

Telegesis		TG-ETRX-SE-IHD-R100-AT-Commands
ZigBee Smart Energy		SE IHD AT-Command Manual 1.00

Telegesis ZigBee® Modules

Smart Energy In-Premise Display AT Command Manual



Current Firmware R100



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1 Introduction

This document describes the SE IHD R1xx AT Command Set firmware to be used with Telegesis ZigBee PRO wireless meshing modules.

SE IHD AT Command Set provides a simple AT-style command interface to implement the In Premise Display device of the Zigbee Smart Energy Application Profile. Using the AT-Command interface described in this document enables quick development of an In Premise Display device and can shorten the time to market significantly. It enables developers to simply design and build ZigBee Smart Energy compliant products without ever having to do embedded firmware or RF work.

The Telegesis ZigBee 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.

No RF experience or expertise is required to add this powerful wireless networking capability to your products. Telegesis ZigBee Modules 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 SE IHD R1xx 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/ETRX35x Product Manuals

Development Kit User Guides

Application notes from www.telegesis.com

The Product Manuals concentrate 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.

Also, it is highly recommended to refer to the ZigBee Smart Energy Profile specification to further understand the various AT Commands and their usage.

1.2 Zigbee Smart Energy Profile

The ZigBee Smart Energy Profile is an application profile which defines the messages necessary to enable 'smart energy' functionality between metering equipment and Home Area Network (HAN) devices. This includes such activities as reading data from energy or water meters, demand response/load control applications, communicating price signals, and presenting simple information or text messages to consumers via in-home devices.

1.2.1 Smart Energy Devices

Various types of devices can participate in a HAN to enable Smart Energy applications and market programs. Typical devices are listed below:

- **Metering devices, including**
 - electric meters
 - communications modules on gas or water metering equipment
 - sub-metering devices measure energy consumption at a specific outlet in the home
 - thermal energy monitoring devices
- **Programmable Communicating Thermostats** combine the flexibility of modern thermostats, with the ability to curtail HVAC usage to heat and cool homes in a more energy efficient manner.
- **Load Control** devices provide direct load curtailment at a specific service outlet within the home, such as a pool pump, water heater, etc.
- **In Premise Displays** display energy consumption, load profile over time, and pricing data to involve the consumer in an interactive dialog, which informs the consumer of energy management options and potential savings.
- **ESI/Gateways** enable communication between Smart Energy devices inside a home, and provide the customer access to a web portal or other IP-connected services.

1.2.2 In Premise Display

The In-Premise Display device relays energy consumption data to the user by way of a graphical or text display. The display may or may not be an interactive device. At a minimum at least one of the following is displayed: current energy usage, a history over selectable periods, pricing information, or text messages. The display may also show critical pricing information to advise the customer when peaks are due to occur so that they can take appropriate action.

Cluster	Implementation	SE IHD R1xx Support	Description
Simple Metering	Client	Supported	Provides the mechanism to retrieve usage information from Electric, Gas, Water, and Thermal metering devices
Price	Client	Supported	Provides the mechanism for communicating Gas, Energy, or Water pricing information within the premise. This pricing information is distributed to the Energy Service Interface (ESI) from either the utilities or from regional energy providers
Message	Client	Supported	Provides the interface for passing text messages between ZigBee devices. Messages are expected to be delivered via the ESI and then unicast to all individually registered devices implementing this cluster
Key Establishment	Server & Client	Supported	Provides the interface for key establishment between devices for secure communication
Demand Response and Load Control	Client	Not supported	Provides an interface to the functionality of Smart Energy Demand Response and Load Control. Devices targeted by this cluster include thermostats and devices that support load control.

Table 1: Clusters Supported by the In-Premise Display Device

1.3 Compatibility with other devices

The SE IHD R1xx AT-Command line Interpreter is based on the Zigbee Smart Energy R15 specification using the ZigBee PRO feature set of ZigBee 2007. Interoperability with other devices that implement the Smart Energy Application Profile and use the ZigBee PRO feature set is guaranteed.

However SE IHD R1xx is not compatible with devices that do not implement the Smart Energy Profile. Also it is not compatible with earlier version of ZigBee, including the general AT Command Set R3xx and R2xx from Telegesis.

2 AT Style Command Conventions

To simplify the communication with the Telegesis 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>.

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.

All Telegesis ZigBee modules feature 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 2: Types of AT commands

When bit 7 of S12 is set each individual reply or prompts 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 3: Different formats of parameters

2.2 Prompt Overview

The following prompts can show up during the operation of the AT Commandset for Smart Energy in-premise displays.

Prompt Overview	
ACK:XX	Acknowledgement for message with sequence number XX was received
NACK:XX	Acknowledgement for message with sequence number XX was not received
OK	OK terminator
ERROR:XX	Error number XX occurred
LeftPAN	Local Node has left the PAN
LostPAN	End Device has lost contact with Parent
JPAN:<channel>,<PID>,<EPID>	Local Node has joined PAN with given parameters
KE:started	Key establishment procedure has started
KE:success	Key establishment procedure completed successfully
KE:error	Key establishment procedure finished with error
PWRCHANGE:XXXX	Local node has changed Power Mode to XXXX
Meter:<Node ID>,<End Point>	Parameters of each meter found on the PAN
Attach Meter:<Node ID>,<End Point>	Binding created between IHD and meter/ESI
Detach Meter	Binding broken
MATR:<Attribute ID>[,<Optional Params>],<Status>,<Attribute Information>	Meter attributes. See +MTRATR command description for more information.
GP:<End Time>,<Status>,<Profile Interval period>,<No Of Periods Delivered>,<Interval 1><Interval 2>...<Interval N>	Energy consumption for profiling purposes. See +MTRPROFILE command description for more information.
Label:<Tier N>,<Status>,<Price Label>	Price label. See +PRICELBL command description for more information.
Price:<Provider ID>,<Rate Label>,<Event ID>,<Current Time>,<Unit of Measure>,<Currency>,<Price Trailing Digit & Price Tier>,<No of Price Tiers & Register Tier>,<Start Time>,<Duration in Minutes>,<Price>,<Price Ratio>,<Generation Price>,<Generation Price Ratio>	Price information received from the ESI. See +CURPRICE command description for more information.
Message:<Message ID>,<Message Control>,<Start Time>,<Duration in Minutes>,<Message>	Message received from the ESI. See +LASTMSG command description and Table 8 for more information.
Cancel: <Message ID>,<Message Control>	ESI sent a cancel message request where Message ID is 32 bit hexadecimal number defining identifier of message which shall be cancelled, Message Control is 8 bit bitmask including message options, see Table 8 for more information.

Table 4. Prompt overview

2.3 Device Overview

Table 5 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)
ZED	End Device (non sleepy)	ZigBee End Device (ZED)
SED	Sleepy End Device	
MED	Mobile Sleepy end Device	

Table 5: 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 Boot Loader Menu
ATS	S-Register Access
AT+TOKDUMP	Display All S-Registers
AT+ESCAN	Scan The Energy Of All Channels
AT+PANSCAN	Scan For Active PAN's
AT+EN	Establish Personal Area Network
AT+JN	Join Network
AT+JPAN	Join Specific PAN
AT+N	Display Network Information
AT+POLL	Poll For Data From Parent
AT+REJOIN	Rejoin Network
AT+FINDMTR	Finds A Meter/ESI On The HAN
AT+ATTACHMTR	Pairs The IHD To A Meter/ESI
AT+DETACHMTR	Un Pairs The IHD From A Meter/ESI
AT+MTRATR	Gets The Requested Attribute From The Metering Cluster Server
AT+MTRPROFILE	Gets The Energy Consumption For Profiling Purposes (Note: this command is not currently available)
AT+PRICELBL	Gets The Label Assigned To The Price Tier 1 To 6 From The Price Cluster Server
AT+CURPRICE	Gets The Current Pricing From The ESI
AT+SCHPRICE	Gets All The Scheduled Pricing From The ESI
AT+LASTMSG	Gets The Last Message From The ESI
AT+ACKMSG	Used To Acknowledge A Message
AT+SETTIME	Set The Time On The IHD
AT+GETTIME	Get The Time On The IHD
AT+SYNCTIME	Sync The IHD's Clock With The ESI
AT+IDENTIFY	Identify The Meter/ESI On The HAN

Table 6: Command Overview

2.4.1 Module Control & Configuration Commands

I – Display Product Identification Information

Execute Command ATI	Response Telegesis <DeviceName> <Firmware Revision> <EUI64> OK
Note On modules manufactured before summer 2007 an invalid <DeviceName> is displayed. This does not affect the functionality of the module.	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	R100 ●

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	R100 ●

&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 to which it is currently joined.
SW release	R100 ●

+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, and 8 data bits regardless of the current serial port settings.
SW release	R100 ●

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 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	R100 ●

TOKDUMP – Display All S-Registers	
Execute Command AT+TOKDUMP Notes Only used on the local node.	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	R100 ●

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	or ERROR:<errorcode>
Note Scanning all channels can take up to 16 seconds.	<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	R100 ●

+PANSCAN – Scan For Active PANs	
Execute Command AT+PANSCAN	Response +PANSCAN:<channel>,<PID>,<EPID>,XX,b
Use on: All nodes	OK
Note Scanning for active PANs can take up to 16 seconds.	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	R100 ●

+EN – Establish Personal Area Network	
<p>Execute Command AT+EN</p> <p>Use on: All nodes which are not part of a PAN</p> <p>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.</p>	<p>Response JPAN:<channel>,<PID>,<EPID> OK</p> <p>or ERROR:<errorcode></p> <p><errorcode> represents the error code explained in section 3.</p> <p>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</p>
SW release	R100 ●

+JN – Join Network	
<p>Execute Command AT+JN</p> <p>Use on: All nodes which are not part of a PAN</p> <p>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.</p>	<p>Response JPAN:<channel>,<PID>,<EPID> OK</p> <p>KE: Started KE: Success</p> <p>or ERROR:<errorcode></p> <p><errorcode> represents the error code explained in section 3.</p> <p>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.</p>
SW release	R100 ●

+JPAN – Join Specific PAN	
<p>Execute Command AT+JPAN:<channel>,<PID or EPID></p> <p>Examples AT+JPAN:20,1234 AT+JPAN:24,0793E14FFB220A38</p> <p>Use on All nodes which are not part of a PAN</p> <p>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.</p>	<p>Response JPAN:<channel>,<PID>,<EPID> OK</p> <p>KE: Started KE: Success</p> <p>or ERROR:<errorcode></p> <p><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.</p>
SW release	R100 ●

+DASSL – Disassociate Local Device From PAN	
<p>Execute Command AT+DASSL</p> <p>Use on All Devices</p> <p>Note Use with care on a Coordinator. It will not be able to rejoin the PAN</p>	<p>Response OK or ERROR<errorcode></p> <p>Prompt LeftPAN</p> <p><errorcode> represents the error code explained in section 3. Instruct local device to leave the PAN.</p>
SW release	R100 ●

+N – Display Network Information	
<p>Read Command AT+N</p> <p>Use on All Devices</p>	<p>Response +N=<devicetype>=<channel>,<power>,<PID>,<EP ID></p> <p>or +N=NoPAN</p> <p>followed by OK</p> <p><devicetype> represents the node's functionality in the PAN (FFD,COO,ZED,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.</p>
SW release	R100

+POLL – Poll The Parent Device	
Execute Command AT+POLL	Response OK
Poll the parent device for new data.	or
Note: Action 0011 is recommended for periodic polling.	ERROR<errorcode>
Use on SEDs MEDs	<errorcode> represents the error code explained in section 3.
SW release	R100 ●

+REJOIN – Rejoin the network	
Execute Command AT+REJOIN:b	Response OK
If b is set to 0 join without the known network key (unencrypted) and if b is set to 1 join encrypted.	or
	ERROR<errorcode>
Use on SED MED FFD	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.
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.	<errorcode> represents the error code explained in section 3.
SW release	R100 ●

2.4.3 Meter & ESI Discovery Commands

+FINDMTR - Find A Meter/ESI On The HAN

Execute Command
AT+FINDMTR:<Match Criteria>

<Match Criteria> is 1, 2 or 3.

1 - SE Meters devices supporting Simple Metering server cluster
 2 - SE ESI device supporting Price server cluster
 3 - SE ESI device supporting Messaging server cluster

Use
 Carry out the ZigBee Service Discovery to find ZigBee SE devices that support the given match criteria.

Notes
SE device:<Node ID>,<End Point> prompt shall show up for all the Meters/ESI that match

Response
OK
SE device:<Node ID>,<End Point>

or **ERROR:<errorcode>**

<Node ID> - 16 bit hexadecimal number
 <End Point> - 8 bit hexadecimal number

<errorcode> represents the error code explained in section 3.

SW release R100 ●

+ATTACHMTR - Pair The IHD To A Meter/ESI

Execute Command
AT+ATTACHMTR:<Node ID>,<End Point>

<Node ID> - 16 bit hexadecimal number
 <End Point> - 8 bit hexadecimal number

Use
 Create a binding between the IHD and Meter/ESI. All the SE IHD AT Commands shall now be sent to this Meter/ESI.

Notes

- This command does not create an entry in the binding table. It only sets the relevant flags.
- Valid end point is 1 to 240

Response
Attach Meter:<Node ID>,<End Point>
OK

or **ERROR:<errorcode>**

<errorcode> represents the error code explained in section 3.

SW release R100 ●

+DETACHMTR - Unpair The IHD From The Meter/ESI	
Execute Command AT+DETACHMTR	Response Detach Meter OK
Use Break the binding between the IHD and Meter/ESI.	or ERROR:<errorcode> <errorcode> represents the error code explained in section 3.
SW release	R100 ●

2.4.4 Metering Cluster Commands

+MTRATR – Gets The Requested Attribute From The Metering Cluster Server	
<p>Execute Command AT+MTRATR:<Attribute ID>[,<Optional Params>]</p> <p><Attribute ID> - 16 bit hexadecimal number <Optional Params> - decimal number <Status> - 8 bit hexadecimal number <Attribute Information>- hexadecimal number (size depends on the attribute requested)</p> <p>Notes</p> <ul style="list-style-type: none"> • <Status> indicates the result of the requested operation. • <Attribute Information> shall only be valid if <Status> = 0x00. If <Status> indicates error, <Attribute Information> is not returned. • <Optional Params> is not required for all the attributes. If it is valid, it shall be returned in the response. 	<p>Response OK MATR:<Attribute ID>[,<Optional Params>],<Status>,<Attribute Information> or ERROR:<errorcode></p> <p><errorcode> represents the error code explained in section 3.</p> <p>Use this command to get the requested attribute from the metering cluster server on the Meter/ESI. Before using this command discover the Meter/ESI on the HAN using AT+FINDMTR and AT+ATTACHMTR.</p> <p>The Attribute IDs and the information returned are shown in Table 7 below.</p>
SW release	R100

Meter attributes			
Attr ID	Attribute Information	Format	Data item received
0000	Current Summation Delivered	48 bit hexadecimal	Recent summed value of energy delivered to the premise
0001	Current Summation Received	48 bit hexadecimal	Recent summed value of energy generated from the premise
0002	Current Max Demand Delivered	48 bit hexadecimal	Maximum demand of energy delivered to the premise
0003	Current Max Demand Received	48 bit hexadecimal	Maximum demand of energy generated from the premise
0004	DFT Summation	48 bit hexadecimal	Snapshot of the energy delivered at Daily Freeze Time
0005	Daily Freeze Time	16 bit hexadecimal	Daily Freeze Time
0006	Power Factor	signed 8 bit hexadecimal	Average power factor
0007	Reading Snap Shot Time	32 bit hexadecimal	Last time all the parameters were updated
0008	Current Max Demand Delivered Time	32 bit hexadecimal	Last time maximum demand for delivered energy was captured

Meter attributes			
Attr ID	Attribute Information	Format	Data item received
0009	Current Max Demand Received Time	32 bit hexadecimal	Last time maximum demand for energy generated was captured
0100, <Tier N>	Current Tier N Summation Delivered	32 bit hexadecimal	Most recent summed value of energy delivered at a specific price tier N(1 to 6) as defined by the TOU schedule
0101, <Tier N>	Current Tier N Summation Received	48 bit hexadecimal	Most recent summed value of energy generated at a specific price tier N(1 to 6) as defined by the TOU schedule
0200	Meter Status	8 bit bitmap	Bitmap reflecting the status of the meter
0300	Unit of Measure	8 bit enumeration	Unit of measure for the energy measured (from look-up table)
0301	Multiplier	24 bit hexadecimal	Value to be multiplied against all the readings from the meter
0302	Divisor	24 bit hexadecimal	Value to be divided against all the readings from the meter
0303	Summation Formatting	8 bit bitmap	Formatting to be applied to all the summation related readings
0304	Demand Formatting	8 bit bitmap	Formatting to be applied to all the demand related readings
0305	Historical Consumption Formatting	8 bit bitmap	Formatting to be applied to all the historical consumption related readings
0306	Metering Device Type	8 bit bitmap	Type of metering device
0400	Instantaneous Demand	signed 24 bit hexadecimal	Current demand for energy at the premise
0401	Current Day Consumption Delivered	24 bit hexadecimal	Summed value of energy delivered since midnight
0402	Current Day Consumption Received	24 bit hexadecimal	Summed value of energy generated since midnight
0403	Previous Day Consumption Delivered	24 bit hexadecimal	Summed value of energy delivered on the previous day
0404	Previous Day Consumption Received	24 bit hexadecimal	Summed value of energy generated on the previous day
0405	Current Partial Profile Interval Start Time Delivered	32 bit hexadecimal	Start time of the current load profile interval being accumulated for the energy delivered
0406	Current Partial Profile Interval Start Time Received	32 bit hexadecimal	Start time of the current load profile interval being accumulated for the energy generated

Meter attributes			
Attr ID	Attribute Information	Format	Data item received
0407	Current Partial Profile Interval Value Delivered	24 bit hexadecimal	Value of the current load profile interval being accumulated for the energy delivered
0408	Current Partial Profile Interval Value Received	24 bit hexadecimal	Value of the current load profile interval being accumulated for the energy generated
0500	Max No Periods Delivered	8 bit hexadecimal	Maximum no. of intervals the meter is capable of returning in response to AT+MTRPROFILE

Table 7. Meter attribute information

+MTRPROFILE - Get The Energy Consumption For Profiling Purposes	
<p>Execute Command AT+MTRPROFILE:<Interval Channel>,<End Time>,<No Of Periods></p> <p><Interval Channel>- 0 or 1 <End Time>- 32 bit hexadecimal number <No Of Periods>- 8 bit hexadecimal number</p> <p>Note This command is not currently available</p>	<p>Response OK</p> <p>GP:<End Time>,<Status>,<Profile Interval period>,<No Of Periods Delivered>,<Interval 1><Interval 2>...<Interval N></p> <p>or ERROR:<errorcode></p> <p><End Time>- 32 bit hexadecimal number <Status>- 8 bit enumeration <Profile Interval period>- 8 bit enumeration <No Of Periods Delivered>- 8 bit hexadecimal no <Interval N>- 24 bit hexadecimal number</p> <p><errorcode> represents the error code explained in section 3.</p>
SW release	R100 ●

2.4.5 Price Cluster Commands

+PRICELBL - Get The Label Assigned To The Price Tier From The ESI	
<p>Execute Command AT+PRICELBL: <Tier N></p> <p><Tier N> - decimal number 1 to 6</p> <p>Use Get the label assigned to the price tier declared in the price received from the ESI</p> <p>Notes < Price Label> is returned only if <Status> = 0x00</p>	<p>Response OK Label:<Tier N>,<Status>,<Price Label></p> <p>or ERROR:<errorcode></p> <p><Status> - 8-bit hexadecimal number < Price Label> - Character string</p> <p><errorcode> represents the error code explained in section 3.</p>
SW release	R100 ●

+CURPRICE - Get The Current Pricing From The ESI	
<p>Execute Command AT+CURPRICE:<Command Options></p> <p><Command Options> - 0 or 1 0 – don't receive price broadcasts from the ESI 1 – receive price broadcasts from the ESI</p> <p>Use Get the pricing information from the ESI for the current time</p>	<p>Response OK</p> <p>Price:<Provider ID>, <Rate Label>,<Event ID>,<Current Time>,<Unit of Measure>,<Currency>,<Price Trailing Digit & Price Tier>,<No of Price Tiers & Register Tier>,<Start Time>,<Duration in Minutes>,<Price>,<Price Ratio>,<Generation Price>,<Generation Price Ratio></p> <p>or ERROR:<errorcode></p> <p><Provider ID>- 32 bit hexadecimal number <Rate Label>- Character string <Event ID>- 32 bit hexadecimal number <Current Time>- 32 bit hexadecimal number <Unit of Measure>- 8 bit enumeration <Currency>- 16 bit hexadecimal number <Price Trailing Digit & Price Tier>- 8 bit bitmap <No of Price Tiers & Register Tier>- 8 bit bitmap <Start Time>- 32 bit hexadecimal number <Duration in Minutes>- 16 bit hexadecimal number <Price>- 32 bit hexadecimal number <Price Ratio>- 8 bit hexadecimal number <Generation Price>- 32 bit hexadecimal number <Generation Price Ratio>- 8 bit hexadecimal number</p> <p><errorcode> represents the error code explained in section 3.</p>
SW release	R100 ●

+SCHPRICE - Get All The Scheduled Pricing From The ESI	
<p>Execute Command AT+SCHPRICE:<Start Time>,<No Events></p> <p><Start Time> - 32 bit hexadecimal number <No Events> - 8 bit hexadecimal number</p> <p>Use Get all currently scheduled pricing information from the ESI</p> <p>Notes Price: prompt will show up for all the prices received from the ESI</p>	<p>Response OK</p> <p>Price:<Provider ID>, <Rate Label>,<Event ID>,<Current Time>,<Unit of Measure>,<Currency>,<Price Trailing Digit & Price Tier>,<No of Price Tiers & Register Tier>,<Start Time>,<Duration in Minutes>,<Price>,<Price Ratio>,<Generation Price>,<Generation Price Ratio></p> <p>or ERROR:<errorcode></p> <p><Provider ID>- 32 bit hexadecimal number <Rate Label>- Character string <Event ID>- 32 bit hexadecimal number <Current Time>- 32 bit hexadecimal number <Unit of Measure>- 8 bit enumeration <Currency>- 16 bit hexadecimal number <Price Trailing Digit & Price Tier>- 8 bit bitmap <No of Price Tiers & Register Tier>- 8 bit bitmap <Start Time>- 32 bit hexadecimal number <Duration in Minutes>- 16 bit hexadecimal number <Price>- 32 bit hexadecimal number <Price Ratio>- 8 bit hexadecimal number <Generation Price>- 32 bit hexadecimal number <Generation Price Ratio>- 8 bit hexadecimal number</p> <p><errorcode> represents the error code explained in section 3.</p>
SW release	R100 ●

2.4.6 Messaging Cluster Commands

+LASTMSG - Get The Last Message From The ESI	
<p>Execute Command AT+LASTMSG</p> <p>Notes</p> <ul style="list-style-type: none"> • If the received message requires confirmation use AT+ACKMSG • The current active message should be replaced if a new message is received from the ESI 	<p>Response OK Message:<Message ID>,<Message Control>,<Start Time>,<Duration in Minutes>,<Message></p> <p>or ERROR:<errorcode></p> <p><Message ID> - 32 bit hexadecimal number <Message Control> - 8 bit bitmap – see Table 8 <Start Time> - 32 bit hexadecimal number <Duration in Minutes> - 16 bit hexadecimal number <Message> - Character string</p> <p><errorcode> represents the error code explained in section 3.</p>
SW release	R100 ●

+ACKMSG - Acknowledge A Message	
<p>Execute Command AT+ACKMSG:<Message ID></p> <p><Message ID> - 32 bit hexadecimal number</p> <p>Use Send an acknowledgement for the last message received from the ESI</p>	<p>Response OK</p> <p>or ERROR:<errorcode></p> <p><errorcode> represents the error code explained in section 3.</p>
SW release	R100 ●

Message control field bit map			
Bits	Enumeration	Value	Description
Bits 0 to 1	Normal transmission only	0	Send message through normal command
	Normal and Anonymous Inter-PAN transmission	1	Send message through normal command function to client and pass message on to the Anonymous Inter-PAN transmission mechanism.
	Anonymous Inter-PAN transmission only	2	Send message through the Anonymous Inter-PAN transmission mechanism.
	Reserved	3	Reserved value for future use.
Bits 2 to 3	Low	0	Message to be transferred with a low level of importance.
	Medium	1	Message to be transferred with a medium level of importance.
	High	2	Message to be transferred with a high level of importance.
	Critical	3	Message to be transferred with a critical level of importance.
Bits 4 to 6	Reserved	N/A	These bits are reserved for future use.
Bit 7	Message Confirmation	0	Message Confirmation not required.
		1	Message Confirmation required.

Table 8 Message control field bit map

2.4.7 Time Cluster Commands

+SETTIME - Set The Time On The IHD	
<p>Execute Command</p> <p>AT+SETTIME:<year>,<month>,<day>,<hour>,<min>,<sec></p> <p><year>,<month>,<day>,<hour>,<min>,<sec> are all decimal numbers</p> <p>Examples</p> <p>AT+SETTIME:9,03,05,08,15,00 (2009, March 5th 8:15 AM)</p> <p>Notes</p> <ul style="list-style-type: none"> • The year is biased by 2000 and must not be lower than 8 (meaning 2008) • Numbers 1 to 9 have to be entered as 01 to 09 	<p>Response</p> <p>OK</p> <p>or ERROR:<errorcode></p> <p><errorcode> represents the error code explained in section 3.</p>
SW release	R100 ●

+GETTIME - Get The Time On The IHD	
<p>Execute Command</p> <p>AT+GETTIME</p> <p>Use</p> <p>Returns current local time in UTC format.</p>	<p>Response</p> <p>Time:<time></p> <p>OK</p> <p>or ERROR:<errorcode></p> <p><time> - 32 bit hexadecimal value representing IHD local time, number of seconds since 0hours, 0minutes, 0 seconds, on the 1st of January, 2000 UTC</p> <p><errorcode> represents the error code explained in section 3.</p>
SW release	R100 ●

+SYNCTIME - Synchronize The IHD's Clock With The ESI	
<p>Execute Command</p> <p>AT+SYNCTIME</p> <p>Use</p> <p>Synchronize the IHD's clock with the ESI/COO</p>	<p>Response</p> <p>OK</p> <p>or ERROR:<errorcode></p> <p><errorcode> represents the error code explained in section 3.</p>
SW release	R100 ●

2.4.8 Identify Cluster Commands

+IDENTIFY - Identify The Meter/ESI On The HAN	
<p>Execute Command AT+IDENTIFY:<Node ID>,<Time></p> <p><Node ID> - 16 bit hexadecimal number <Time> - 16 bit hexadecimal number</p> <p>Use Used to identify the attached Meter/ESI. The Meter/ESI on receiving this command shall identify itself (for ex: playing a tune) if it supports the Identify Cluster Server.</p> <p>Notes</p> <ul style="list-style-type: none"> • Use AT+ATTACHMTR before sending this command • <Time> is in seconds 	<p>Response OK</p> <p>or ERROR:<errorcode></p> <p><errorcode> represents the error code explained in section 3.</p>
SW release	R100 •

3 List of Error codes

01	Fatal Error, 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
0A	Message could not be sent
0C	Too many characters
0D	License Problem
0E	PAN could not be established because duplicate PAN ID was detected
0F	Fatal error initialising the network
10	Error boot loading
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 boot loader
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
A6	Error in trying to encrypt at APS level. No link key entry in the table for the destination
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
B1	Not attached to a meter
B2	ESI end point not known

4 S-Registers

Most S-Registers of the modules can be read and written. The S-Registers are summarised in the table below.

S-Register Overview		Local 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	(•/-)
S10	Extended Function	(•/•)
S11	Device Specific	(•/•)
S12	UART Setup	(•/•)
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	(•/•)

Table 9: 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.

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 module are restored.

4.2 S-Registers for Network Setup

S00 – Channel Mask	
<p>Description The 802.15.4 channel mask.</p> <p>Operations R/W LOCAL</p> <p>Becomes effective When Joining, Scanning or establishing a PAN</p> <p>Note The channel mask does not affect the AT+JPAN command</p> <p>Storage Non-Volatile</p>	<p>Parameters XXXX</p> <p>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.</p> <p>Range 0001 - FFFF</p> <p>Factory Default FFFF</p>
SW release	R100 ●

S01 – Transmit Power Level	
<p>Description The device transmit power level in dBm.</p> <p>Operations R/W LOCAL</p> <p>Becomes effective When Joining or establishing a PAN</p> <p>Storage Non-Volatile</p>	<p>Parameters snn</p> <p>Where snn represents a signed 8-bit decimal number.</p> <p>Range 4 to -43</p> <p>Setting S01 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.</p> <p>Factory Default 3</p>
SW release	R100 ●

S02 – Preferred PAN ID	
<p>Description The 802.15.4 PAN ID.</p> <p>Operations R/W LOCAL</p> <p>Becomes effective When Joining or establishing a PAN</p> <p>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</p> <p>Storage Non-Volatile</p>	<p>Parameters <PID></p> <p>Where <PID> represents a 16-bit hexadecimal number</p> <p>Range 0000 – FFFF</p> <p>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.</p> <p>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.</p> <p>Factory Default 0000</p>
SW release	R100 ●

S03 – Preferred Extended PAN ID	
<p>Description The extended PAN ID.</p> <p>Operations R/W LOCAL</p> <p>Becomes effective When Joining or establishing a PAN</p> <p>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</p> <p>Storage Non-Volatile</p>	<p>Parameters <EPID></p> <p>Where <EPID> represents a 64-bit hexadecimal number</p> <p>Range 0000000000000000 – FFFFFFFFFFFFFFFF</p> <p>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.</p> <p>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.</p> <p>Factory Default 0000000000000000</p>
SW release	R100 ●

S04 – Local EUI64	
<p>Description The local node's unique EUI64 identifier.</p> <p>Operations R LOCAL</p> <p>Storage Non-Volatile</p>	<p>Parameters <EUI64></p> <p>Range 0000000000000000 – FFFFFFFFFFFFFFFF</p> <p>Factory Default <unique number></p>
SW release	R100 ●

S05 – Local 16-Bit NodeID	
<p>Description The local node's 16-bit NodeID.</p> <p>Note Reading this register while not associated with a network will result in an undefined return value.</p> <p>Operations R LOCAL</p> <p>Storage Non-Volatile</p>	<p>Parameters <NodeID></p> <p>Range 0000-FFFF</p> <p>Factory Default n/a</p>
SW release	R100 ●

S06 – Parent's EUI64	
<p>Description The parent node's unique EUI64 identifier.</p> <p>Note The return value is undefined for nodes without parents (coordinator and nodes that are not joined to a network)</p> <p>Operations R LOCAL</p> <p>Storage Non-Volatile</p>	<p>Parameters <EUI64></p> <p>Range 0000000000000000 – FFFFFFFFFFFFFFFF</p> <p>Factory Default n/a</p>
SW release	R100 ●

S07 – Parent’s 16-Bit NodeID

<p>Description The parent node’s 16-bit NodeID.</p> <p>Operations R LOCAL</p> <p>Note The return value is undefined for nodes without parents (coordinator and nodes that are not joined to a network)</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Parameters <NodeID></p> <p>Range 0000-FFFF</p> <p>Factory Default n/a</p> <p>R100 ●</p>
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S08 – Network Key

<p>Description The network key which can be written using the password. The default password for R1xx is “password”.</p> <p>Operations W LOCAL</p> <p>Write operation ATS08=<key>:<password></p> <p>Becomes effective Only when establishing a PAN</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Range From 0 to 2¹²⁸-1</p> <p>The 128-bit AES network key in hexadecimal representation (32 characters).</p> <p>When set to all 0’s (default) a random network key is generated when establishing a PAN.</p> <p>This key is transmitted to all joining nodes and can be encrypted using the link key.</p> <p>Factory Default 00000000000000000000000000000000</p> <p>R100 ●</p>
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4.3 S-Registers for Module Setup

S0A – Main Function																
<p>Description Defines the behaviour of the Device.</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Write operation ATS0A=XXXX:<Password></p> <p>Note For security reasons this register is password protected. The default password for R1xx is “password”.</p> <p>Storage Non-Volatile</p>	<p>Parameters XXXX</p> <p>Where XXXX represents a 16-bit hexadecimal number.</p> <p>Range 0000 to FFFF</p> <p>Bit E-F: Device Selection</p> <table border="1" data-bbox="858 757 1406 936"> <thead> <tr> <th>Bit F</th> <th>Bit E</th> <th>Device Type</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>Router (FFD)</td> </tr> <tr> <td>1</td> <td>0</td> <td>End Device</td> </tr> <tr> <td>0</td> <td>1</td> <td>Sleepy End Device</td> </tr> <tr> <td>1</td> <td>1</td> <td>Mobile End Device</td> </tr> </tbody> </table> <p>Bit B: Reserved Bit A: Reserved Bit 9: Reserved Bit 8: Set: Use Pre-Configured Trust Centre Link Key when joining Bit 7: Set: Trust centre uses hashed link key Bit 5: Reserved Bit 4: Reserved Bit 3: Reserved Bit 2: Reserved Bit 1: Reserved Bit 0: Set: Don't allow other nodes to join the network using this node as their parent</p> <p>Factory Default 0100</p>	Bit F	Bit E	Device Type	0	0	Router (FFD)	1	0	End Device	0	1	Sleepy End Device	1	1	Mobile End Device
Bit F	Bit E	Device Type														
0	0	Router (FFD)														
1	0	End Device														
0	1	Sleepy End Device														
1	1	Mobile End Device														
SW release	R100 ●															

S0B – User Readable Name	
<p>Description Password protected user defined name which can be used to identify the node</p> <p>Operations R/W LOCAL</p> <p>Write operation ATS0B=<name>:<password></p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p>	<p>Parameters CCCCCCCCCCCCCCCC</p> <p>Name with up to 16 characters.</p> <p>Factory Default Telegesis</p>
SW release	R100 ●

S0C – Password	
<p>Description The local node's password.</p> <p>Operations W LOCAL</p> <p>Write operation ATS0C=<NEW>:<OLD></p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p>	<p>Parameters CCCCCCCC</p> <p>8 case sensitive characters (8 bytes). Note that the password must have exactly 8 characters.</p> <p>Factory Default password</p>
SW release	R100 ●

S0D – Device Information	
<p>Description String containing the module's order code and firmware revision.</p> <p>Operations R LOCAL</p> <p>Storage Non-Volatile</p>	<p>Parameters ccc...ccc</p> <p>Text string</p> <p>Example ETRX2 R100X</p> <p>Factory Default N/A</p>
SW release	R100 ●

S10 – Extended Function	
<p>Description Defines the behaviour of the Device.</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Parameters XXXX</p> <p>Where XXXX represents a 16-bit hexadecimal number.</p> <p>Range 0000 to FFFF</p> <p>Bit D: Reserved Bit C: Reserved Bit B: Reserved Bit A: Reserved Bit 9: Reserved Bit 8: Reserved Bit 7: Reserved Bit 6: Reserved Bit 5: Reserved Bit 4: Reserved Bit 3: Changes to S01 take effect instantly Bit 2: Reserved Bit 1: Reserved Bit 0: Reserved</p> <p>Factory Default 0000</p> <p>R100</p>

S11 – Device Specific	
Description Defines the behaviour of the Device.	Parameters XXXX
Operations R/W LOCAL	Where XXXX represents a 16-bit hexadecimal number.
Becomes effective Instantly	Range 0000 to FFFF
	Bit F (MSB): Reserved Bit E: Set: Enable Boost mode regardless of setting in S01 Bit D: Reserved Bit C: Reserved Bit B: Reserved Bit 9: Reserved Bit 8: Reserved Bit 7: Reserved Bit 6: Reserved Bit 5: Reserved Bit 4: Reserved Bit 3: Reserved Bit 2: Reserved Bit 1: Reserved Bit 0: Reserved
Storage Non-Volatile	Factory Default 0000
SW release	R100

4.4 I/O related S-Registers

S12 – UART Setup

<p>Description The device’s RS232 Baudrate and mode. The default setting of 0500 results in: 19200bps, no parity, 1 stop bit, 8 data bits.</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>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. Note that in case the 128-byte output buffer of the module is full data will be dropped.</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Parameters XXXX</p> <p>Where XXXX represents a 16-bit hexadecimal number.</p> <p>Range of the most significant byte 00 to 0C</p> <p>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</p> <p>Range of the least significant byte 00 to FF</p> <p>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</p> <p>Factory Default 0500</p> <p>R100</p>
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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. The user can pick any of the actions from the list in section 5 of this document and assign them to any event.

Two events are triggered 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 3 of these 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.

S27 – Functionality at Bootup 1	
Description Describes the immediate action taken after boot-up.	Parameters XXXX
Operations R/W LOCAL	If set to 0 the functionality is disabled. Please see section 5 for a list of available functionalities.
Becomes effective Instantly	
Storage Non-Volatile	Factory Default 0000 (none)
SW release	R100 ●

S28 – Functionality at Bootup 2	
Description Describes the immediate action taken after boot-up (and the functionality in S27).	Parameters XXXX
Operations R/W LOCAL	If set to 0 the functionality is disabled. Please see section 5 for a list of available functionalities.
Becomes effective Instantly	
Storage Non-Volatile	Factory Default 0000 (none)
SW release	R100 ●

S29 –Timer/Counter 0	
<p>Description A multi purpose Timer/Counter whose functionality is defined by S2A</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Parameters XXXX</p> <p>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.</p> <p>Factory Default 0004 (1s interval)</p> <p>R100 ●</p>

S2A – Functionality For Timer/Counter 0	
<p>Description Defines the functionality for Timer/Counter 0 events.</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Parameters XXXX</p> <p>If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.</p> <p>Factory Default 8010 (end devices poll parent)</p> <p>R100 ●</p>

S2B –Timer/Counter 1	
<p>Description A multi purpose Timer/Counter whose functionality is defined by S2C</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Parameters XXXX</p> <p>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.</p> <p>Factory Default 0000</p> <p>R100 ●</p>

S2C – Functionality For Timer/Counter 1

<p>Description Defines the functionality for Timer/Counter 1 events.</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Parameters XXXX</p> <p>If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.</p> <p>Factory Default 0000</p> <p>R100 ●</p>
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S2D –Timer/Counter 2

<p>Description A multi purpose Timer/Counter whose functionality is defined by S2E</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Parameters XXXX</p> <p>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.</p> <p>If set to 0 the corresponding functionality is disabled.</p> <p>Factory Default 00F4 (1 min 1s interval)</p> <p>R100 ●</p>
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S2E – Functionality For Timer/Counter 2

<p>Description Defines the functionality for Timer/Counter 2 events.</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Parameters XXXX</p> <p>If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.</p> <p>Factory Default 8014 (leave network if I am alone)</p> <p>R100 ●</p>
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S2F –Timer/Counter 3	
<p>Description A multi purpose Timer/Counter whose functionality is defined by S30</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Parameters XXXX</p> <p>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.</p> <p>Factory Default 00F2 (1min interval)</p> <p>R100 ●</p>

S30 – Functionality For Timer/Counter 3	
<p>Description Defines the functionality for Timer/Counter 3 events.</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Parameters XXXX</p> <p>If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.</p> <p>Factory Default 8015 (if not part of a network do AT+JN)</p> <p>R100 ●</p>

S31 –Timer/Counter 4	
<p>Description A multi purpose Timer/Counter whose functionality is defined by S32</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Parameters XXXX</p> <p>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.</p> <p>Factory Default 0000</p> <p>R100 ●</p>

S32 – Functionality For Timer/Counter 4	
<p>Description Defines the functionality for Timer/Counter 4 events.</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Parameters XXXX</p> <p>If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.</p> <p>Factory Default 0000</p> <p>R100 ●</p>

S33 –Timer/Counter 5	
<p>Description A multi purpose Timer/Counter whose functionality is defined by S34</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Parameters XXXX</p> <p>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.</p> <p>Factory Default 0000</p> <p>R100 ●</p>

S34 – Functionality For Timer/Counter 5	
<p>Description Defines the functionality for Timer/Counter 5 events.</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p> <p>SW release</p>	<p>Parameters XXXX</p> <p>If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.</p> <p>Factory Default 0000</p> <p>R100 ●</p>

S35 –Timer/Counter 6	
<p>Description A multi purpose Timer/Counter whose functionality is defined by S36</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p>	<p>Parameters XXXX</p> <p>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.</p> <p>Factory Default 0000</p>
SW release	R100 ●

S36 – Functionality For Timer/Counter 6	
<p>Description Defines the functionality for Timer/Counter 6 events.</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p>	<p>Parameters XXXX</p> <p>If set to 0 the functionality is disabled. Please see section 5 for a list of the functionality.</p> <p>Factory Default 0000</p>
SW release	R100 ●

S37 –Timer/Counter 7	
<p>Description A multi purpose Timer/Counter whose functionality is defined by S38</p> <p>Operations R/W LOCAL</p> <p>Becomes effective Instantly</p> <p>Storage Non-Volatile</p>	<p>Parameters XXXX</p> <p>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.</p> <p>Factory Default 0000</p>
SW release	R100 ●

S38 – Functionality For Timer/Counter 7	
Description Defines the functionality for Timer/Counter 6 events.	Parameters XXXX
Operations R/W LOCAL	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	R100 ●

S39 – Power Mode	
Description The current power mode of the module	Parameters XXXX
Operations R/W LOCAL	Range 0000 – 0003
Becomes effective Instantly	The module's power level as described in section 6.
Storage Volatile	Factory Default Defined in S3A
SW release	R100 ●

S3A – Initial Power Mode	
Description The module's power mode after start-up and reset.	Parameters XXXX
Operations R/W LOCAL	Range 0000 – 0003
Becomes effective After hard or soft reset	The module's power mode as described in section 6.
Storage Non-Volatile	Factory Default 0000
SW release	R100 ●

5 Built in Functionality

The following table gives an overview of the built-in functionality which can be triggered either at 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 SOA)
...	Reserved
0020	Get the recent summed value of energy delivered to the premise
0021	Get the maximum demand of energy delivered to the premise
0022	Get the most recent summed value of energy delivered at price tier 1 as defined by the TOU schedule
0023	Get the most recent summed value of energy delivered at price tier 1 as defined by the TOU schedule
0024	Get the most recent summed value of energy delivered at price tier 1 as defined by the TOU schedule
0025	Get the most recent summed value of energy delivered at price tier 1 as defined by the TOU schedule
0026	Get the most recent summed value of energy delivered at price tier 1 as defined by the TOU schedule
0027	Get the most recent summed value of energy delivered at price tier 1 as defined by the TOU schedule
0028	Get the current demand for energy at the premise
0029	Get the summed value of energy delivered since midnight
...	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 10 gives the hardware dependent theoretical figures for the ETRX2 as stated in the current hardware manual, whereas Table 11 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 10: 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 11: 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.

EM250 SNR vs LQI

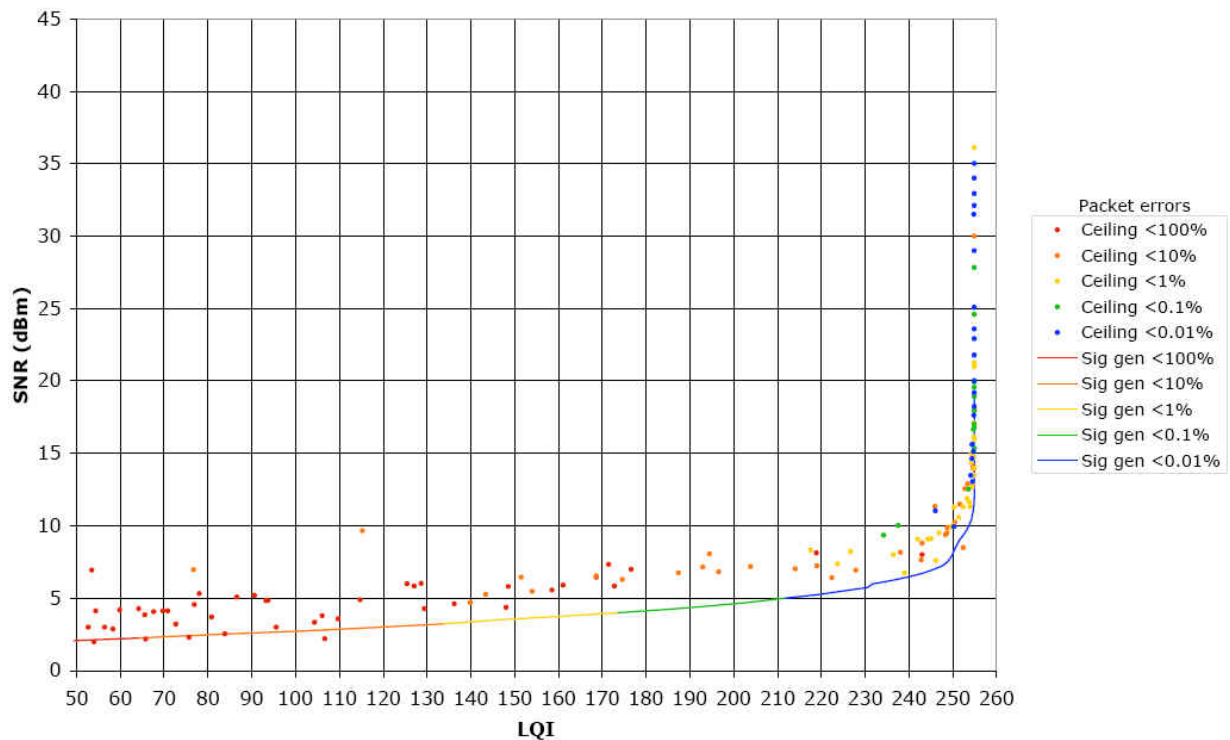


Figure 1: LQI vs. SNR (source: Ember)

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 12: 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 Trademarks

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11 References

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