TG-ETRX-R301-AT-Commands

ETRX2 ZigBee® Modules

AT-Command Dictionary

Current Firmware R301

Telegesis

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1 Introduction

This document describes the AT-Command interface firmware of the ETRX2, ZigBee PRO wireless meshing modules.

The Telegesis ETRX2 modules have been designed to be built into any device and provide a low cost, low power ZigBee solution based on the industry leading EmberZNet ZigBee 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 ETRX2 offers fast integration opportunities and the shortest possible time to market for your product.

Important note

Using the AT-Command interface described in this document can shorten the time to market significantly, however customers using the ETRX2 range of Telegesis modules also have the option of using Ember's EZSP over UART interface or of developing custom firmware using the Ember Development tools.

1.1 Document Overview

This document is meant as an AT-Command and S-Register reference for R3xx revisions of the firmware based on EmberZNet3.x. In order to learn how your products can profit from wireless mesh networking please also refer to the following documents:

- ETRX2 Product Manual
- R3xx Firmware User Guide
- Migration guide for existing R2xx firmware customers
- ETRX2 Development Kit User Guide
- Application notes from www.telegesis.com

The ETRX2 Product Manual concentrates on the hardware specification of the modules. The Development Kit User Guide contains all of the information required to set up your development kit and run firmware upgrades where necessary.

1.2 A Note on ZigBee® Compliance

The Telegesis R300 firmware has been tested and certified for MSP (manufacturer specific profile) compliance by a test house appointed by the ZigBee Alliance.

This certification includes tests guaranteeing that:

- Modules running the Telegesis AT-Command set won't interfere with existing ZigBee Networks in a malicious way
- Modules running the Telegesis AT-Command set can join a 3rd party ZigBee PRO network and use its routing capabilities
- Modules running the Telegesis AT-Command set can allow 3rd party nodes to join into a network consisting of Telegesis nodes and use its routing capabilities

In addition to implementing a manufacturer specific application profile the AT-Command set allows for a certain level of transparency allowing to communicate with 3rd party nodes running any public application profile.

If you want to use the term ZigBee or the ZigBee Logo in your product documentation the current regulations state that you have to

i) Be at least an adopting member of the ZigBee Alliance in the year you release your product
ii) Re-certify for MSP compliance with an approved testhouse

If you intend to get your product re-certified feel free to contact Telegesis for additional information. Also if you intend to build a product compliant to a public application profile (e.g. Home Automation, Smart Energy) feel free to contact us to discuss your options.

1.3 Important notes

1.3.1 Hardware compatibility

R3xx firmware will not run on the STRX2 module.

1.3.2 Unexpected start-up in bootloader mode

The bootloader which runs on the ETRX2 can be triggered using the command AT+BLOAD as described in Section 3, 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.

1.3.3 Compatibility with other devices

The R3xx Telegesis AT-Command line Interpreter is a Manufacturer Specific Profile using the ZigBee PRO feature set of ZigBee 2007. Interoperability with other devices that use the ZigBee PRO feature set is extremely limited at the moment, and R3xx is not compatible with earlier version of ZigBee, including Telegesis R2xx firmware.

2 AT Style Command Conventions

To simplify the communication with the ETRX2 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><CR><LF> and/or a prompt <CR><LF><Prompt><CR><LF> where the prompt could also be an error message.

Example:

ATS00?<CR>
<CR><LF>FFFF<CR><LF>
<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 S0E or S0F prompts may appear whenever the corresponding event occurs.

Example:

<CR><LF><BCAST:000D6F000005A666,04=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 ETRX2 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 serial link mode XON/XOFF handshaking is used. Optional hardware handshaking can be enabled as described in the register description of S12 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.
Execute Command **ATXXX**	This command executes routines of the module and returns parameters

Table 1: Types of AT commands

When bit 7 of S12 is set any reply or prompt is additionally started with the STX and ended with the ETX character to aid the interpretation of the incoming strings on a host processor.

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
XXXX	16-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
<PID>	16-bit hexadecimal PAN ID (0000 to FFFF)
<EPID>	64-bit hexadecimal extended PAN ID
<channel>	decimal channel (802.15.4 channel 11-26)
<password>	8 character password
<EUI64>	64-bit IEEE 802.15.4 address in hexadecimal

Table 2: Different formats of parameters

2.2 Prompt Overview

The following prompts can show up during the operation of the ETRX2 modules. Most of the prompts can be disabled using register S0E and S0F.

Prompt Overview	
ACK:XX	Acknowledgement for message no XX was received
NACK:XX	Acknowledgement for message no XX was not received
SR:XX,<EUI>,<NodeID>,…	Source Record received
BCAST:[<EUI64>,]XX=<text>	A Broadcast with XX characters has been received
MCAST:[<EUI64>,]XX=<text>	A Multicast with XX characters has been received
UCAST:[<EUI64>,]XX=<text>	A Unicast with XX characters has been received
SDATA:[<EUI64>,],<ioread>,<A/D1>,<A/D2>, <sequence number>,<Vcc>	A data message has been received at the sink
COO:<EUI64>,<NodeID>	A coordinator identifying itself
FFD:<EUI64>,<NodeID>	A router identifying itself
SED:<EUI64>,<NodeID>	A sleepy end device identifying itself
MED:<EUI64>,<NodeID>	A mobile sleepy end device identifying itself
OK	OK terminator
ERROR:XX	Error number XX occurred
NEWNODE: <NodeID>,<EUI64>, <Parent NodeID>	Shown on Coordinator: New node has joined the PAN
LeftPAN	Local Node has left the PAN
JPAN:<channel>,<PID>,<EPID>	Local Node has joined PAN with given parameters
ADSK:<EUI64>,<NodeID>	Received Sink Advertisement

Table 3: Prompt Overview

2.3 Device Overview

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

Device Types		ZigBee Naming Convention
COO	Coordinator	ZigBee Coordinator (ZC)
FFD	Router	ZigBee Router (ZR)
SED	Sleepy End Device	ZigBee End Device (ZED)
MED	Mobile Sleepy end Device	

Table 4: Device Overview

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 Defaults**
AT+BLOAD	**Enter The Bootloader Menu**
AT+CLONE	**Clone Local Node To Remote Node**
AT+RECOVER	**Recover From A Failed Clone Attempt**
ATS	**S-Register Access**
ATREMS	**Remote S-Register Access**
ATSALL	**Remote S-Register Access**
AT+TOKDUMP	**Display All S-Registers**
AT+ESCAN	**Scan The Energy Of All Channels**
AT+PANSCAN	**Scan For Active Pans**
AT+EN	**Establish Personal Area Network**
AT+JN	**Join Network**
AT+JPAN	**Join Specific Pan**
AT+DASSL	**Disassociate Local Device From Pan**
AT+DASSR	**Disassociate Remote Node From PAN**
AT+N	**Display Network Information**
AT+SN	**Scan Network**
AT+NTABLE	**Display Neighbour Table**
AT+ATABLE	**Display Address Table**
AT+ASET	**Set Address Table Entry**
AT+MTABLE	**Display Multicast Table**
AT+MSET	**Set Multicast Table Entry**
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**

Command Overview (continued)	
AT+MCAST	Transmit A Multicast
AT+MCASTB	Transmit A Multicast Of Binary Data
AT+FNDSR	Find The Source Route To A Remote Device
AT+SR	Set Source Route To Remote Device
AT+POLL	Poll For Data From Parent
AT+REJOIN	Rejoin The Network
AT+IDENT	Play A Tune On Remote Devboard
AT+RDATAB	Send Binary Raw Data

Table 5: Command Overview

2.4.1 Module Control & Configuration Commands

I – Display Product Identification Information	
Execute Command **ATI** Note On modules manufactured before summer 2007 an invalid <DeviceName> is displayed. This does not affect the functionality of the module.	Response **Telegesis <DeviceName>** **R<Firmware Revision>** **<EUI64>** **OK** Where <DeviceName> is the order code of the device, <Firmware Revision> is the firmware revision and <EUI64> is the Device's IEEE 802.15.4 identifier
SW release	R300

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	R300

&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 and the node leaves the network it is currently joined to.
SW release	R300

+BLOAD – Enter The Bootloader Menu	
Execute Command **AT+BLOAD**	Response **<entering bootloader>** The device leaves the AT command line and enters the bootloader menu for downloading new firmware. A description of the bootloading process can be found in the Development Kit Product Manual. Please note that the bootloader will run at a baudrate of 115k2, no parity, 8 data bits regardless of the current serial port settings.
SW release	R300

+CLONE – Clone Local Node To Remote Node	
Execute Command **AT+CLONE:<EUI64>,<password>** Use on: All devices Note The default password for R3xx nodes is "password".	Response **Cloning…** or **ERROR<errorcode>** Where <errorcode> represents the error code explained in section 3. This command clones the firmware of the local node to a remote node within the same PAN, which address is given by <EUI64>. <password> represents the remote node's 8-character password. After completion a soft reset is caused on the remote end.
SW release	R300

+RECOVER – Recover From A Failed Clone Attempt	
Execute Command **AT+RECOVER** Use on: All devices. PAN must use channel 13. Note Use this command in cases where the cloning operation was interrupted and the remote device therefore remains in the bootloader. For more information on over-the-air firmware upgrading please refer to the Development Kit Manual.	Response **Recovering…** or **ERROR<errorcode>** 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.
SW release	R300

S – S-Register Access	
Read Command **ATSXX[x]?**	Response **<data>** **OK** or **ERROR:<errorcode>** The module displays the contents of S-register xx 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 **ATSXX[x]=<data>** Notes Some S-Registers require a password for write access. See S-Register description for details. **The default password for R3xx is "password".** 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 XX and if applicable stored in non-volatile memory. 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	R300

REMS – Remote S-Register Access	
Read Command **ATREMS:<address>,XX[X]?** Where <address> can be the remote node's EUI64, NodeID or address table index	Response **<data>** **OK** or **ERROR:<errorcode>** The module displays the contents of the remote S-register XX 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 **ATREMS:<address>,XX[X]=<data>** Notes Some S-Registers require a password for write access. See S-Register description for details. **The default password for R3xx is "password".** 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 the remote S-register number XX and if applicable stored in non-volatile memory. 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	R300

SALL – Remote S-Register Access	
Write Command **ATSALL:<group ID>,XX[X]=<data>** Where group IDs are remote node's multicast IDs or FFFF - Broadcast to all devices FFFE - Broadcast to all non-sleepy devices Notes Some S-Registers require a password for write access. See S-Register description for details. **The default password for R3xx is "password".** 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 the remote S-register number XX on all nodes addressed by the multicast group ID. 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	R300

TOKDUMP – Display All S-Registers	
Execute Command **AT+TOKDUMP** Notes Only used on the local node. You cannot display all the registers of a remote device.	Response **<data>** **OK** The module displays the contents of all local S-Registers. The data format for each individual S Register is given in the S-Register description in section 4.
SW release	R300

2.4.2 Network Control & Configuration Commands

+ESCAN – Scan The Energy Of All Channels	
Execute Command **AT+ESCAN** Use on: All nodes Note Scanning all channels can take up to 16 seconds.	Response **+ESCAN:** **11:XX** **12:XX** **…** **26:XX** **OK** or **ERROR:<errorcode>** <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	R300

+PANSCAN – Scan For Active PANs	
Execute Command **AT+PANSCAN** Use on: All nodes Note Scanning for active PANs can take up to 16 seconds.	Response **+PANSCAN:<channel>,<PID>,<EPID>,XX,b** **OK** or **ERROR:<errorcode>** <errorcode> represents the error code explained in section 3. The node gives a list of all PANs found. <channel> represents the channel, <PID> the PAN ID, <EPID> the extended PAN ID, XX the ZigBee stack profile (00 = Custom, 01 = ZigBee, 02 = ZigBee PRO) and b indicates whether the network is allowing additional nodes to join (1 = joining permitted). The node does not join any of the PANs found.
SW release	R300

+EN – Establish Personal Area Network	
Execute Command **AT+EN** Use on: All nodes which are not part of a PAN Note When issuing this command the local device becomes a Coordinator (and Trust Centre). 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.	Response **JPAN:<channel>,<PID>,<EPID>** **OK** or **ERROR:<errorcode>** <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 and extended PAN ID on the quietest channel. If a PAN ID and/or extended PAN ID is specified in S02 or S03 the provided IDs are used instead of random ones, given the selected IDs are not already in use by other networks within range
SW release	R300

+JN – Join Network	
Execute Command **AT+JN** 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.	Response **JPAN:<channel>,<PID>,<EPID>** **OK** or **ERROR:<errorcode>** <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 any PAN which allows joining it will automatically join in via the remote node with the highest RSSI. In case registers S02 and S03 differ from the default value of all zeros the node will only join a PAN with the specified Pan ID and/or extended PAN ID.
Remote Action On the Trust Centre / Coordinator	Prompt **NEWNODE:<node EUI64>,<NodeID>,<parent EUI64>**
SW release	R300

+JPAN – Join Specific PAN	
Execute Command **AT+JPAN:<channel>,<PID or EPID>** Examples **AT+JPAN:20,1234** **AT+JPAN:24,0793E14FFB220A38** Use on All nodes which are not part of a PAN Notes This command can only be executed if the local node is not part of a PAN already. The JPAN command overrides the channel mask in register S00 and the PID and EPID in S02 and S03.	Response **JPAN:<channel>,<PID>,<EPID>** **OK** or **ERROR:<errorcode>** <errorcode> represents the error code explained in section 3. The local node joins a particular PAN on <CHANNEL> with the specified <PID> or <EPID> via the remote node with the highest RSSI.
Remote Action On the Trust Centre / Coordinator	Prompt **NEWNODE:<node EUI64>,<NodeID>,<parent EUI64>**
SW release	R300

+DASSL – Disassociate Local Device From PAN	
Execute Command **AT+DASSL** Use on All Devices Note Use with care on a Coordinator. It will not be able to rejoin the PAN	Response **OK** or **ERROR<errorcode>** Prompt **LeftPAN** <errorcode> represents the error code explained in section 3. Instruct local device to leave the PAN.
SW release	R300

+DASSR – Disassociate Remote Node from PAN	**(ZDO)**
Execute Command **AT+DASSR:<address>** Where <address> can be a node's EUI64, NodeID or address table index Use on All Devices Note Use with care on a Coordinator. It will not be able to rejoin the PAN	Response **SEQ:XX** **OK** or **ERROR:<errorcode>** <errorcode> represents the error code explained in section 3. Instruct device to leave the PAN.
Remote Action	Prompt **LeftPAN**
SW release	R300

+N – Display Network Information	
Read Command **AT+N?** Use on All Devices	Response **+N=<devicetype>=<channel>,<power>,<PID>,<EPID>** or +N=**NoPAN** followed by **OK** <devicetype> represents the node's functionality in the PAN (FFD,COO,SED,MED), <power> the node's output power in dBm, <channel> the IEEE 802.15.4 radio channel (11-26), <PID> the node's PAN ID and <EPID> the node's extended PAN ID.
SW release	R300

+SN – Scan Network	
Execute Command **AT+SN[:nn]** All Telegesis devices 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. Use on All Devices Note In case no parameter is specified 30 is used by default.	Response **OK** or **ERROR<errorcode>** Prompts **FFD:<EUI64>,<NodeID>[,syy,zz]** **SED:<EUI64>,<NodeID> [,syy,zz]** **MED:<EUI64>,<NodeID>[,syy,zz]** **COO:<EUI64>,<NodeID>[,syy,zz]** Parameters **nn ranging from 00 to 30** <errorcode> represents the error code explained in section 3. In case bit C of register S10 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 7. Source route messages may also be displayed.
SW release	R300

+NTABLE – Display Neighbour Table	**(ZDO)**
Read Command **AT+NTABLE:index,<address>** Where <address> can be the remote node's EUI64, NodeID or address table index Note: Also the local node can be the target of this command (e.g. use address table index FF as the address) Use on All Devices	Response **SEQ:XX** **OK or ERROR<errorcode>** This command requests the target node to respond by listing its neighbour table starting from the requested index. Can be used to find the identity of all ZigBee devices in the network including non Telegesis devices.
	Prompt (example) **NTable: 03** **No.| Type | EUI | ID | LQI** **0. | FFD | 000D6F000015896B | BC04 | FF** **1. | FFD | 000D6F00000B3E77 | 739D | FF** **2. | FFD | 000D6F00000AAD11 | 75E3 | FF** In this example the neighbour table contains three entries, which are displayed. In case the table contains more than three entries it may be required to repeat this command and increase the index count until the full table is derived.
SW release	R300

2.5 Messaging

+ATABLE – Display Address Table	
Read Command **AT+ATABLE** Use on All Devices Note: Entry 05 contains the address of the node's sink. The user can overwrite it to manually select a different sink.	Response **No. | Active | ID | EUI** **00 | N | 0000 |000D6F0000012345** **(…)** **OK** The Address Table contains nodes which can be addressed by referring to the corresponding address table entry.
SW release	R300

+ASET – Set Address Table Entry	
Read Command **AT+ASET:XX,<NodeID>,<EUI64>** Where XX is the entry number of the address table entry which is to be written. If the NodeID is unknown, the NodeID must be substituted with "FFFF". Use on All Devices	Response **OK** or **ERROR:<errorcode>** <errorcode> represents the error code explained in section 3.
SW release	R300

+MTABLE – Display Multicast Table	
Read Command **AT+MTABLE** Use on All Devices Note: For Multicasts to be displayed using the MCAST prompt, endpoint 01 must be selected as the target endpoint.	Response **No. | ID | EP** **00 | 1234 | 01** **01 | 0000 | 00** **02 | 0000 | 00** **03 | 0000 | 00** **04 | 0000 | 00** **OK** The multicast-table contains all multicast IDs which will be received by the local node.
SW release	R300

+MSET – Set Multicast Table Entry	
Read Command **AT+MSET:XX,<ID>,<endpoint>** Where XX is the index number of the multicast-table entry which is to be written. For the AT-Command interface operation the endpoint should always be set to 01. Use on All Devices	Response **OK** or **ERROR:<errorcode>** <errorcode> represents the error code explained in section 3.
SW release	R300

+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>,<NodeID> [,syy,zz]** **SED:<EUI64>,<NodeID> [,syy,zz]** **MED:<EUI64>,<NodeID> [,syy,zz]** **COO:<EUI64>,<NodeID> [,syy,zz]** The prompt above will be displayed on all nodes which can hear the ping. In case bit C of register S10 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 7. <EUI64> is the identifier and <NodeID> the NodeID of the sending device
SW release	R300

+BCAST – Transmit A Broadcast	
Execute Command **AT+BCAST:nn,<data>** Example **AT+BCAST:00,Hello world** Use on: All devices Note: Use broadcasts sparingly! The ZigBee specification only allows any node to repeat or originate up to 8 broadcasts in every 8 second interval. Broadcasts use a lot of bandwidth.	Response **OK** or **ERROR<errorcode>** Where <errorcode> represents the error code explained in section 3. Parameters **nn ranging from 00 to 30** A Maximum of 82 bytes are sent (with attached EUI only 74 bytes). 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 (max. 30 hops).
Remote action	Prompt **BCAST:[<EUI64>,]<length>=<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, <length> is the length of the payload and <data> is the data which was attached to the broadcast. The EUI64 is only displayed if it is part of the network header (set bit 0 of S10 to disable attaching the EUI64 to outgoing messages).
SW release	R300

+BCASTB – Transmit A Broadcast Of Binary Data	
Execute Command **AT+BCASTB:nn,XX** Where nn is the number of hops the message will travel and 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.	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 52 (hexadecimal)** **nn ranging from 00 to 30 (decimal)** A maximum of 82 bytes are sent (with attached EUI only 74 bytes). 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 (max 30 hops).
Remote action	Prompt **BCAST:<EUI64>,<length>=<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 <length> is the length of the message in hexadecimal. The EUI64 is only displayed if it is part of the network header (set bit 0 of S10 to disable attaching the EUI64 to outgoing messages).
SW release	R300

+UCAST – Transmit A Unicast	
Execute Command **AT+UCAST:<address>=<data>** Example **AT+UCAST:000D6F0000012345,Hello** Where <address> can be the remote node's EUI64, NodeID or address table index Use on All Devices Note Unicasts can be addressed either by referencing the recipient's EUI64, NodeID or an entry in the address table. The maximum payload is 82 bytes. It gets reduced by 8 bytes when appending the EUI to the network header (default) and also it gets reduced by 2 bytes per hop in case a source route is known. The later event can neither be suppressed nor foreseen.	Response **SEQ:XX** **OK** or **ERROR:<errorcode>** Where <errorcode> represents the error code explained in section 4. Prompt **ACK:XX** or **NAK:XX** Up to 82 bytes are sent to the node up to 30 hops away. On successful transmission the user is given the transmissions sequence 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.
Remote action	Prompt **UCAST:[<EUI64>,]<length>=<data>** Where <EUI64> is the address of the sender and <length> is the length of the message in hexadecimal. The EUI64 is only displayed if it is part of the network header (set bit 0 of S10 to disable attaching the EUI64 to outgoing messages).
SW release	R300

+UCASTB – Transmit A Unicast Of Binary Data	
Execute Command **AT+UCASTB:XX,<address>** Where <address> can be the remote node's EUI64, NodeID or address table index and XX is the number (in hexadecimal) of data bytes to be sent. Use on All Devices Notes This command is particularly useful if the data may contain <CR> and <Backspace> characters. The ACK and/or NACK prompt can be disabled in S0E Unicasts can be addressed either by referencing the recipient's EUI64, NodeID or an entry in the address table. The maximum payload is 82 bytes. It gets reduced by 8 bytes when appending the EUI to the network header (default) and also it gets reduced by 2 bytes per hop in case a source route is known. The later event can neither be suppressed nor foreseen.	Response **> <data being entered>** **SEQ:XX** **OK** or **ERROR:<errorcode>** Prompt **ACK:XX** or **NAK:XX** Parameters **XX ranging from 00 to 52 (hex)** After the '>' prompt a number of XX characters are expected to be entered. Up to 82 bytes are sent to the node with address <EUI64>. In case bit 9 of S10 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.
Remote action	Prompt **UCAST:[<EUI64>,]<length>=<data>** Where <EUI64> is the address of the sender and <length> is the length of the message in hexadecimal. The EUI64 is only displayed if it is part of the network header (set bit 0 of S10 to disable attaching the EUI64 to outgoing messages).
SW release	R300

+SCAST – Transmit Data To The Sink	
Execute Command **AT+SCAST:<data>** Example **AT+SCAST:Hello world** Use on All Devices Notes - If a sink cannot be reached for three consecutive transmissions the sink is assumed unavailable and a new one is sought - The ACK and/or NACK prompt can be disabled in S0E - When attaching the node's EUI64 to the network frame the maximum payload reduces to 76 bytes	Response **SEQ:XX** **OK** or **ERROR<errorcode>** Where <errorcode> represents the error code explained in section 3. Prompt **ACK:XX** or **NAK:XX** Parameters Up to 82 bytes are sent to the node's sink. On successful transmission the user is given the sequence 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.
Remote action	Prompt **UCAST:[<EUI64>,]<length>=<data>** Where <EUI64> is the address of the sender and <length> is the length of the message in hexadecimal. The EUI64 is only displayed if it is part of the network header (set bit 0 of S10 to disable attaching the EUI64 to outgoing messages).
SW release	R300

+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 Notes - If a sink cannot be reached for three consecutive transmissions the sink is assumed unavailable and a new one is sought. - The ACK and/or NACK prompt can be disabled in S0E - When attaching the node's EUI64 to the network frame the maximum payload reduces to 76 bytes	Response **> <data being entered>** **SEQ:XX** **OK** or **ERROR<errorcode>** Parameters **XX ranging from 00 to 52 (hex)** After the '>' prompt a number of XX characters are expected to be entered. A maximum of 82 bytes are sent to the network's sink. (In case bit 9 of S10 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 "NAK" in case the message was not acknowledged. A NAK does not guarantee that the message has not reached its destination.
Remote action	Prompt **UCAST:[<EUI64>,]XX=<data>** Where <EUI64> is the address of the sender and <length> is the length of the message in hexadecimal. The EUI64 is only displayed if it is part of the network header (set bit 0 of S10 to disable attaching the EUI64 to outgoing messages).
SW release	R300

+SSINK – Search For A Sink	
Read Command **AT+SSINK** Search for a sink on the network If a sink is already known and no better sink is found, no prompt will be displayed. A sink, which is already known can be found at index 05 of the address table. Use on All Devices	Response **OK** or **ERROR<errorcode>** Prompt **SINK:<EUI64>,<NodeID>** <errorcode> represents the error code explained in section 3.
SW release	R300

+MCAST – Transmit A Multicast	
Execute Command **AT+MCAST:nn,<ID>,<data>** Use on: All devices Notes - When attaching the node's EUI64 to the network frame the maximum payload reduces to 76 bytes - Entries in the multicast table must be set to endpoint 01 to trigger the desired prompt	Response **OK** or **ERROR<errorcode>** Where <errorcode> represents the error code explained in section 3. Parameters **nn ranging from 00 to 30** Up to 82 bytes are sent to the multicast group <ID>. 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 nn = 00 the entire network will (max. 30 hops).
Remote action	Prompt **MCAST:[<EUI64>,]<Length>=<data>** Where <EUI64> is the address of the sender and <length> is the length of the message in hexadecimal. The EUI64 is only displayed if it is part of the network header (set bit 0 of S10 to disable attaching the EUI64 to outgoing messages).
SW release	R300

+MCASTB – Transmit A Multicast Of Binary Data	
Execute Command **AT+MCASTB:XX,nn,<ID>** 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 Notes When attaching the node's EUI64 to the network frame the maximum payload reduces to 76 bytes 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 9 of S10 is set a timeout error is generated if no character is received for 1 second. Parameters **XX ranging from 00 to 52 (hex)** **nn ranging from 00 to 30** Up to 82 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 **MCAST:[<EUI64>,]<length>=<data>** Where <EUI64> is the address of the sender and <length> is the length of the message in hexadecimal. The EUI64 is only displayed if it is part of the network header (set bit 0 of S10 to disable attaching the EUI64 to outgoing messages).
SW release	R300

+FNDSR – Find the Source Route to a remote device	
Execute Command **AT+FNDSR:<address>** Where <address> can be the remote node's EUI64 or address table index Tries to find source route information to the specified device by sending an acknowledged unicast to the remote device. Use on Sink, COO Use on A Sink	Response **OK** or **ERROR<errorcode>** Prompt **SR:XX,<EUI64>,<NodeID>,<NodeID>…** Where XX represents the number of hops to the remote node, EUI64 its EUI64 number followed by a list of NodeIDs starting with the remote node listing all nodes along the path to the local node <errorcode> represents the error code explained in section 3.
SW release	R300

+SR – Set Source Route to Remote Device	
Execute Command **AT+SR:<NodeID>,<NodeID>,…** Set the source route of a message sent to a remote device, starting with the NodeID of the remote device followed by all NodeIDs on the route from the remote node to the local node Use on All Devices Note: Setting up invalid routes may lead to listed devices becoming unavailable. To confirm a route use AT+FNDSR.	Response **OK** or **ERROR<errorcode>** <errorcode> represents the error code explained in section 3. Stores route information for up to 30 hops which will be used when sending any message to a remote node, which is part of the listed devices.
SW release	R300

+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	R300

+REJOIN – Rejoin the network	
Execute Command **AT+REJOIN:b** If b is set to 0 join without the known network key (unencrypted) and if b is set to 1 join encrypted. Use on SED MED FFD Notes Polling a parent on an end device that has lost its parent will automatically call AT+REJOIN:1. Furthermore functionality 0012 and 0013 make use of this command.	Response **OK** or **ERROR<errorcode>** If the contact with the network has been lost, because an end device has lost its parent, the network has changed channel, or updated its encryption key the command AT+REJOIN can be used to rejoin the network. <errorcode> represents the error code explained in section 3.
SW release	R300

+IDENT – Play A Tune On Remote Devboard	
Execute Command **AT+IDENT:<address>** Where <address> can be the remote node's EUI64, NodeID or address table index Use on All Devices	Response **SEQ:XX** **OK** or **ERROR<errorcode>** Prompt **ACK:XX** or **NAK:XX** <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 ETRX2.
SW release	R300

+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 67 (hex)** After the '>' prompt a number of XX characters are expected to be entered. Up to 103 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:snn,<data>** where snn is the RSSI, or **<data>** in case bit 9 of S0E is set. Displaying the data can also be disabled by setting bit D of S0E.
SW release	R300

3 List of Error codes

01 Couldn't poll Parent because of Timeout
02 Unknown command
04 Invalid S-Register
05 Invalid parameter
06 Recipient could not be reached
07 Message was not acknowledged
08 No sink known
09 Address Table entry is in use and cannot be modified
0A Message could not be sent
0B Local node is not sink
0C Too many characters
0D License Problem
0F Fatal error initialising the network
10 Error bootloading
12 Fatal error initialising the stack
18 Node has run out of Buffers
19 Trying to write read-only register
20 Invalid password
25 Cannot form network
27 No network found
28 Operation cannot be completed if node is part of a PAN
2C Error leaving the PAN
2D Error scanning for PANs
33 No response from the remote bootloader
34 Target did not respond during cloning
35 Timeout occurred during xCASTB
39 MAC Transmit Queue is Full
70 Invalid Operation
74 Message too long
91 Operation only possible if joined to a PAN
93 Node is not part of a Network
94 Cannot join network
96 Mobile End Device Move to new Parent Failed
98 Cannot join ZigBee 2006 Network as Router
A1 More than 8 broadcasts were sent within 8 seconds
AB Trying to join, but no beacons could be heard
AC Network key was sent in the clear when trying to join secured
AD Did not receive Network Key
AE No Link Key received
AF Preconfigured Key Required

4 S-Registers

Most S-Registers of the 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	Transmit Power Level	**(•/•)**	**(•/•)**
S02	Preferred PAN ID	**(•/•)**	**(•/•)**
S03	Preferred Extended PAN ID	**(•/•)**	**(•/•)**
S04	Local EUI	**(•/-)**	**(•/-)**
S05	Local NodeID	**(•/-)**	**(•/-)**
S06	Parent's EUI	**(•/-)**	**(•/-)**
S07	Parent's NodeID	**(•/-)**	**(•/-)**
S08	Network Key[1]	**(-/•)**	**(-/•)**
S09	Link Key[1]	**(-/•)**	**(-/•)**
S0A	Main Function[1]	**(•/•)**	**(•/•)**
S0B	User Readable Name [1]	**(•/•)**	**(•/•)**
S0C	Password[1]	**(•/•)**	**(•/•)**
S0D	Device Information	**(•/-)**	**(•/-)**
S0E	Prompt Enable 1	**(•/•)**	**(•/•)**
S0F	Prompt Enable 2	**(•/•)**	**(•/•)**
S10	Extended Function	**(•/•)**	**(•/•)**
S11	Device Specific	**(•/•)**	**(•/•)**
S12	UART Setup	**(•/•)**	**(•/•)**
S13	Pull-up enable	**(•/•)**	**(•/•)**
S14	Pull-down enable	**(•/•)**	**(•/•)**
S15	I/O Configuration (reserved for future use)	**(•/•)**	**(•/•)**
S16	Data Direction of I/O Port **(volatile)**	**(•/•)**	**(•/•)**
S17	Initial Value of S16	**(•/•)**	**(•/•)**
S18	Output Buffer of I/O Port **(volatile)**	**(•/•)**	**(•/•)**
S19	Initial Value of S18	**(•/•)**	**(•/•)**
S1A	Input Buffer of I/O Port **(volatile)**	**(•/-)**	**(•/-)**
S1B	Special Function pin 1 **(volatile)**	**(•/•)**	**(•/•)**
S1C	Initial Value of S1B	**(•/•)**	**(•/•)**
S1D	Special Function Pin 2 **(volatile)**	**(•/•)**	**(•/•)**
S1E	Initial Value of S1D	**(•/•)**	**(•/•)**
S1F	A/D1	**(•/-)**	**(•/-)**
S20	A/D2	**(•/-)**	**(•/-)**
S21	A/D3	**(•/-)**	**(•/-)**
S22	A/D4	**(•/-)**	**(•/-)**
S23	Immediate functionality at IRQ0	**(•/•)**	**(•/•)**
S24	Immediate functionality at IRQ1	**(•/•)**	**(•/•)**
S25	Immediate functionality at IRQ2	**(•/•)**	**(•/•)**
S26	Immediate functionality at IRQ3	**(•/•)**	**(•/•)**

S-Register Overview (continued)		Local R/W	Remote R/W
S27	Functionality 1 at Boot-up	**(•/•)**	**(•/•)**
S28	Functionality 2 at Boot-up	**(•/•)**	**(•/•)**
S29	Timer/Counter 0	**(•/•)**	**(•/•)**
S2A	Functionality for Timer/Counter 0	**(•/•)**	**(•/•)**
S2B	Timer/Counter 1	**(•/•)**	**(•/•)**
S2C	Functionality for Timer/Counter 1	**(•/•)**	**(•/•)**
S2D	Timer/Counter 2	**(•/•)**	**(•/•)**
S2E	Functionality for Timer/Counter 2	**(•/•)**	**(•/•)**
S2F	Timer/Counter 3	**(•/•)**	**(•/•)**
S30	Functionality for Timer/Counter 3	**(•/•)**	**(•/•)**
S31	Timer/Counter 4	**(•/•)**	**(•/•)**
S32	Functionality for Timer/Counter 4	**(•/•)**	**(•/•)**
S33	Timer/Counter 5	**(•/•)**	**(•/•)**
S34	Functionality for Timer/Counter 5	**(•/•)**	**(•/•)**
S35	Timer/Counter 6	**(•/•)**	**(•/•)**
S36	Functionality for Timer/Counter 6	**(•/•)**	**(•/•)**
S37	Timer/Counter 7	**(•/•)**	**(•/•)**
S38	Functionality for Timer/Counter 7	**(•/•)**	**(•/•)**
S39	Power mode **(volatile)**	**(•/•)**	**(•/•)**
S3A	Initial Power Mode	**(•/•)**	**(•/•)**
S3B	Start-up Functionality Plaintext A	**(•/•)**	**(•/•)**
S3C	Start-up Functionality Plaintext B	**(•/•)**	**(•/•)**
S3D	Supply Voltage	**(•/-)**	**(•/-)**
S3E	Multicast Table Entry 00	**(•/•)**	**(•/•)**
S3F	Multicast Table Entry 01	**(•/•)**	**(•/•)**
S40	Source and Destination Endpoints for xCASTs **(volatile)**	**(•/•)**	**(•/•)**
S41	Initial Value of S40	**(•/•)**	**(•/•)**
S42	Cluster ID for xCASTs **(volatile)**	**(•/•)**	**(•/•)**
S43	Initial Value of S42	**(•/•)**	**(•/•)**
S44	Profile ID for xCASTs **(volatile)**	**(•/•)**	**(•/•)**
S45	Initial Value of S44	**(•/•)**	**(•/•)**
S46	Start-up Functionality 16 bit number **(volatile)**	**(•/•)**	**(•/•)**

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. S16, S18, S1A, S1B, S1D and S39 are directly accessing volatile I/O registers to prevent memory corruption due to constant I/O access. Registers S17, S19, S1C, S1E, S3A, S41 and S43 represent the non-volatile registers which define the contents of S16, S18, S1B, S1D, S39, S40 and S42 respectively after booting up or reset.

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. To overcome this 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 module's 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 ETRX2 module are restored.

4.2 S-Registers for Network Setup

S00 – Channel Mask	
Description The 802.15.4 channel mask. 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 Storage **Non-Volatile**	Parameters **XXXX** Where XXXX represents a 16-bit decimal number enabling IEEE 802.15.4 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. Range **0001 - FFFF** Factory Default **3FFC**
SW release	R300

S01 – Transmit Power Level	
Description The device's transmit power level in dBm. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective When Joining or establishing a PAN Storage **Non-Volatile**	Parameters **snn** Where snn represents a signed 8-bit decimal number. Range **4 to -43** Setting S02 to 4 enables the radio boost mode increasing both output power as well as sensitivity (the actual radio power setting will remain at 3). Actual values are {4,3, 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 result in the next lowest output power. Factory Default **3**
SW release	R300

S02 – Preferred PAN ID	
Description The 802.15.4 PAN ID. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective When Joining or establishing a PAN Notes Two networks operating on the same channel with the same PAN ID, but a different EPID are detected to be in conflict with each other. PAN ID conflicts are detected by the stack and resolved by one of the networks dynamically changing its PAN ID. The preferred PID does not affect the AT+JPAN command Storage **Non-Volatile**	Parameters **<PID>** Where <PID> represents a 16-bit hexadecimal number Range **0000 – FFFF** When establishing a PAN the coordinator will pick a random PAN ID if S02 is set to 0000. If set to any value between 0001 and FFFF this number will be used as PAN ID instead, unless trying to use a PAN ID which already exists on the same channel. In this case a random PAN ID will be used instead. When joining only a PAN with the ID stored in S02 will be joined unless S02 is set to 0000. In this case the next best PAN which allows joining is joined. Factory Default **0000**
SW release	R300

S03 – Preferred Extended PAN ID	
Description The extended PAN ID. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective When Joining or establishing a PAN Note The EPID is used for PAN ID conflict detection. It is therefore recommended to use a random EPID at all times. The preferred EPID does not affect the AT+JPAN command Storage **Non-Volatile**	Parameters **<EPID>** Where <EPID> represents a 64-bit hexadecimal number Range **0000000000000000 – FFFFFFFFFFFFFFFF** When establishing a PAN the coordinator will pick a random EPID if S03 is set to all 0's. If set to any other value this number will be used as EPID instead. When joining only a PAN with the EPID stored in S03 will be joined unless S03 is set to all 0's. In this case the next best PAN which allows joining is joined. Factory Default **0000000000000000**
SW release	R300

S04 – Local EUI64	
Description The local nodes unique EUI64 identifier. Operations **R LOCAL** **R REMOTE** Storage **Non-Volatile**	Parameters **<EUI64>** Range **0000000000000000 – FFFFFFFFFFFFFFFF** Factory Default <unique number>
SW release	R300

S05 – Local 16-Bit NodeID	
Description The local node's 16-bit NodeID. Note Reading this register while not associated with a network will result in an undefined return value. Operations **R LOCAL** **R REMOTE** Storage **Non-Volatile**	Parameters **<NodeID>** Range **0000-FFFF** Factory Default n/a
SW release	R300

S06 – Parent's EUI64	
Description The parent node's unique EUI64 identifier. Note **The return value is undefined for nodes without parents (coordinators and nodes that are not joined to a network)** Operations **R LOCAL** **R REMOTE** Storage **Non-Volatile**	Parameters **<EUI64>** Range **0000000000000000 – FFFFFFFFFFFFFFFF** Factory Default n/a
SW release	R300

S07 – Parent's 16-Bit NodeID	
Description The parent node's 16-bit NodeID. Operations **R LOCAL** **R REMOTE** Note **The return value is undefined for nodes without parents (coordinators and nodes that are not joined to a network)** Storage **Non-Volatile**	Parameters **<NodeID>** Range **0000-FFFF** Factory Default n/a
SW release	R300

S08 – Network Key	
Description The network key which can be written using the password. The default password for R3xx is "password". Operations **W LOCAL** **W REMOTE** Write operation **ATS08=<key>:<password>** **ATREMS:<address>,08=<key>:<password>** Becomes effective Only when establishing a PAN Storage **Non Volatile**	Range **From 0 to 2^{128}-1** The 128-bit AES network key in hexadecimal representation (32 characters). When set to all 0's (default) a random network key is generated when establishing a PAN. This key is transmitted to all joining nodes and can be encrypted using the link key. Factory Default **00000000000000000000000000000000**
SW release	R300

S09 – Trust Centre Link Key	
Description The link key which can be written using the password. The default password for R3xx is "password". Operations **W LOCAL** **W REMOTE** Write operation **ATS09=<key>:<password>** **ATREMS:<address>,09=<key>:<password>** Becomes effective When Joining or establishing a PAN Storage **Non Volatile**	Range **From 0 to 2^{128}-1** The 128-bit trust centre link key in hexadecimal representation (32 characters). When set to all 0s (default) a random trust centre link key is generated when establishing a PAN. Factory Default **00000000000000000000000000000000**
SW release	R300

4.3 S-Registers for Module Setup

S0A – Main Function	
Description Defines the behaviour of the Device. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Write operation **ATS0A=XXXX:<Password>** **ATREMS:<address>,0A=XXXX:<Password>** Note For security reasons this register is password protected. The default password for R3xx is "password". Storage **Non-Volatile**	Parameters **XXXX** Where XXXX represents a 16-bit hexadecimal number. Range **0000 to FFFF** **Bit F:** Set: Mobile End Device (MED). Unset: Sleepy End Device (SED) (Note: bit E must also be set) **Bit E:** Set: Device is an End Device (bit F specifies Sleepy or Moving End Device) **Bit A:** Set: When joining don't ask for Trust Centre link key **Bit 8:** Set: Use Pre-Configured Trust Centre Link Key when joining **Bit 7:** Set: Trust centre uses hashed link key **Bit 5:** Set: Don't allow nodes to join **Bit 4:** Set: Send Network key encrypted with the link key to nodes joining **Bit 3:** Set: Don't allow nodes to re-join unsecured **Bit 2:** Set: Send Network key encrypted with the link key to nodes re-joining unsecured **Bit 1:** Reserved **Bit 0:** Set: Don't allow other nodes to join the network using this node as their parent Factory Default **0000**
SW release	R301

S0B – User Readable Name	
Description Password protected user defined name which can be used to identify the node Operations **R/W LOCAL** **R/W REMOTE** Write operation **ATS0B=<name>:<password>** **ATREMS:<address>,0B=<name>:<password>** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **ccccccccccccccccccc** Name with up to 20 characters. Factory Default **Telegesis**
SW release	R300

S0C – Password	
Description The local node's password. Operations **W LOCAL** **W REMOTE** Write operation **ATS0C=<NEW>:<OLD>** **ATREMS:<address>,0C=<NEW>:<OLD>** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **cccccccc** 8 case sensitive characters (8 bytes). Note that the password **must** have exactly 8 characters. Factory Default **password**
SW release	R300

S0D – Device Information	
Description String containing the module's order code and firmware revision. Operations **R LOCAL** **R REMOTE** Storage **Non-Volatile**	Parameters **ccc…ccc** Text string Example **ETRX2 R300** Factory Default **N/A**
SW release	R300

S0E – Prompt Enable 1	
Description Defines the behaviour of the Device. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** Where XXXX represents a 16-bit hexadecimal number. Range **0000 to FFFF** **Bit F:** Set: Disable '>' prompt when entering binary data **Bit E:** Set: Disable UCAST, MCAST,BCAST data **Bit D:** Set: Disable RAW data **Bit C:** Set: Disable SEQ prompt **Bit B:** Set: Disable SINK prompt **Bit A:** Set: Disable SR: prompt **Bit 9:** Set: Disable RAW wrapper **Bit 8:** Set: Disable NEWNODE prompt **Bit 7:** Set: Disable NAK:XX prompt **Bit 6:** Set: Disable ACK:XX **Bit 5:** Set: Disable UCAST, MCAST,BCAST wrapper **Bit 4:** Set: Disable LeftPAN prompt **Bit 3:** Set: Disable JPAN prompt **Bit 2:** Set: Disable PWRCHANGE:nn prompt **Bit 1:** Set: Disable OK prompt **Bit 0:** Set: Disable ERROR:XX prompt Factory Default **0000**
SW release	R300

S0F – Prompt Enable 2	
Description Defines the behaviour of the Device. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** Where XXXX represents a 16-bit hexadecimal number. Range **0000 to FFFF** **Bit 3 – Bit F:** Reserved **Bit 2:** Set: Show all Sink Advertisements **Bit 1:** Set: Disable showing messages received by Endpoints 0 and 2 **Bit 0:** Set: Disable COO,FFD,SED and MED prompts Factory Default **0006**
SW release	R301

S10 – Extended Function	
Description Defines the behaviour of the Device. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** Where XXXX represents a 16-bit hexadecimal number. Range **0000 to FFFF** **Bit C:** Set: Display RSSI and LQI of the last hop when devices report to AT+SN or AT+PING **Bit B:** Set: UCASTs and SCASTs wait for ACK **Bit A:** Set: Disable playing Tune when receiving AT+IDENT **Bit 9:** Set: Enable one second character timeout when entering data for xCASTB. **Bit 8:** Set: Don't actively search for a sink if none is known **Bit 7:** Set: Node doesn't replace existing sink with better one (lower cost) **Bit 6:** Set: Node doesn't lose sink if it couldn't be reached for three times **Bit 5:** Set: Sink won't reply to nodes searching for a sink **Bit 4:** Set: Node is Sink **Bit 3:** Changes to S01 take effect instantly **Bit 2:** Send BCAST[B] messages to routers only **Bit 1:** Set: Send UCAST[B] and SCAST[B] messages unacknowledged **Bit 0:** Set: Don't attach EUI64 to NWK frame when sending a message. Factory Default **0000**
SW release	R301

S11 – Device Specific	
Description Defines the behaviour of the Device. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** Where XXXX represents a 16-bit hexadecimal number. Range **0000 to FFFF** **Bit F (MSB):** Set: I/O3 is PWM as defined by S2F/S31. Unset: Standard I/O pin. **Bit E:** Set: Enable Boost mode regardless of setting in S02 **Bit D:** Set: Present A/D-Reference at I/O0 during measurement **Bit C:** Set: I/O8 turns into A/D3, which can be read from S21 **Bit B:** Set: Pad 38 turns into A/D4, which can be read from S22 **Bit 9:** Set: Enable wakeup on UART activity (1st input character is discarded) **Bit 8:** Set: Enable debouncing for all IRQs (100ms) **Bit 7:** Set: IRQ3 on rising edge **Bit 6:** Set: IRQ3 on falling edge **Bit 5:** Set: IRQ2 on rising edge **Bit 4:** Set: IRQ2 on falling edge **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 Factory Default **0005**
SW release	R301

4.4 I/O related S-Registers

S12 – UART Setup	
Description The device's RS232 Baudrate and mode. The default setting of 0500 results in: 19200bps, no parity, 1 stop bit, 8 data bits. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective Instantly Note 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 I/O2. 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 ETRX2 is full data will be dropped. Storage **Non-Volatile**	Parameters **XXXX** Where XXXX represents a 16-bit hexadecimal number. 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 Range of the least significant byte **00 to FF** bit 7 set: Enable STX ETX wrapper bit 6 Reserved 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 Factory Default **0500**
SW release	R300

S13 – Pull-up enable	
Description Enables the built-in pull-ups for each individual I/O pin of the ETRX2. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective After Reset 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. Storage **Non-Volatile**	Parameters **XXXX** Where XXXX represents a 16-bit hexadecimal number. Range **0000 to FFFF** representing I/O pins `xxxx BA98 7654 3210` e.g. setting bit 7 to 1 will enable the pull-up for I/O pin 7 Factory Default **0000**
SW release	R300

S14 – Pull-down enable	
Description Enables the built-in pull-downs for each individual I/O pin of the ETRX2. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective After Reset Note To achieve ultra low current consumption it is recommended not to use the built-in pull-downs and leave this register in its default state. Storage **Non-Volatile**	Parameters **XXXX** Where XXXX represents a 16-bit hexadecimal number. Range **0000 to FFFF** representing I/O pins `xxxx BA98 7654 3210` e.g. setting bit 7 to 1 will enable the pull-down for I/O pin 7 Factory Default **0000**
SW release	R300

S15 – I/O Configuration (not yet in use)	
Description Some I/O pins of the ETRX2 have an alternative functionality, which will be enabled using this register Operations **R/W LOCAL** **R/W REMOTE** Becomes effective Instantly Storage **Non-Volatile**	Parameters **XXXX** Where XXXX represents a 16-bit hexadecimal number. Range **0000 to FFFF** **Bits 0 to F:** Reserved Factory Default **0000**
SW release	R300

S16 – Data Direction of I/O Port	
Description The data direction of the module's I/O port Operations **R/W LOCAL** **R/W REMOTE** Becomes effective Instantly Storage **Volatile**	Parameters **XXXX** Where XXXX represents a 16-bit hexadecimal number. Range **0000 to FFFF** representing I/O pins `xxxx BA98 7654 3210` 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. Factory Default **Defined in S17**
SW release	R300

S17 – Initial Setting of S16	
Description The initial setting of S0D stored in non volatile memory Operations **R/W LOCAL** **R/W REMOTE** Becomes effective After Soft or Hard Reset Storage **Non-Volatile**	Parameters **XXXX** Where XXXX represents the initial value of S16 which is loaded after boot-up, soft or hard reset. Factory Default **00F8**
SW release	R300

S18 – Output Buffer Of I/O Port	
Description The output buffer of the module's I/O port Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Volatile**	Parameters **XXXX** Where XXXX represents a 16-bit hexadecimal number. Range **0000 to FFFF** representing I/O pins `xxxx BA98 7654 3210` If the I/O pin has been defined as an output in S16 the pin will drive the logic level defined by S18. Factory Default **Defined in S19**
SW release	R300

S19 – Initial Setting of S18	
Description The initial setting of S18 stored in non volatile memory Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **After Soft or Hard Reset** Storage **Non-Volatile**	Parameters **XXXX** Where XXXX represents the initial value of S18 which is loaded after boot-up, soft or hard reset. Factory Default **00F0**
SW release	R300

S1A – Input Buffer of I/O Port	
Description The Logical Levels at the I/O Pins Operations **R LOCAL** **R REMOTE** Becomes effective **Instantly** Storage **Instant Reading of Port Status**	Range **0000 to FFFF** representing I/O pins `xxxx BA98 7654 3210` S11 represents the logic level at each pin of the I/O port. Factory Default n/a
SW release	R300

S1B – PWM Pin Top Value	
Description The mode of operation for the special function pin Operations **R/W LOCAL** **R/W REMOTE** Operations **Instantly** Storage **Volatile**	Parameters **XXXX** Range **0000 to FFFF** 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 that the PWM is enabled in S2E. Factory Default **Defined in S1C**
Examples See User Guide	
SW release	R300

S1C – Initial value of S1B	
Description The initial setting of S1B stored in non volatile memory Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **After Soft or Hard Reset** Storage **Non-Volatile**	Parameters **XXXX** Where XXXX represents the initial value of S1B which is loaded after boot-up, soft or hard reset. Factory Default **3A98 (800Hz 50% m/s ratio)**
SW release	R300

S1D – PWM Pin Compare Value	
Description The mode of operation for the special function pin Operations **R/W LOCAL** **R/W REMOTE** Operations **Instantly** Storage **Volatile**	Parameters **XXXX** Range **0000 to FFFF** 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. Factory Default **Defined in S1E**
SW release	R300

S1E – Initial Value S1D	
Description The initial setting of S1D stored in non volatile memory Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **After Soft or Hard Reset** Storage **Non-Volatile**	Parameters **XXXX** Where XXXX represents the initial value of S1D which is loaded after boot-up, soft or hard reset. Factory Default **1D4C (800Hz 50% m/s ratio)**
SW release	R300

S1F – A/D1 Reading	
Description The analogue reading of A/D1 Operations **R LOCAL** **R REMOTE** Becomes effective **Instantly** Storage **Instant Reading of analogue input**	Parameters **XXXX** Representation The hexadecimal reading of the analogue input in mV with respect to ground. Range 0000 – 04B0 (0 – 1200)
SW release	R300

S20 – A/D2 Reading	
Description The analogue reading of A/D2 Operations **R LOCAL** **R REMOTE** Becomes effective **Instantly** Storage **Instant Reading of analogue input**	Parameters **XXXX** Representation The hexadecimal reading of the analogue input in mV with respect to ground. Range 0000 – 04B0 (0 – 1200)
SW release	R300

S21 – A/D3 Reading (only when bit C of S11 is set, invalid otherwise)	
Description The analogue reading of A/D2 Operations **R LOCAL** **R REMOTE** Becomes effective **Instantly** Storage **Instant Reading of analogue input**	Parameters **XXXX** 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 C of S11. Range 0000 – 04B0 (0 – 1200)
SW release	R300

S22 – A/D4 Reading (only when bit B of S11 is set, invalid otherwise)	
Description The analogue reading of A/D2 Operations **R LOCAL** **R REMOTE** Becomes effective **Instantly** Storage **Instant Reading of analogue input**	Parameters **XXXX** 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 D of S11. Range 0000 – 04B0 (0 – 1200)
SW release	R300

4.5 S-Registers Defining the Functionality of the Module

There are 14 events which can trigger a user-selectable action to prevent the need for a host microcontroller for simple applications. Four out of those 14 events are the external interrupts which can be enabled in Register S11. The actions to be performed on those four interrupt events are defined in S23 to S26. The user can pick any of the actions from the list in section 5 of this document and assign them to any event.

Another two consecutive events are triggering when the unit is reset or power cycled and the stack has booted up again.

The remaining 8 events are timed events. Registers S29 to S38 control those 8 timers and their corresponding events. Please note that the first 5 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.

S23 – Immediate Functionality At IRQ0 (I/O0)	
Description Describes the immediate action taken on IRQ0. Transitions on I/O0 generate IRQ0. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of available functionalities. Factory Default **0001 (Wakeup to power mode 0)**
SW release	R300

S24 – Immediate Functionality At IRQ1 (I/O1)	
Description Describes the immediate action taken on IRQ1. Transitions on I/O1 generate IRQ1. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of available functionalities. Factory Default **0000 (none)**
SW release	R300

S25 – Immediate Functionality At IRQ2 (I/O10)	
Description Describes the immediate action taken on IRQ2. Transitions on I/O10 generate IRQ2. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of available functionalities. Factory Default **0000 (none)**
SW release	R300

S26 – Immediate Functionality At IRQ3 (I/O11)	
Description Describes the immediate action taken on IRQ3. Transitions on I/O11 generate IRQ3. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of available functionalities. Factory Default **0000 (none)**
SW release	R300

S27 – Functionality at Bootup 1	
Description Describes the immediate action taken after boot-up. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of available functionalities. Factory Default **0000 (none)**
SW release	R300

S28 – Functionality at Bootup 2	
Description Describes the immediate action taken after boot-up (and the functionality in S27). Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of available functionalities. Factory Default **0000 (none)**
SW release	R300

S29 –Timer/Counter 0	
Description A multi purpose Timer/Counter whose functionality is defined by S2A Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	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. Factory Default **0004 (1s interval)**
SW release	R300

S2A – Functionality For Timer/Counter 0	
Description Defines the functionality for Timer/Counter 0 events. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality. Factory Default **8010 (end devices poll parent)**
SW release	R300

S2B –Timer/Counter 1	
Description A multi purpose Timer/Counter whose functionality is defined by S2C Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	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. Factory Default **00F0 (1 min interval)**
SW release	R300

S2C – Functionality For Timer/Counter 1	
Description Defines the functionality for Timer/Counter 1 events. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality. Factory Default **821E (sink advertisement for 30 hops)**
SW release	R300

S2D –Timer/Counter 2	
Description A multi purpose Timer/Counter whose functionality is defined by S2E Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	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. Factory Default **00F4 (1 min 1s interval)**
SW release	R300

S2E – Functionality For Timer/Counter 2	
Description Defines the functionality for Timer/Counter 2 events. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality. Factory Default **8014 (leave network if I am alone)**
SW release	R300

S2F –Timer/Counter 3	
Description A multi purpose Timer/Counter whose functionality is defined by S30 Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	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. Factory Default **00F2 (1min interval)**
SW release	R300

S30 – Functionality For Timer/Counter 3	
Description Defines the functionality for Timer/Counter 3 events. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality. Factory Default **8015 (if not part of a network do AT+JN)**
SW release	R300

S31 –Timer/Counter 4	
Description A multi purpose Timer/Counter whose functionality is defined by S32 Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	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. Factory Default **FFFF (~4.5 hour Interval)**
SW release	R300

S32 – Functionality For Timer/Counter 4	
Description Defines the functionality for Timer/Counter 4 events. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality. Factory Default **8011 (Change the Network Key if I am the COO)**
SW release	R300

S33 –Timer/Counter 5	
Description A multi purpose Timer/Counter whose functionality is defined by S34 Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	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. Factory Default **0000**
SW release	R300

S34 – Functionality For Timer/Counter 5	
Description Defines the functionality for Timer/Counter 5 events. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality. Factory Default **0000**
SW release	R300

S35 –Timer/Counter 6	
Description A multi purpose Timer/Counter whose functionality is defined by S36 Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	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. Factory Default **0000**
SW release	R300

S36 – Functionality For Timer/Counter 6	
Description Defines the functionality for Timer/Counter 6 events. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality. Factory Default **0000**
SW release	R300

S37 –Timer/Counter 7	
Description A multi purpose Timer/Counter whose functionality is defined by S38 Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	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. Factory Default **0000**
SW release	R300

S38 – Functionality For Timer/Counter 7	
Description Defines the functionality for Timer/Counter 6 events. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **XXXX** If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality. Factory Default **0000**
SW release	R300

S39 – Power Mode	
Description The current power mode of the module Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Volatile**	Parameters **XXXX** Range **0000 – 0003** The modules power level as described in section 6. Factory Default **Defined in S3A**
SW release	R300

S3A – Initial Power Mode	
Description The module's power mode after start-up and reset. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **After hard or soft reset** Storage **Non-Volatile**	Parameters **XXXX** Range **0000 – 0003** The module's power mode as described in section 6. Factory Default **0000**
SW release	R300

S3B – Start-up Functionality Plaintext A	
Description Contains Text which is used by some of the actions described in section 5. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **Up to 50 characters** Factory Default **BUTTON3**
SW release	R300

S3C – Start-up Functionality Plaintext B	
Description Contains Text which is used by some of the actions described in section 5. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Non-Volatile**	Parameters **Up to 50 characters** Factory Default **BUTTON4**
SW release	R300

S3D – Supply Voltage	
Description The Supply voltage of the device in mV. Operations **R LOCAL** **R REMOTE** Becomes effective **N/A** Storage **Volatile**	Parameters **nnnn** Where nnnn represents the supply voltage in mV. Factory Default **N/A**
SW release	R300

4.6 Advanced Messaging Settings

S3E – Multicast Table Entry 00	
Description The ID portion of Multicast Table Entry 00 Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **After boot-up or reset** Note Same effect as AT+MSET, but can be set at boot-up by built-in functionality Storage **Non-Volatile**	Parameters **XXXX** If S3E is not set to all 0's multicast table entry 1 to endpoint 1 (the AT command layer's endpoint) is set with the setting of this register is created instantly and after a reset. Factory Default **0000**
SW release	R300

S3F – Multicast Table Entry 01	
Description The ID portion of Multicast Table Entry 01 Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **After boot-up or reset** Note As for S3E Storage **Non-Volatile**	Parameters **XXXX** If S3F is not set to all 0's multicast table entry 2 to endpoint 1 (the AT command layer's endpoint) is set with the setting of this register is created instantly and after a reset. Factory Default **0000**
SW release	R300

S40 – Source and Destination Endpoints for xCASTs (volatile)	
Description The source and destination endpoints for all messages. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Volatile**	Parameters **ssdd** Where ss is the hexadecimal source endpoint and dd is the hexadecimal destination endpoint. Factory Default **Defined in S41**
SW release	R300

S41 – Initial Setting of S40	
Description The initial setting of S40 stored in non volatile memory Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **After Soft or Hard Reset** Storage **Non-Volatile**	Parameters **ssdd** Where ss is the hexadecimal source endpoint and dd is the hexadecimal destination endpoint. Factory Default **0101**
SW release	R300

S42 – Cluster ID for xCASTs (volatile)	
Description The Cluster ID any xCAST message is sent to. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Volatile**	Parameters **XXXX** The cluster ID of any xCAST message Factory Default **Defined in S43**
SW release	R300

S43 – Initial Setting of S42	
Description The initial setting of S42 stored in non volatile memory Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **After Soft or Hard Reset** Storage **Non-Volatile**	Parameters **XXXX** The cluster ID of any xCAST message Factory Default **0002**
SW release	R300

S44 – Profile ID for xCASTs (volatile)	
Description The profile ID for all messages. Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **Instantly** Storage **Volatile**	Parameters **XXXX** The profile ID of any xCAST message Factory Default **Defined in S45**
SW release	R300

S45 – Initial Setting of S44	
Description The initial setting of S44 stored in non volatile memory Operations **R/W LOCAL** **R/W REMOTE** Becomes effective **After Soft or Hard Reset** Storage **Non-Volatile**	Parameters **XXXX** The profile ID of any xCAST message Factory Default **C091**
SW release	R300

S46 – Start-up Functionality 16 bit number	
Description Volatile 16 bit register which can be used by some of the build in functionality Operations **R/W LOCAL** **R/W REMOTE** Storage **Volatile**	Parameters **XXXX** Factory Default **0000**
SW release	R301

5 Built in Functionality

The following table gives an overview of the built-in functionality which can be triggered either by the four external interrupts, boot-up, 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. When triggered by a timer the timer will restart only in case the most significant bit of the action is set to 1 (e.g. instead of 0001 set 8001).

Overview of Actions	
0000	No operation of the corresponding interrupt/timer/counter
0001	Change to power mode 0.
0002	Change to power mode 1.
0003	Change to power mode 2.
0004	Change to power mode 3.
…	Reserved
0010	If I am a Mobile/Sleepy end device Poll Parent for data.
0011	Update the Network key with new random key.
0012	Check for other devices on the network. If no other devices could be found for three consecutive tries, attempt a rejoin using the current network key each time this functionality is triggered. Note: No functionality on COOs.
0013	Check for other devices on the network. If no other devices could be found for three consecutive tries, attempt a rejoin using the current network key. If this is unsuccessful try an unsecured rejoin each time this functionality is triggered from there on. Note: No functionality on COOs.
0014	Check for other devices on the network. If no other devices could be found for three consecutive tries, attempt a rejoin using the current network key. If this is unsuccessful try a rejoin using the current link key the next time this functionality is triggered. If this is unsuccessful leave the current network the next time this action is triggered. Note: No functionality on COOs.
0015	In case I am not joined to a network scan for and join the next best
0016	Reserved
0017	Allow joining for 60 Seconds (in case it is disabled in S0A)
…	Reserved
003x	Toggle I/Ox
004x	Flash I/Ox (pull low) for 250ms
005x	Set I/Ox to 0
006x	Set I/Ox to 1
…	Reserved
0108	The unit sends the contents of S3B to the networks sink.
0109	The unit sends the contents of S3C to the networks sink.
0110	Sends the reading of the I/O, the two analogue ports and V_{cc} 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.
0111	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.
0112	Send a Tracking Message to all nearby routers which will forward this message and the RSSI reading to their nearest sink.

Overview of Actions	
0113	Same as 0112, 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 S3B as a RAW transmission.
0121	Sends the contents of S3C as a RAW transmission.
02XX	If I am a Sink advertise me for x hops (max. no. of hops: 30). If I am a COO create aggregation routes needed for Trust Centre
…	Reserved
…	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 S23, S24, S25 or S26 to 24XX .
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. **Notes:** This event is triggered by receiving a character on the serial port. N ≤ 64.
…	Reserved
2100	The contents of S3B is sent to the local command line followed by carriage return. Note: No AT-Prefix required!
2101	The contents of S3C is sent to the local command line followed by carriage return. Note: No AT-Prefix required!
…	Reserved
24XX	Start timers masked in XX.
25XX	Toggle timers masked in XX.
26XX	Stop timers masked in XX.
…	Reserved
3XXX	Change I/O port to the LSBs.
4XXX	Change data direction of the I/O port to the LSBs.
…	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 ETRX2 as stated in the current hardware manual, whereas Table 8 shows the firmware dependent average power consumption of an ETRX2 measured with light to medium network traffic.

6.1 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 7: 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[1]	Asleep	Asleep	User defined	0.7mA[1]
3	Asleep	Asleep	Off	0.7µA	Asleep	Asleep	Off	0.7µA

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 (S3A) 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.

[1] 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 Energy Levels and LQI

7.1 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.

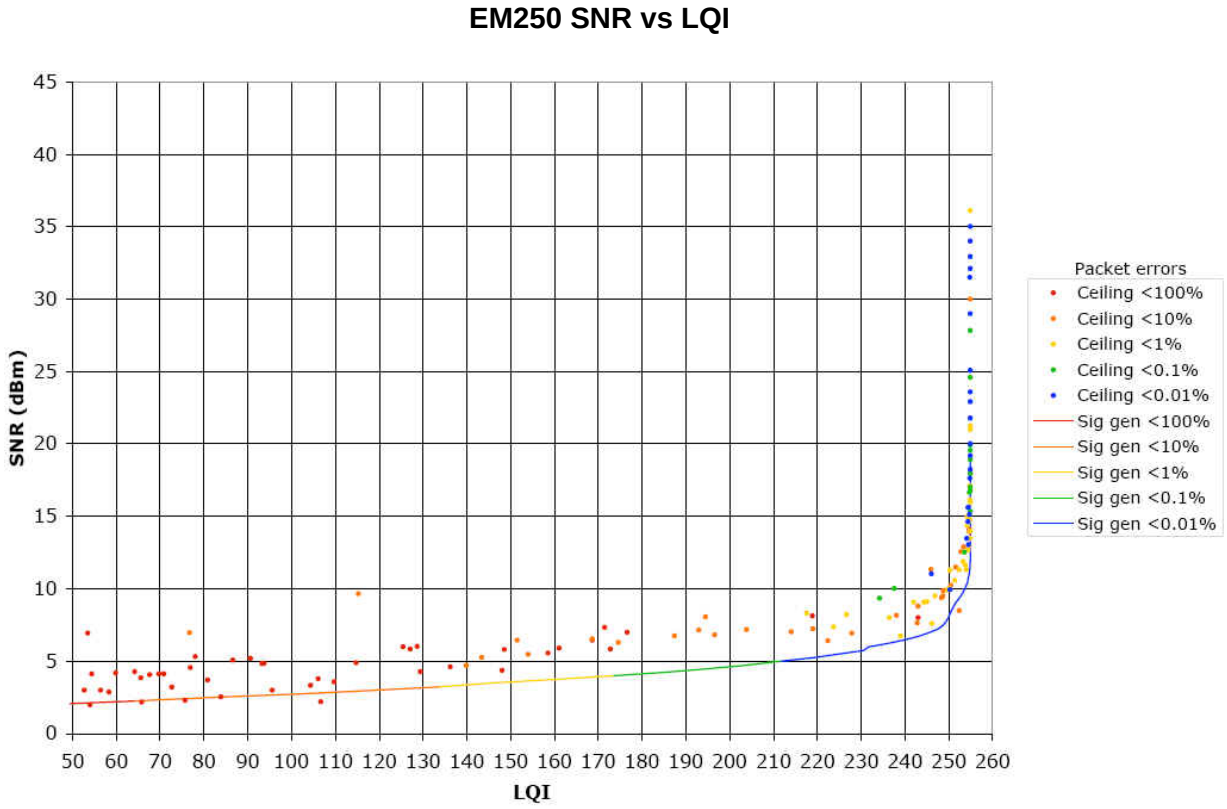

Figure 1: LQI vs. SNR (source : Ember)

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 9: LQI/Cost relationship

7.2 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.

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).

8 Upgrading from R2xx to R300

R300 firmware can be loaded on to an ETRX2 by bootloading through the serial port or by re-flashing with an Ember Insight Adaptor. Cloning over the air is awkward because the new R300 node and the old R2xx node will not join the same PAN. It is possible to clone by using an extra R2xx device, as shown in the step-by-step guide below.

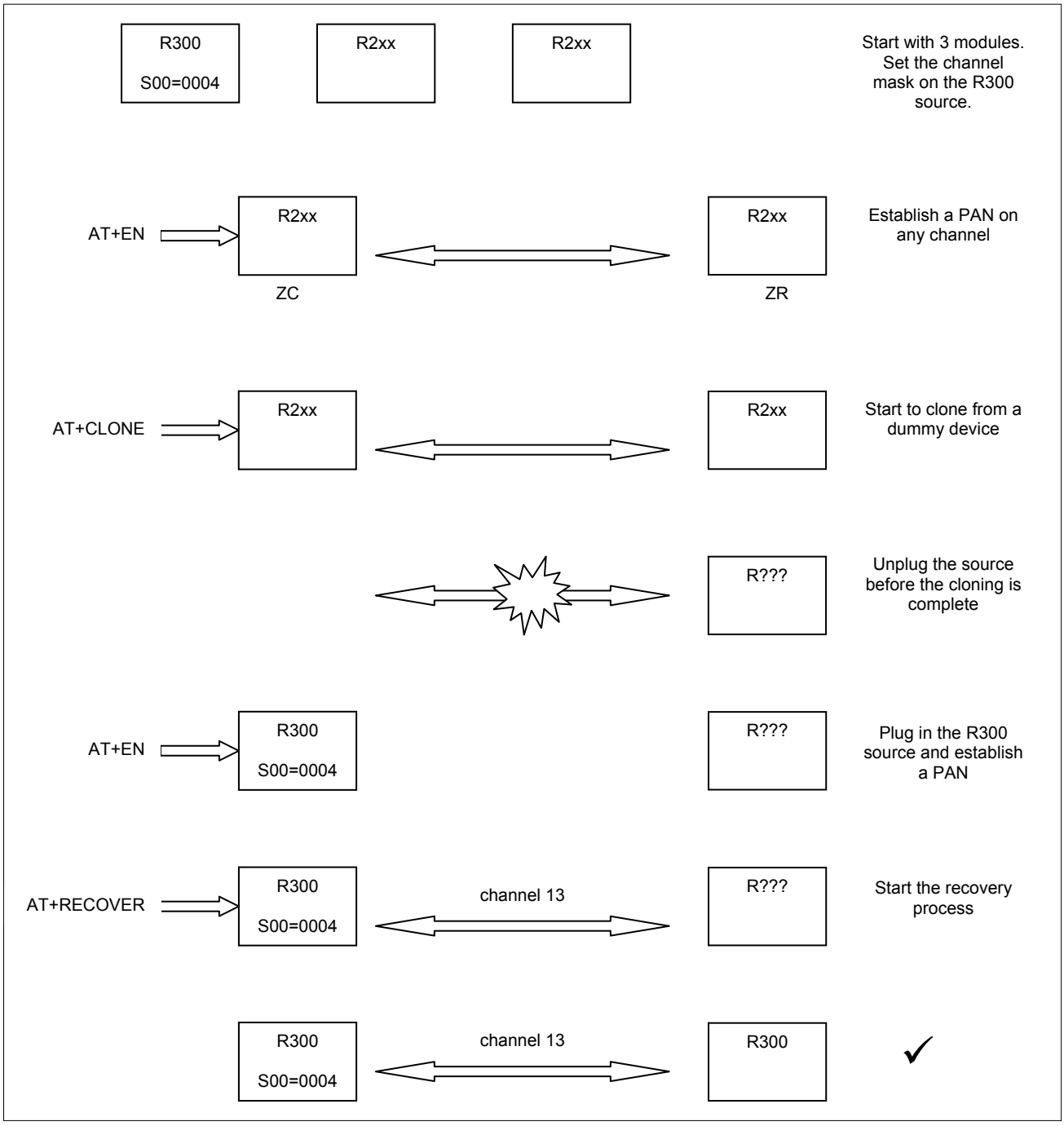

Figure 2. Cloning from an R300 device

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12 References

Telegesis – www.telegesis.com

Ember – www.ember.com