRX1 the reading represents the contents of the 10-bit ADC register.
SW release	R209

S14 – A/D3 Reading (ETRX2 only when bit 7 of S2F is set, reserved otherwise)

Description	Parameters
The analogue reading of A/D2	**XXXX**
Operations **R LOCAL** **R REMOTE**	**Representation** The hexadecimal reading of the analogue input in mV with respect to ground. The return value will be 0xFFFF in case A/D3 has not been enabled by setting bit 7 of S2E.
Becomes effective **Instantly**	**Range** ETRX2: 0000 – 04B0 (0 – 1200)
Storage **Instant Reading of analogue input**	
SW release	R209

4.5   S-Registers Defining the Functionality of the Module

There are 10 events which can trigger a user-selectable action to prevent the need for a host microcontroller for simple applications. Two out of those 10 events are the two external interrupts which can be enabled in Register S2E. The actions to be performed on those two interrupt events are defined in S15 and S16. The user can pick any of the actions form the list in section 5 of this document and assign them to any event.

The remaining 8 events are timed events. Registers S17 to S28 control those 8 timers and their corresponding events. Please note that the first 4 timers are used by default for network management tasks, which can be modified by the user when changing the corresponding registers. A timer will increment every 250ms (4 times a second) and when the timer reaches the value stored in the timer/counter register the corresponding action will be executed.

S15 – Immediate Functionality At IRQ0	
Description Describes the immediate action taken on IRQ0.	Parameters **XXXX**
Operations **R/W LOCAL** **R/W REMOTE**	If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.
Becomes effective **Instantly**	
Storage **Non-Volatile**	Factory Default **0001 (Wakeup to power mode 0)**
SW release	R200

S16 – Immediate Functionality At IRQ1	
Description Describes the immediate action taken on IRQ1.	Parameters **XXXX**
Operations **R/W LOCAL** **R/W REMOTE**	If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.
Becomes effective **Instantly**	
Storage **Non-Volatile**	Factory Default **0001 (Wakeup to power mode 0)**
SW release	R200

S17 –Timer/Counter 0

Description	Parameters
A multi purpose Timer/Counter which functionality is defined by S18	**XXXX**
	A 16-bit hexadecimal number representing a threshold for either a timer or counter event to be triggered. When reading this register the threshold rather than the actual timer/counter value is displayed.
Operations **R/W LOCAL** **R/W REMOTE**	
	If set to 0 the corresponding functionality is disabled.
Becomes effective **Instantly**	
Storage **Non-Volatile**	**Factory Default** **0004 (1s interval)**
SW release	R200

S18 – Functionality For Timer/Counter 0

Description	Parameters
Defines the functionality for Timer/Counter 0 events.	**XXXX**
Operations **R/W LOCAL** **R/W REMOTE**	If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.
Becomes effective **Instantly**	
Storage **Non-Volatile**	**Factory Default** **0011 (end devices poll parent)**
SW release	R200

S19 –Timer/Counter 1

Description	Parameters
A multi purpose Timer/Counter which functionality is defined by S1A	**XXXX**
	A 16-bit hexadecimal number representing a threshold for either a timer or counter event to be triggered. When reading this register the threshold rather than the actual timer/counter value is displayed.
Operations **R/W LOCAL** **R/W REMOTE**	
	If set to 0 the corresponding functionality is disabled.
Becomes effective **Instantly**	
Storage **Non-Volatile**	**Factory Default** **00F0 (1 min interval)**
SW release	R200

S1A – Functionality For Timer/Counter 1

Description	Parameters
Defines the functionality for Timer/Counter 1 events.	**XXXX**
Operations **R/W LOCAL** **R/W REMOTE**	If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.
Becomes effective **Instantly**	
Storage **Non-Volatile**	Factory Default **0013 (sink advertisement)**
SW release	R200

S1B –Timer/Counter 2

Description	Parameters
A multi purpose Timer/Counter which functionality is defined by S1C	**XXXX**
Operations **R/W LOCAL** **R/W REMOTE**	A 16-bit hexadecimal number representing a threshold for either a timer or counter event to be triggered. When reading this register the threshold rather than the actual timer/counter value is displayed.
Becomes effective **Instantly**	If set to 0 the corresponding functionality is disabled.
Storage **Non-Volatile**	Factory Default **00F4 (1 min 1s interval)**
SW release	Changed in R208

S1C – Functionality For Timer/Counter 2

Description	Parameters
Defines the functionality for Timer/Counter 2 events.	**XXXX**
Operations **R/W LOCAL** **R/W REMOTE**	If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.
Becomes effective **Instantly**	
Storage **Non-Volatile**	Factory Default **0014 (leave network if I am alone)**
SW release	R200

S1D –Timer/Counter 3

Description A multi purpose Timer/Counter which functionality is defined by S1E	Parameters **XXXX** A 16-bit hexadecimal number representing a threshold for either a timer or counter event to be triggered. When reading this register the threshold rather than the actual timer/counter value is displayed. If set to 0 the corresponding functionality is disabled.
Operations **R/W LOCAL** **R/W REMOTE**	
Becomes effective **Instantly**	
Storage **Non-Volatile**	Factory Default **00F0 (1min interval)**
SW release	R200

S1E – Functionality For Timer/Counter 3

Description Defines the functionality for Timer/Counter 3 events.	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.
Operations **R/W LOCAL** **R/W REMOTE**	
Becomes effective **Instantly**	
Storage **Non-Volatile**	Factory Default **0016 (if not part of a network do AT+JN)**
SW release	R200

S1F –Timer/Counter 4

Description A multi purpose Timer/Counter which functionality is defined by S20	Parameters **XXXX** A 16-bit hexadecimal number representing a threshold for either a timer or counter event to be triggered. When reading this register the threshold rather than the actual timer/counter value is displayed. If set to 0 the corresponding functionality is disabled.
Operations **R/W LOCAL** **R/W REMOTE**	
Becomes effective **Instantly**	
Storage **Non-Volatile**	Factory Default **0000**
SW release	R200

S20 – Functionality For Timer/Counter 4

Description	Parameters
Defines the functionality for Timer/Counter 4 events.	**XXXX**
Operations **R/W LOCAL** **R/W REMOTE**	If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.
Becomes effective **Instantly**	
Storage **Non-Volatile**	Factory Default **0000**
SW release	R200

S21 –Timer/Counter 5

Description	Parameters
A multi purpose Timer/Counter which functionality is defined by S22	**XXXX**
Operations **R/W LOCAL** **R/W REMOTE**	A 16-bit hexadecimal number representing a threshold for either a timer or counter event to be triggered. When reading this register the threshold rather than the actual timer/counter value is displayed.
Becomes effective **Instantly**	If set to 0 the corresponding functionality is disabled.
Storage **Non-Volatile**	Factory Default **0000**
SW release	R200

S22 – Functionality For Timer/Counter 5

Description	Parameters
Defines the functionality for Timer/Counter 5 events.	**XXXX**
Operations **R/W LOCAL** **R/W REMOTE**	If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.
Becomes effective **Instantly**	
Storage **Non-Volatile**	Factory Default **0000**
SW release	R200

S23 –Timer/Counter 6

Description	Parameters
A multi purpose Timer/Counter which functionality is defined by S24	**XXXX** A 16-bit hexadecimal number representing a threshold for either a timer or counter event to be triggered. When reading this register the threshold rather than the actual timer/counter value is displayed. If set to 0 the corresponding functionality is disabled.
Operations **R/W LOCAL** **R/W REMOTE**	
Becomes effective **Instantly**	
Storage **Non-Volatile**	Factory Default **0000**
SW release	R200

S24 –Functionality For Timer/Counter 6

Description	Parameters
Defines the functionality for Timer/Counter 6 events.	**XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.
Operations **R/W LOCAL** **R/W REMOTE**	
Becomes effective **Instantly**	
Storage **Volatile**	Factory Default **0000**
SW release	R200

S25 – Initial Functionality For Timer/Counter 6

Description	Parameters
Defines the setting of S24 after power up or reset.	**XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.
Operations **R/W LOCAL** **R/W REMOTE**	
Becomes effective **After hard or soft reset**	
Storage **Non-Volatile**	Factory Default **0000**
SW release	R200

S26 –Timer/Counter 7

Description A multi purpose Timer/Counter which functionality is defined by S27	Parameters **XXXX** A 16-bit hexadecimal number representing a threshold for either a timer or counter event to be triggered. When reading this register the threshold rather than the actual timer/counter value is displayed. If set to 0 the corresponding functionality is disabled.
Operations **R/W LOCAL** **R/W REMOTE**	
Becomes effective **Instantly**	
Storage **Non-Volatile**	Factory Default **0000**
SW release	R200

S27 – Functionality For Timer/Counter 7

Description Defines the functionality for Timer/Counter 7 events.	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.
Operations **R/W LOCAL** **R/W REMOTE**	
Becomes effective **Instantly**	
Storage **Volatile**	Factory Default **0000**
SW release	R200

S28 – Initial Functionality For Timer/Counter 7

Description Defines the setting of S27 after power up or reset.	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.
Operations **R/W LOCAL** **R/W REMOTE**	
Becomes effective **After hard or soft reset**	
Storage **Non-Volatile**	Factory Default **0000**
SW release	R200

S29 – Power Mode

Description The current power mode of the module	Parameters **nn**
Operations **R/W LOCAL** **R/W REMOTE**	Range **00 – 03** The modules power level as described in section 6.
Becomes effective **Instantly**	
Storage **Volatile**	Factory Default **Defined in S2A**
SW release	R200

S2A – Initial Power Mode

Description The module's power mode after start-up and reset.	Parameters **nn**
Operations **R/W LOCAL** **R/W REMOTE**	Range **00 – 03** The modules power level as described in section 6.
Becomes effective **After hard or soft reset**	
Storage **Non-Volatile**	Factory Default **00**
SW release	R200

S2B – Start-up Functionality Plaintext A

Description	Parameters
Contains Text which is used by some of the actions described in section 5.	**Up to 50 characters**
Operations **R/W LOCAL** **R/W REMOTE**	
Becomes effective **Instantly**	
Storage **Non-Volatile**	**Factory Default** **<none>**
SW release	R208 – removed default setting

S2C – Start-up Functionality Plaintext B

Description	Parameters
Contains Text which is used by some of the actions described in section 5.	**Up to 50 characters**
Operations **R/W LOCAL** **R/W REMOTE**	
Becomes effective **Instantly**	
Storage **Non-Volatile**	**Factory Default** **<none>**
SW release	R208 – removed default setting

S2D – Parent's EUI64

Description	Parameters
Contains the local unit's parent EUI64 in case the unit is a SED or MED	**<n/a>** if the device isn't a SED or MED, or **<EUI64>**
Operations **R LOCAL** **R REMOTE**	
Storage **Stack Parameter**	
SW release	R200

4.6 Device Specific S-Registers

S2E – Device Specific

Description	Parameters
Defines the behaviour of the specific device. Functionality differs between ETRX1 and ETRX2.	**XXXX** Where XXXX represents a 16-bit hexadecimal number.

Operations
R/W LOCAL
R/W REMOTE

Becomes effective
Instantly

Note
Default settings are underlined

Parameters (ETRX1):

ETRX1:

Bit F (MSB): Set: Behaviour of I/O3 is defined by S2F. Unset: Standard I/O pin.
Bit E: Set: A/D readings from S12 and S13 represent the 10-bit reading rather than the voltage
Bit D: Set: Pull-ups enabled globally
Bit C – Bit 5: Reserved
Bit 4: Set: Enable debouncing on IRQ pins(100ms)
Bit 3: Set: IRQ1 on rising edge
Bit 2: Set: IRQ1 on falling edge
Bit 1: Set: IRQ0 on rising edge
Bit 0: Set: IRQ0 on falling edge

ETRX2:

Bit F (MSB): Set: I/O3 is PWM as defined by S2F/S31. Unset: Standard I/O pin.
Bit E – Bit D: Reserved
Bit C: Set: Transmitter adds PAN ID to raw data packets. Receiver ignores packets with wrong ID
Unset: PAN ID not used with raw data, devices in all PANs on the same radio channel receive data
Bit B – Bit 9: Reserved
Bit 8: Set: Enable Boost mode regardless of setting in S02
Bit 7: Set: I/O8 turns into A/D3, which can be read from S14
Bit 6: Set: Present A/D-Reference at I/O0 during measurement
Bit 5: Set: Enable wakeup on UART activity
Bit 4: Set: Enable debouncing on IRQ pins(100ms)
Bit 3: Set: IRQ1 on rising edge
Bit 2: <u>Set</u>: IRQ1 on falling edge
Bit 1: Set: IRQ0 on rising edge
Bit 0: <u>Set</u>: IRQ0 on falling edge

Storage
Non-Volatile

Factory Default
0005

SW release	Last modified in R209

S2F – Operation of the special function pin 1

Description	Parameters
The mode of operation for the special function pin	**XXXX**
	Range
Operations	**0000 to FFFF**
R/W LOCAL	
R/W REMOTE	**ETRX1**
Operations	If the special function pin is enabled by setting bit 15 of S2E, the first byte of S2F is written to the OCR2 register of the Atmega128 and the second byte of S2F is written to the TCCR2 register of the Atmel AtMega 128L. This allows I/O3 to output a PWM or constant carrier signal. For more information see the Atmega128 datasheet.
Instantly	
	ETRX2
Storage	
Volatile	This register represents the top value of the 16-bit counter counting from 0 to top repeatedly incrementing at 12MHz. When reaching top I/O3 is set, given the PWM is enabled in S2E.
	Factory Default
	Defined in S30
Examples	
See User Guide	
SW release	R200

S30 – Initial value of S2F

Description	Parameters
The initial setting of S2F stored in non volatile memory	**XXXX**
Operations	Where XXXX represents the initial value of S2F which is loaded after boot-up, soft or hard reset.
R/W LOCAL	
R/W REMOTE	
Becomes effective	
After Soft or Hard Reset	
	Factory Default
Storage	**ETRX1: 4D1B (800Hz 50% m/s ratio)**
Non-Volatile	**ETRX2: 3A98 (800Hz 50% m/s ratio)**
SW release	R200

S31 – Operation Of The Special function Pin 2 (ETRX2 only – reserved on ETRX1)

Description	Parameters
The mode of operation for the special function pin	**XXXX**
	Range
Operations	**0000 to FFFF**
R/W LOCAL	
R/W REMOTE	**ETRX2**
Operations	If the special function pin is enabled by setting bit 15 of S2E, this register represents the compare value of the 16-bit counter counting from 0 to top repeatedly incrementing at 12MHz. When reaching compare I/O3 is cleared.
Instantly	
Storage	
Volatile	
	Factory Default
	Defined in S32
SW release	R203 (ETRX2 only)

S32 – Initial Value S31 (ETRX2 only – Reserved on ETRX1)

Description	Parameters
The initial setting of S31 stored in non volatile memory	**XXXX**
Operations	Where XXXX represents the initial value of S31 which is loaded after boot-up, soft or hard reset.
R/W LOCAL	
R/W REMOTE	
Becomes effective	
After Soft or Hard Reset	
Storage	Factory Default
Non-Volatile	**1D4C (800Hz 50% m/s ratio)**
SW release	R203 (ETRX2 only)

S33 – Supply Voltage

Description	Parameters
The Supply voltage of the device in mV.	**nnnn**
Operations	Where nnnn represents the supply voltage in mV.
R LOCAL	
R REMOTE	
Becomes effective	
N/A	
Storage	Factory Default
	N/A
Volatile	
SW release	R204 (ETRX2 only)

5 Built in Functionality

The following table gives an overview of the built-in functionality which can be triggered either by the two external interrupts IRQ0 and IRQ1 or by 8 individually programmable timers/counters. If the node is in a low power mode and the action requires the node to wakeup, the node will do so and go back to its original power mode after completion of the action. To get more information on the built-in functionality please refer to the R2xx User Guide document where the built-in functionality is described in detail.

Overview of Actions	
0000	No operation of the corresponding interrupt/timer/counter
0001	Change to power mode 0. In case this was triggered by a timer, the timer will stop.
0002	Change to power mode 1. In case this was triggered by a timer, the timer will stop.
0003	Change to power mode 2. In case this was triggered by a timer, the timer will stop.
0004	Change to power mode 3. In case this was triggered by a timer, the timer will stop.
0005	Change to power mode 0. In case this was triggered by a timer, the timer will restart.
0006	Change to power mode 1. In case this was triggered by a timer, the timer will restart.
0007	Change to power mode 2. In case this was triggered by a timer, the timer will restart.
0008	Change to power mode 3. In case this was triggered by a timer, the timer will restart.
…	Reserved
0010	If I am a Mobile/Sleepy end device Poll Parent for data and stop timer (if applicable)
0011	If I am a Mobile/Sleepy end device Poll Parent for data and restart timer (if applicable)
0012	If I am a Sink advertise and stop timer (if applicable)
0013	If I am a Sink advertise and restart timer (if applicable)
0014	Check for neighbours in local neighbour table. If no neighbours are present for 5 consecutive times leave the PAN. Note: It takes about 80 seconds for a neighbour to age out of the neighbour table.
0015	In case I am not joined to a network scan for and join the next best network and stop the timer (if applicable)
0016	In case I am not joined to a network scan for and join the next best network and restart the timer (if applicable)
0017	Allow joining for 60 Seconds (in case it is disabled in S06) and stop timer (if applicable)
0018	Copy local inputs to remote outputs: Read the local S11 and if changed since the previous time, write the reading to the remote S0F, whose address is given in S2B. If applicable the timer will stop.
0019	Same as 0018, but if applicable the timer will restart.
001A	Copy remote inputs to local outputs: Read the remote unit's S11, whose address is given in S2C and write the reading to the local S0F. If applicable the timer will stop.
001B	Same as 001A, but if applicable the timer will restart.
…	Reserved
002x	Toggle I/Ox and stop timer (if applicable)
003x	Toggle I/Ox and restart timer (if applicable)
004x	Flash I/Ox (pull low) for 250ms and restart timer afterwards
…	Reserved
0100	Sends the reading of the I/O and the two analogue ports to the network's sink and if no sink is known the unit will search for a sink instead. After 3 unsuccessful transmissions the sink is assumed unavailable and a new sink is searched. If applicable the timer will stop.
0101	Sends the reading of the I/O and the two analogue ports to the network's sink and if no sink is known the unit will search for a sink instead. After 3 unsuccessful transmissions the sink is assumed unavailable and a new sink is searched. If applicable the timer will restart.

Overview of Actions (continued)

0102	Same as 0100, but to charge an external RC timer I/O7 is pulled high whilst sending the data and left high impedance the rest of the time.
0103	Same as 0101, but to charge an external RC timer I/O7 is pulled high whilst sending the data and left high impedance the rest of the time.
0108	The unit sends the contents of S2B to the networks sink. If applicable the timer will stop.
0109	The unit sends the contents of S2B to the networks sink. If applicable the timer will restart.
010A	The unit sends the contents of S2C to the networks sink. If applicable the timer will stop.
010B	The unit sends the contents of S2C to the networks sink. If applicable the timer will restart.
…	Reserved
0110	Sends the reading of the I/O and the two analogue ports as well as an 8-bit transmission counter which increments with every transmission to the network's sink and if no sink is known the unit will search for a sink instead. After 3 unsuccessful transmissions the sink is assumed unavailable and a new sink is searched. If applicable the timer will stop.
0111	Sends the reading of the I/O and the two analogue ports as well as an 8-bit transmission counter which increments with every transmission to the network's sink and if no sink is known the unit will search for a sink instead. After 3 unsuccessful transmissions the sink is assumed unavailable and a new sink is searched. If applicable the timer will restart.
0112	Same as 0110, but to charge an external RC timer I/O7 is pulled high whilst sending the data and left high impedance the rest of the time.
0113	Same as 0111, but to charge an external RC timer I/O7 is pulled high whilst sending the data and left high impedance the rest of the time.
0120	Sends the contents of S2B as a RAW transmission. If applicable the timer will stop.
0121	Same as 0120, but if applicable the timer will restart.
0122	Sends the contents of S2C as a RAW transmission. If applicable the timer will stop.
0123	Same as 0122, but if applicable the timer will restart.
…	Reserved
0200	Show status on I/O10. LED on (pin driven low) = no connection. Blinking fast = Auto-searching for PAN. Blinking slow = connected to PAN. The accompanying counter register defines the update interval. Note: I/O10 must be defined to be an output in S0D/S0E.
0201	Show AT Command line's error status on I/O11. LED off no error. LED blinking = error. Reset by 'OK' prompt. The accompanying counter register defines the update interval. Note: I/O11 must be defined to be an output in S0D/S0E.
…	Reserved
2000	When triggered the number of times listed in the accompanying counter a message is sent to the sink containing a transmission counter and the reading of the analogue and digital inputs. Note: Can only be triggered by setting S15 or S16 to 400x.
2001	When enabling this action the command line is disabled and as soon as a number of bytes in excess of the number N specified in the accompanying timer/counter register is received on the serial port, a SCAST containing these characters is sent to the network's sink. If no sink is known a sink is searched instead. After 3 unsuccessful transmissions the sink is assume unavailable and a new sink is searched. **Notes:** This event is triggered by receiving a character on the serial port. N ≤ 64.
…	Reserved
3000	The contents of S2B is sent to the local command line[2] followed by carriage return. If applicable the timer will stop. Note: No AT-Prefix required!
3001	The contents of S2B is sent to the local command line[1] followed by carriage return. If applicable the timer will restart. Note: No AT-Prefix required!
3002	The contents of S2C is sent to the local command line[1] followed by carriage return. If applicable the timer will stop. Note: No AT-Prefix required!

---

[2] All commands being entered at the instance this action is triggered are interrupted and overwritten.

Overview of Actions (continued)	
3003	The contents of S2C is sent to the local command line[1] followed by carriage return. If applicable the timer will restart. Note: No AT-Prefix required!
…	Reserved
400x	Start timer x. If applicable the timer will stop.
401x	Start timer x. If applicable the timer will restart.
402x	Toggle timer x. If applicable the timer will stop.
403x	Toggle timer x. If applicable the timer will restart.
404x	Stop timer x. If applicable the timer will stop.
405x	Stop timer x. If applicable the timer will restart.
…	Reserved
8xxx	Change I/O port to the LSBs and if applicable the timer will stop.
9xxx	Change I/O port to the LSBs and if applicable the timer will restart.
Axxx	Change data direction of the I/O port to the LSBs and if applicable the timer will stop.
Bxxx	Change data direction of the I/O port to the LSBs and if applicable the timer will restart.
…	Reserved

6 Power Consumption

As the module's power consumption is firmware dependent, the values in the following tables supersede any of the numbers given in previous revisions of the AT command dictionary. Table 7 gives the hardware dependent theoretical figures for the ETRX1 as stated in the current hardware manual, whereas table 8 shows the firmware dependent average power consumption of an ETRX1 measured with light to medium network traffic.

Table 9 and 10 represent those figures for the ETRX2 respectively.

6.1 ETRX1 Power Consumption

Typical values at 3.3V 25°C.

Parameter	Min.	Typ.	Max.	Units	Condition
Supply Current		30		mA	TX –1dBm
		22		mA	TX –10dBm
		19		mA	TX –20dBm
		18		mA	TX –30dBm
		29		mA	RX
		20		µA	Asleep, Timers on
		15		µA	Asleep, Timers off

Table 7: **Power Consumption**

Mode	Router,COO				MED,SED			
	MCU	Radio	Timers	I	MCU	Radio	Timers	I
0	Awake	Awake	User defined	29mA	Awake	Asleep	User defined	11mA
1	Idle	Awake	User defined	23mA	Idle	Asleep	User defined	6mA
2	Awake	Awake	User defined	1 mA[3]	Asleep	Asleep	User defined	1 mA[1]
3	Asleep	Asleep	off	15µA	Asleep	Asleep	Off	15µA

Table 8: **Averaged power consumption during operation**

Notes:
- Sleep modes 1-3 should not be used on a router or coordinator, however it was found that mode 1 may work on a router with light to medium network traffic. Successful operation of a router in mode 1 cannot be guaranteed and needs to be evaluated carefully for each target application in case the additional energy saving is vital.
- Wakeup from mode 3 is only possible by external interrupt or reset. Make sure never to set the initial power mode (S2A) to mode 03 unless you want the device to always wake up into this mode.
- Modules in power mode 2 and 3 will not respond to commands on the command line, so always make sure you have defined means to wake it up from these modes.
- If no means of waking up from any of the power down modes has been defined and the module appears unresponsive the Telegesis factory default resetter can be used to reset the modules factory defaults via the serial port.

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[3] Assuming the unit polls every second. If no polling and other timed actions are performed the power consumption can be as little as 20µA in this mode.

6.2 ETRX2 Power Consumption

Typical values at 3.3V 25°C.

Parameter	Min.	Typ.	Max.	Units	Condition
Supply Current		36		mA	TX 4dBm
		32		mA	TX –1dBm
		29		mA	TX –10dBm
		28		mA	TX –20dBm
		37		mA	RX
		1.5		µA	Asleep, Timers on
		0.7		µA	Asleep, Timers off

Table 9: **Power Consumption**

Mode	Router, COO				MED,SED			
	MCU	Radio	Timers	I	MCU	Radio	Timers	I
0	Awake	Awake	User defined	36mA	Awake	Asleep	User defined	9mA
1	Idle	Awake	User defined	32mA	Idle	Asleep	User defined	4.5mA
2	Awake	Awake	User defined	0.7mA[4]	Asleep	Asleep	User defined	0.7mA[1]
3	Asleep	Asleep	off	0.7µA	Asleep	Asleep	Off	0.7µA

Table 10: **Averaged power consumption during operation**

Notes:
- Sleep modes 1-3 should not be used on a router or coordinator, however it was found that mode 1 may work on a router with light to medium network traffic. Successful operation of a router in mode 1 cannot be guaranteed and needs to be evaluated carefully for each target application in case the additional energy saving is vital.
- Wakeup from mode 3 is only possible by external interrupt or reset. Make sure never to set the initial power mode (S2A) to mode 03 unless you want the device to always wake up into this mode.
- Modules in power mode 2 and 3 will not respond to commands on the command line, so always make sure you have defined means to wake it up from these modes.
- If no means of waking up from any of the power down modes has been defined and the module appears unresponsive the Telegesis factory default resetter can be used to reset the modules factory defaults via the serial port.
- In order to achieve ultra low power consumption of sub 1µA it is required to either define all I/Os to be outputs, or to pull all inputs to a defined level as floating input pins will increase the current consumption. Furthermore as described in the hardware manual a pull down of 10kΩ must be attached to the SIF_MOSI pin for lowest possible power consumption.

For more details please refer to the separate application note regarding power consumption, which can be found on www.telegesis.com.

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[4] Assuming the unit polls every second. If no polling and other timed actions are performed the power consumption can be as little as 1.5µA in this mode.

7 Notes on Backwards Compatibility With ETRX1

EmberZNet2.x (R2xx) is not over-the-air compatible to EmberNet3.3 (R1xx), so OTA bootloading the firmware from a device running EmberZNet2.x to a device running EmberNet3.3 or vice versa is not possible.

In order to over-the-air upgrade devices running R1xx to R2xx you must use the pass-through bootloader (available from R112 onwards) on an R1xx device as described in the Development Kit manual.

When upgrading an ETRX1 module from R1xx to R2xx you must ensure that the Ember bootloader on the target node has version number 1004 or higher. In order to find out the revision number of the local bootloader simply enter the bootloader using the **AT+BLOAD** command. After pressing 'enter', the first line of the bootloader menu will show the revision number of the bootloader which will be either 1001, 1004 or 1005. If the revision number is 1001 please contact Telegesis about upgrading the bootloader.

Note: For cloning a local nodes firmware to a remote node, the local nodes bootloader revision must be 1005 or higher.

The new firmware will detect R1xx EEPROM entries and translate them to R2xx ones. Downgrading from R2xx to R1xx currently is not possible as there are no provisions to downgrade the EEPROM entries. If you require to downgrade from R2xx to R1xx please contact zigbeesupport@telegesis.com for instructions.

8 Notes on Energy Levels and LQI

8.1 Interpreting LQI on the ETRX2

On the EM250, which contains the radio for the ETRX2 module, the LQI is closely related to the SNR (signal noise ratio). The graph below shows the relation between the SNR and the LQI reading.
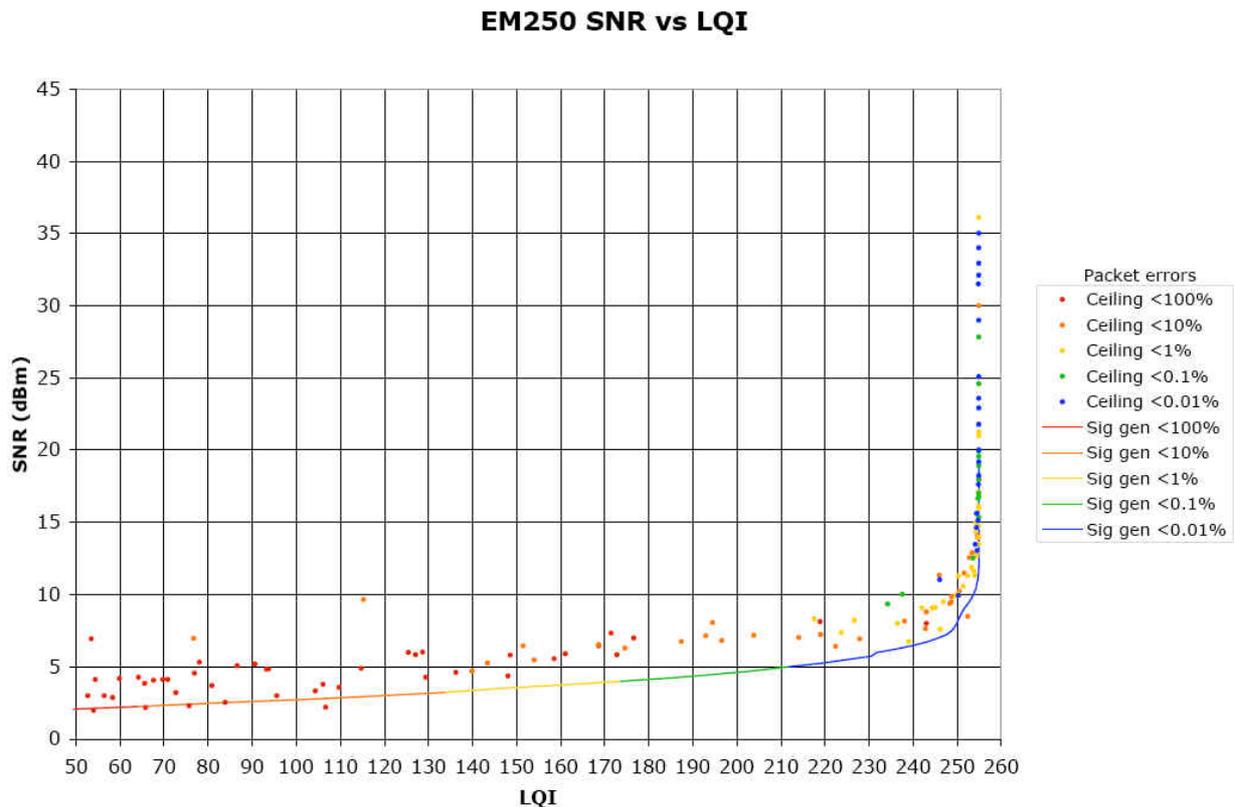
Figure 1: **LQI vs. SNR (source : Ember)**

With EmberZNet2.5 (R208 onwards) the maximum (best) LQI reading has been increased from 0xF0 (EmberZNet2.3 - R207) to 0xFF.

From the LQI the stack calculates the cost for a particular link based on the following table:

Cost	LQI
1	254 - 255
3	247 - 253
5	200 - 246
7	0 - 199

Table 11: **LQI/Cost relationship**

8.2 Interpreting LQI on the ETRX1

On the EM2420, which is the radio on the ETRX1 module, the LQI is based on the link correlator error output, so effectively on the PER.

The hexadecimal reading of the LQI can be interpreted as follows: Numbers 0 to 80 correspond linearly to 0 to 80%. Then between 80 and 255, it is still linear but from 81 to 255 corresponds to the values 80.x to 100%.

With EmberZNet2.5 (R208 onwards) the maximum (best) LQI reading has been increased from 0xF0 (EmberZNet2.3 - R207) to 0xFF.

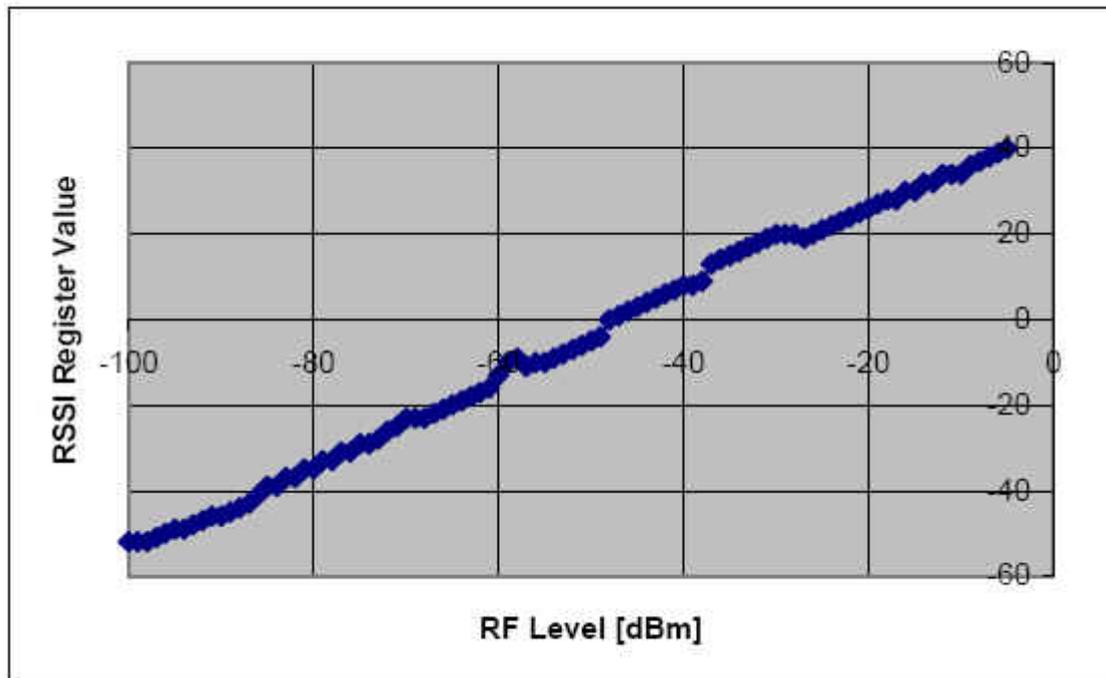From the LQI the stack calculates the cost for a particular link based on the following table:

Cost	LQI
1	248 - 255
3	238 - 247
5	200 - 237
7	0 - 199

Table 12: LQI/Cost relationship

8.3 Interpreting RSSI Energy Levels on the ETRX1

The readings from **AT+ESCAN** on the ETRX1 represent the hexadecimal readings from the EM2420's RSSI register, offset by +127 to make it a positive number.

Figure 2: **RSSI Register Value (source: EM2420 datasheet)**

The actual RF-level in dBm for each RSSI register value can be obtained from Figure 2.

8.4 Interpreting RSSI Energy Levels on the ETRX2

On the ETRX2 the readings from AT+ESCAN represent the hexadecimal readings from the EM250's RSSI register, offset by +127 to make it a positive number.

Since the actual radio hardware differs from the ETRX1 the readings will differ from the ones observed on the ETRX2.

The EM250 calculates the RSSI over an 8-symbol period as well as at the end of a received packet. It utilizes the RX gain settings and the output level of the ADC within its algorithm. The linear range of RSSI is specified to be 40dB over all temperatures. At room temperature, the linear range is approximately 60dB (-90 dBm to -30dBm).

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12 References

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