

Telegesis		TG-PM-0514-sETRX357-LRS r0
sETRX357-LRS family		Product Manual

sETRX357-LRS ZIGBEE® MODULES



PRODUCT MANUAL



Table of Contents

1	INTRODUCTION	5
1.1	Hardware Description.....	5
2	PRODUCT APPROVALS	6
2.1	FCC Approvals.....	6
2.1.1	FCC Labelling Requirements	7
2.2	IC (Industry Canada) Approvals	7
2.2.1	IC Labelling Requirements	8
3	MODULE PIN-OUT	9
3.1	Interface to Optional 8Mbit Flash.....	11
4	HARDWARE DESCRIPTION	12
4.1	Hardware Interface.....	12
5	FIRMWARE DESCRIPTION	13
5.1	Token Settings	14
5.2	Custom Firmware.....	14
5.3	Boost Mode vs. Normal Mode	14
5.4	Software Interface.....	15
6	ABSOLUTE MAXIMUM RATINGS	16
6.1	Environmental Characteristics.....	16
6.2	Recommended Operating Conditions.....	16
7	DC ELECTRICAL CHARACTERISTICS	17
8	DIGITAL I/O SPECIFICATIONS	18
9	A/D CONVERTER CHARACTERISTICS	19
10	AC ELECTRICAL CHARACTERISTICS	19
10.1	TX Power Characteristics.....	21
10.2	Power Settings for Regulatory Compliance	22
11	PHYSICAL DIMENSIONS	23
12	RECOMMENDED REFLOW PROFILE	24
13	PRODUCT LABEL DRAWING	25
13.1	Date Codes.....	26
14	RECOMMENDED FOOTPRINT	27
14.1	Recommended Placement	29
14.2	Example carrier board.....	30
15	RELIABILITY TESTS	31
16	APPLICATION NOTES	31
16.1	Safety Precautions.....	31

16.2	Design Engineering Notes.....	31
16.3	Storage Conditions.....	32
17	PACKAGING	32
18	ORDERING INFORMATION.....	33
19	TRADEMARKS.....	34
20	DISCLAIMER.....	34
21	ROHS DECLARATION.....	34
22	DATA SHEET STATUS	34
23	LIFE SUPPORT POLICY	34
24	RELATED DOCUMENTS	35
25	CONTACT INFORMATION.....	35

Preliminary



Image not shown actual size; enlarged to show detail.

Module Features

- Small form factor, SMT module 23mm x 16mm
- Side Castellations for easy soldering and inspection
- Three antenna options: Integrated chip antenna, U.FL coaxial connector or RF pad
- Based on 32-bit ARM® Cortex-M3
- Industry standard JTAG Programming and real time network level debugging via the Ember Debug Port
- Up to 192kB of flash and 12kB of RAM
- Optional 8Mbit Flash Chip
- Lowest Deep Sleep Current of sub 1µA with retained RAM and GPIO and multiple sleep modes
- Ultra Wide supply voltage range (2.1 to 3.6V; 2.3V to 3.6V on "8" variants)
- Optional 32.768kHz watch crystal can be added externally
- Module ships with standard Telegesis AT-style command interface based on the ZigBee PRO feature set
- Can act as an End Device, Router or Coordinator
- Up to 22 general-purpose I/O lines including analogue inputs
- Firmware upgrades via serial port or over the air (password protected)
- Hardware supported encryption (AES-128)
- FCC and IC modular compliance
- Operating temperature range: -40°C to +85°C

Radio Features

- Based on the Silicon Labs EM357 family of single chip ZigBee® SoCs
- 2.4GHz ISM Band
- 250kbit/s over the air data rate – NB: actual usable data throughput with ZigBee is about 20kbps
- 15 channels (IEEE802.15.4 Channel 11 to 25)
- SiGe SE2432L integrated PA and LNA
- +20dBm output power (adjustable down to -41dBm)
- High sensitivity of -106dBm typ. @ 1% packet error rate
- RX Current: 33mA, TX Current: approx 140mA at 20dBm

The Telegesis sETRX357-LRS family of modules are low power 2.4GHz ZigBee modules with an added frontend module (SiGe SE2432L) containing both PA and LNA for highest possible link budget.

Based on the Silicon Labs EM357 family of single chip ZigBee solutions the new long range modules offer three possible RF output configurations, namely an on board antenna, U.FL coaxial antenna connector or a RF pad. A further option is an 8Mbit flash chip which can be switched off completely for lowest possible power consumption.

The module's unique AT-style command line interface allows designers to quickly integrate ZigBee technology without complex software engineering. For custom application development the sETRX357 series integrates with ease into Ember's InSight development environment.

Suggested Applications

- ZigBee Smart Energy applications
- Wireless Alarms and Security
- Home/Building Automation
- Wireless Sensor Networks
- M2M Industrial Controls
- Lighting and ventilation control
- Remote monitoring
- Environmental monitoring and control

Development Kit

- Development kit containing everything required to set up a mesh network quickly and evaluate range and performance of the sETRX357-LRS.
- AT-style software interface command dictionary can be modified for high volume customers.
- Custom software development available upon request.

Example AT-Style Commands

AT+BCAST	Send a Broadcast
AT+UCAST:<address>	Send a Unicast
AT+EN	Establish PAN network
AT+JN	Join PAN

At power-up the last configuration is loaded from non-volatile S-Registers, which can eliminate the need for an additional host controller.

1 Introduction

This document describes the Telegesis small form factor sETRX357-LRS family of ZigBee long range modules which have been designed to be easily integrated into another device and to provide a fast, simple and low cost wireless mesh networking interface.

The Telegesis sETRX3-LRS series modules are based on the Silicon Labs ZigBee compliant platform consisting of the EM357 single chip family combined with the ZigBee PRO compliant EmberZNet meshing stack. Integration into a wide range of applications is made easy using a simple AT style command interface and advanced hardware design.

The configurable functionality of the Telegesis AT Commandset often allows the sETRX357-LRS series of ZigBee modules to be used without an additional host microcontroller saving even more integration time and costs. In addition to the Telegesis AT Commandset, the sETRX357-LRS family can be used with custom-built firmware whilst representing an ideal platform for custom firmware development in conjunction with the Silicon Labs ZigBee development kits.

No RF experience or expertise is required to add this powerful wireless networking capability to your products. The sETRX357-LRS family offers fast integration opportunities and the shortest possible time to market for your product.

1.1 Hardware Description

The main building blocks of the sETRX357-LRS family are the single chip EM357 SoC from Silicon Labs, a SiGe SE2432L frontend module combining a Power Amplifier with a Low Noise Amplifier, a 24MHz reference crystal and RF front-end circuitry optimized for best RF performance. The modules are available with on-board antenna, a U.FL connector or a RF pad for attaching external antennae. Modules with the U.FL connector are identified by the “HR” suffix, modules with the antenna pad by the “AP” suffix.

The integrated antenna is an Antenova Rufa, and details of the radiation pattern and further data are available from the Antenova website [5].

Module	Chip	Flash	RAM	Antenna	Additional 8Mbit Flash
sETRX37-LRS	EM357	192kB	12kB	Chip	No
sETRX357HR-LRS	EM357	192kB	12kB	External	No
sETRX357AP-LRS	EM357	192kB	12kB	Pad	No
sETRX37-LRS8	EM357	192kB	12kB	Chip	Yes
sETRX357HR-LRS8	EM357	192kB	12kB	External	Yes
sETRX357AP-LRS8	EM357	192kB	12kB	Pad	Yes

Table 1: Order Codes

The LNA and RF power amplifier of the LRS devices improve the output power by 12dB and the sensitivity by 5dB which will increase the range by up to 700% relative to unamplified devices with suitable propagation conditions (where local regulations permit the use of the maximum output power).

The sETRX357 family is used for ZigBee (www.zigbee.org) applications. In case it is desired to develop custom firmware instead of using the pre-loaded AT-Command interface, the Silicon Labs toolchain, consisting of Ember Desktop together with a comprehensive integrated development environment (IDE), is required.

2 Product Approvals

The sETRX357-LRS family has been designed to meet all national regulations for world-wide use. In particular the following certifications have been obtained:

2.1 FCC Approvals

The Telegesis sETRX357-LRS and sETRX357-LRS8 modules with integrated Antenna as well as the sETRX357HR-LRS and sETRX357HR-LRS8 modules including the antennas listed in table 2 and the power levels listed in section 10.2 have been tested to comply with FCC CFR Part 15 (USA) The devices meet the requirements for modular transmitter approval as detailed in the FCC public notice DA00.1407.transmitter.

FCC statement:

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.



FCC ID: S4GSEM357L

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. End users must follow the specific operating instructions for satisfying RF exposure compliance. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Item	Part No.	Manufacturer	Type	Impedance	Gain
1	BT-Stubby (straight)	EAD Ltd. [6]	¼ Wave	50Ω	0dBi
2	BT-Stubby (right-angle)	EAD Ltd. [6]	¼ Wave	50Ω	0dBi
3	CJ-2400-6603	Chang Jia	½ Wave	50 Ω	2.0dBi
4	Rufa (on board)	Antenova	Chip	50Ω	2.1dBi (peak)

Table 2. Approved Antennae

An end user deploying sETRX357-LRS, sETRX357HR-LRS, sETRX357-LRS8 or sETRX357HR-LRS8 modules together with an antenna listed in Table 2 is not required to obtain a new authorization for the module – BUT this does not preclude the possibility that some other form of authorization or testing may be required for the end product depending upon local territorial regulations.

The FCC requires the user to be notified that any changes or modifications made to this device that are not expressly approved by Telegesis (UK) Ltd. may void the user's authority to operate the equipment.

When using the sETRX357-LRS with approved antennae, it is required to prevent end-users from replacing them with non-approved ones. The antenna(s) must be installed such that a minimum

separation distance of 2.6cm is maintained between the radiator (antenna) and all persons at all times.

2.1.1 FCC Labelling Requirements

When integrating the sETRX357-LRS, sETRX357HR-LRS, sETRX357-LRS8 or sETRX357HR-LRS8 modules into a product it must be ensured that the FCC labelling requirements are met. This includes a clearly visible label on the outside of the finished product specifying the Telegesis FCC identifier (**FCC ID: S4GSEM357L**) as well as the notice above. This exterior label can use wording such as “**Contains Transmitter Module FCC ID: S4GSEM357L**” or “**Contains FCC ID: S4GSEM357L**” although any similar wording that expresses the same meaning may be used.

2.2 IC (Industry Canada) Approvals

The Telegesis sETRX357-LRS family with integrated Antenna as well as the sETRX357HR-LRS family have been approved by Industry Canada to operate with the antenna types listed in Table 2 with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

IC-ID: 8735A-SEM357L

- This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.
- Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication.
- This device has been designed to operate with the antennas listed in Table 2, and having a maximum gain of 2.1 dBi. Antennas not included in this list or having a gain greater than 2.1 dBi are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

French Statements

- Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.
- Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

OEM Responsibilities

The sETRX357-LRS and sETRX357HR-LRS families of modules have been certified for integration into products only by OEM integrators under the following conditions:

1. The antenna(s) must be installed such that a minimum separation distance of 2.6cm is maintained between the radiator (antenna) and all persons at all times.
2. The transmitter module must not be co-located or operating in conjunction with any other antenna or transmitter.

As long as the two conditions above are met, further transmitter testing will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

IMPORTANT NOTE: In the event that these conditions can not be met (for certain configurations or co-location with another transmitter), then Industry Canada certification is no longer considered valid and the IC Certification Number can not be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate Industry Canada authorization.

2.2.1 IC Labelling Requirements

The sETRX357-LRS and sETRX357HR-LRS modules are labelled with their own IC Certification Number. As the IC Certification Number is not visible when the module is installed inside another device, the outside of the device into which the module is installed must display a label referring to the enclosed module. In that case, the final end product must be labelled in a visible area with the following:

“Contains Transmitter Module IC: 8735A-SEM357L”

or

“Contains IC: 8735A-SEM357L”

The OEM of the sETRX357-LRS and sETRX357HR-LRS family modules must only use the approved antenna(s) listed above, which have been certified with this module.

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module or change RF related parameters in the user's manual of the end product.

3 Module Pin-out

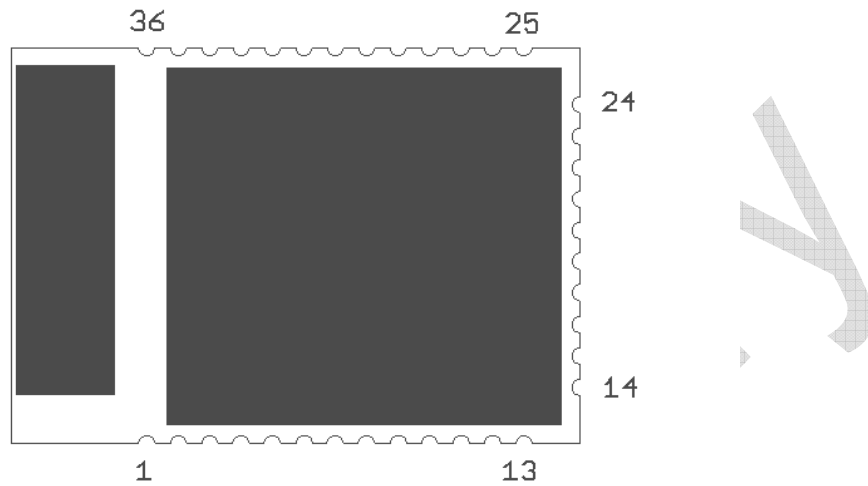


Figure 1. sETRX357-LRS series Module Pin-out (top view)

The table below gives details about the pin assignment for direct SMD soldering of the sETRX357-LRS series modules to the application board. For more information on the alternate functions please refer to [2]. Also refer to the Telegesis AT Command-set documentation to understand how the pre-programmed firmware makes use of the individual I/Os.

All GND pads are connected within the module, but for best RF performance all of them should be grounded externally.

sETRX35x Pad	Name	EM35x Pin	Default use	Alternate Functions
1	GND	GND	GND	
2	GND	GND	GND	
3	PC5 {1}	11		TX_ACTIVE
4	nReset {6}	12	nReset	
5	PC6	13	I/O	OSC32B, nTX_ACTIVE
6	PC7	14	I/O	OSC32A, OSC32_EXT, FLASH_ENABLE{7}
7	GND	GND	GND	GND
8	PA7 {5}	18	I/O	TIM1C4
9	PB3 {2,3}	19	I/O, CTS	SC1nCTS, SC1SCLK, TIM2C3
10	PB4 {2,3}	20	I/O, RTS	TIM2C4, SC1nRTS, SC1nSSEL
11	PA0	21	I/O	TIM2C1, SC2MOSI, Flash MOSI{7}
12	PA1	22	I/O	TIM2C3, SC2SDA, SC2MISO, Flash MISO{7}
13	GND	GND	GND	
14	PA2	24	I/O	TIM2C4, SC2SCL, SC2SCLK, Flash CLK{7}
15	PA3	25	I/O	SC2nSSEL, TRACECLK, TIM2C2, Flash CS{7}
16	PA4	26	I/O	ADC4, PTI_EN, TRACEDATA
17	PA5 {4}	27	I/O	ADC5, PTI_DATA, nBOOTMODE, TRACEDATA3
18	PA6 {5}	29	I/O	TIM1C3
19	PB1 {3}	30	TXD	SC1MISO, SC1MOSI, SC1SDA, SC1TXD, TIM2C1
20	PB2 {3}	31	RXD	SC1MISO, SC1MOSI, SC1SCL, SC1RXD, TIM2C2
21	JTCK	32		SWCLK
22	PC2	33	I/O	JTDO, SWO
23	PC3	34	I/O	JTDI
24	GND	GND	GND	
25	PC4	35	I/O	JTMS, SWDIO
26	n/c	n/c		Reserved, don't connect
27	PC1	38	I/O	ADC3, SWO, TRACEDATA0
28	PC0 {5}	40	I/O	JRST, IRQD, TRACEDATA1
29	PB7 {5}	41	I/O	ADC2, IRQC, TIM1C2
30	PB6 {5}	42	I/O	ADC1, IRQB, TIM1C1
31	n/c	n/c		Reserved, don't connect
32	Vcc	Vcc	Vcc	Supply Voltage
33	GND	GND	GND	
34	RF	n/a		Optional RF Pad
35	GND	GND	GND	
36	GND	GND	GND	

Table 3: Pin Information
Notes:

- {1} When the alternate GPIO function is selected, TX_ACTIVE becomes an output that indicates that the EM35x radio transceiver is in transmit mode. PC5 must be used in this mode as it is used internally as TX_ACTIVE to control the external RF frontend.
- {2} The serial UART connections TXD, RXD, CTS and RTS are PB1, PB2, PB3 and PB4 respectively
- {3} When using the Telegesis AT Commandset, RTS/CTS handshaking is selectable in firmware. See the AT Command Manual.
- {4} If PA5 is driven low at power-up or reset the module will boot up in the bootloader
- {5} PA6, PA7, PB6, PB7 and PC0 can source or sink high current (8mA)
- {6} nRESET is level-sensitive, not edge-sensitive. The module is held in the reset state while nRESET is low
- {7} functionality available on versions with "L" suffix: Optional on chip flash (Winbond W25Q80BLUXIG)

Alternate functions depend on the firmware, but the Telegesis R3xx AT Command-set functions are indicated here for convenience.

3.1 Interface to Optional 8Mbit Flash

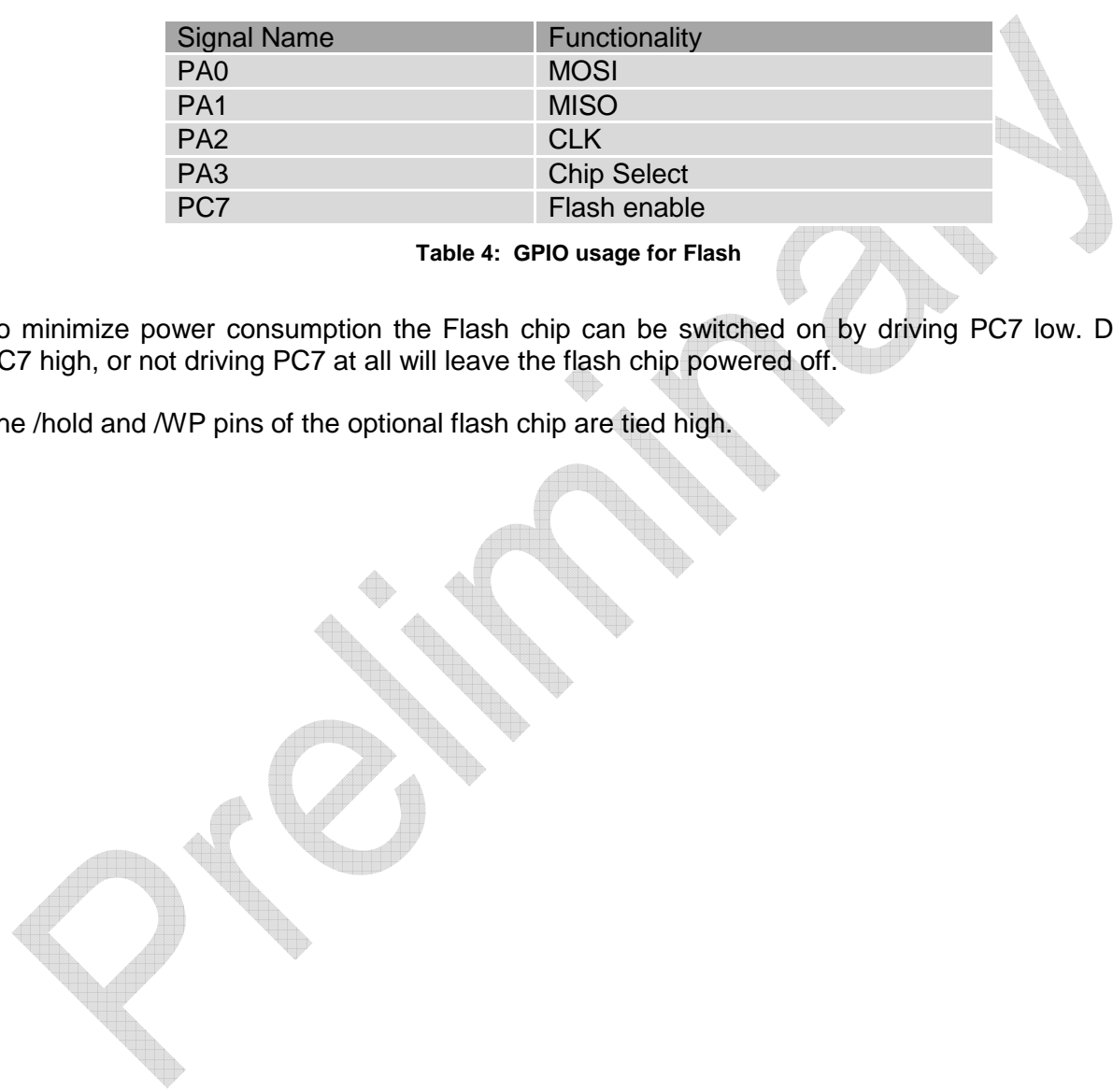
Table 4 shows the connectivity to the optional Winbond W25Q80BLUXIG 8Mbit SPI flash chip which is fitted to all module variants with the “8” suffix.

Signal Name	Functionality
PA0	MOSI
PA1	MISO
PA2	CLK
PA3	Chip Select
PC7	Flash enable

Table 4: GPIO usage for Flash

To minimize power consumption the Flash chip can be switched on by driving PC7 low. Driving PC7 high, or not driving PC7 at all will leave the flash chip powered off.

The /hold and /WP pins of the optional flash chip are tied high.



4 Hardware Description

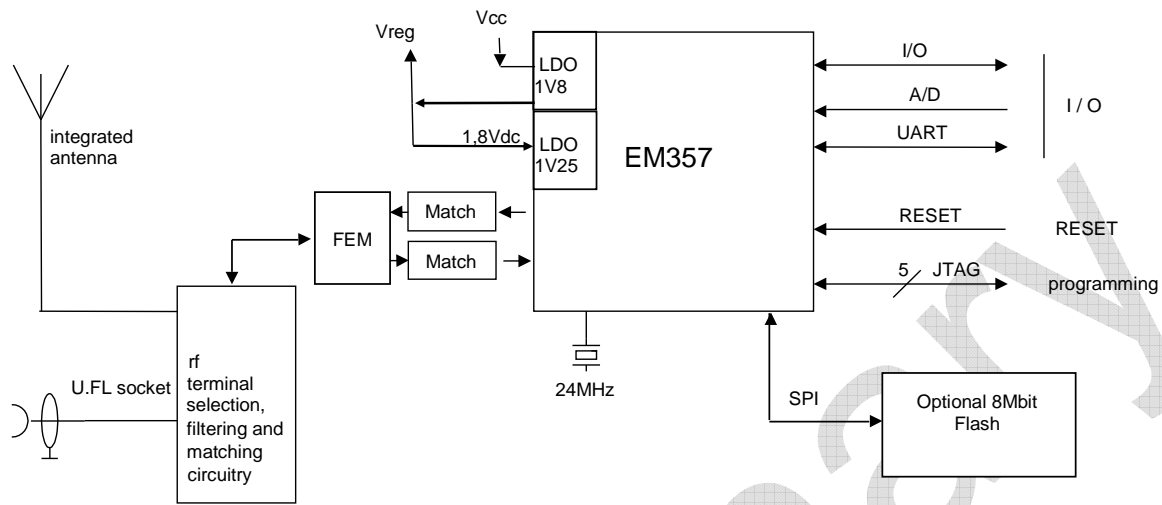


Figure 2. Block Diagram

The sETRX357-LRS family of modules are based on the Silicon Labs EM357 family of ZigBee SoCs plus a frontend module containing a PA, LNA and RF switch in addition to the RF antenna matching circuitry. The EM357 family of ZigBee SoCs are fully integrated 2.4GHz ZigBee transceivers with a 32-bit ARM® Cortex M3™ microprocessor, flash and RAM memory, and peripherals.

The industry standard serial wire and JTAG programming and debugging interfaces together with the standard ARM system debug components help to streamline any custom software development.

In addition to this a number of MAC functions are also implemented in hardware to help maintain the strict timing requirements imposed by the ZigBee and IEEE802.15.4 standards.

The new advanced power management features allow faster wakeup from sleep and new power-down modes allow this 3rd generation module to offer a longer battery life than any 2nd generation modules on the market.

The EM357 has fully integrated voltage regulators for both required 1.8V and 1.25V supply voltages. The voltages are monitored (brown-out detection) and the built in power-on-reset circuit eliminates the need for any external monitoring circuitry. A 32.768kHz watch crystal can be connected externally to pads 3 and 4 in case more accurate timing is required.

4.1 Hardware Interface

All GPIO pins of the EM357 chip are accessible on the module's pads. Whether signals are used as general purpose I/Os, or assigned to a peripheral function like ADC is set by the firmware. When using the Telegesis AT Commandset please refer to the AT Commandset manual and the development kit manual for this information and when developing custom firmware please refer to the EM357 datasheet [2].

5 Firmware Description

By default, the modules will be pre-loaded with a standalone bootloader which supports over-the-air bootloading as well as serial bootloading of new firmware.

In order to enter the standalone bootloader using a hardware trigger pull PA5 to ground and power-cycle or reset the module. To avoid entering the standalone bootloader unintentionally make sure not to pull this pin down during boot-up unless the resistance to ground is $>10k\Omega$. (A pull-up is not required).

In addition to the standalone bootloader the modules also contain the current release of the Telegesis AT-style command interface as described in the Telegesis AT command dictionary and the Telegesis user guide. Check www.telegesis.com for updates. Each module comes with a unique 64-bit 802.15.4 identifier which is stored in non-volatile memory. The commands and responses pass through the serial port of the sETRX357-LRS as ASCII text, so a simple terminal application will usually suffice. We provide Telegesis Terminal for interaction with the module but it is not an essential feature.

The pre-loaded AT-style command interface firmware is based on the latest EmberZNet PRO meshing stack which implements routers/coordinators as well as (sleepy) end devices. [End devices have no routing responsibility and therefore are allowed to go to sleep, whilst still being able to send and receive messages via a parent router. In addition to classical sleepy and non-sleepy end devices the module firmware also supports mobile (sleepy) end devices capable of changing their parent quickly whenever they change their position within the network.]

A router is typically a mains powered device whilst a sleepy end device (SED) can be battery powered.

The module is also able to act as a coordinator and Trust Centre through external host control. The AT style command line supplies all the tools required to set up and manage a ZigBee network by allowing easy access to the low-level functionality of the stack.

The Telegesis firmware uses the meshing and self-healing EmberZNet PRO stack to overcome many of the limitations of the tree network topology of the ZigBee 2006 stack by using the ZigBee PRO featureset.

The Telegesis firmware allows low-level access to physical parameters such as channel and power level. Parameters that define the functionality of the sETRX357-LRS module and also allow standalone functionality are saved in non-volatile memory organised in so-called S-Registers. The SPI and I2C buses are not supported by the current firmware release, but can be used with custom firmware.

5.1 Token Settings

The sETRX357-LRS series modules' manufacturing tokens will be pre-programmed with the settings shown in the table below.

Token	Description	TG Default
MFG_CIB_OBS	Option Bytes	<not written>
MFG_CUSTOM_VERSION	Optional Version Number	<not written>
MFG_CUSTOM_EUI_64	Custom EUI	<not written>
MFG_STRING	Device Specific String	TELEGESIS
MFG_BOARD_NAME	Hardware Identifier	<Order Code>
MFG_MANUF_ID	Manufacturer ID	0x1010
MFG_PHY_CONFIG	Default Power Settings	0xFFFD
MFG_BOOTLOAD_AES_KEY	Bootloader Key	<not written>
MFG_EZSP_STORAGE	EZSP related	<not written>
MFG_CBKE_DATA	SE Security	<not written>
MFG_INSTALLATION_CODE	SE Installation	<not written>
MFG_OSC24M_BIAS_TRIM	Crystal Bias	<not written>
MFG_SYNTH_FREQ_OFFSET	Frequency offset	<not written>
MFG_OSC24M_SETTLE_DELAY	Crystal Stabilizing Time	<not written>
MFG_SECURITY_CONFIG	Security Settings	<not written>
MFG_CCA_THRESHOLD	CCA Threshold	0xFEBF
MFG_SECURE_BOOTLOADER_KEY	Secure Bootloader Key	<not written>

Table 5. Manufacturing tokens

5.2 Custom Firmware

For high volume customers the firmware can be customised on request. In addition to this the sETRX357-LRS series of modules is an ideal platform for developing custom firmware. In order to develop custom firmware the Silicon Labs Ember toolchain is required.

When writing firmware for the sETRX357-LRS it is important to ensure that pins PB0 and PC5 are correctly configured in order that the RF front-end module can operate correctly. The application note "Writing customised firmware for the ETRX357-LRS" which can be downloaded from the Telegesis website is also applicable to the sETRX357-LRS.

5.3 Boost Mode vs. Normal Mode

The Ember EM357 chips support a "boost mode" power setting next to the "normal mode" power setting. The "boost mode" setting increases the sensitivity and output power of the radio transceiver, however with the LRS variants enabling boost mode has no positive effect on either the output power or the sensitivity and therefore it is recommended to not use boost mode on this platform. The Telegesis AT Command-set firmware automatically disables boost mode on LRS series modules and adjusts the power maximum power settings.

Section 10.2 lists the requirements for the maximum power settings for use of the LRS family in different countries.

5.4 Software Interface

Using the default firmware the sETRX357-LRS is controlled using a simple AT-style command interface and (mostly) non-volatile S-Registers. In order to get a full listing of all the available AT-Commands, please refer to the AT command dictionary document which corresponds to the firmware revision you intend to use.

In addition to the command dictionary there are user guides explaining the features of the firmware in more detail. If you need to find out which firmware resides on your module simply type "**ATI**" followed by a carriage return and you will be prompted with the module's manufacturing information.

The Development Kit manual describes how to upgrade the firmware either via a serial link or over the air.

Preliminary

6 Absolute Maximum Ratings

No.	Item	Symbol	Absolute Maximum Ratings	Unit
1	Supply voltage	V_{CC}	-0.3 to +3.6	Vdc
2	Voltage on any Pad	V_{in}	-0.3 to $V_{CC} + 0.3$	Vdc
3	Voltage on any Pad pin (PA4, PA5, PB5, PB6, PB7, PC1), when used as an input to the general purpose ADC with the low voltage range selected	V_{in}	-0.3 to +2.0	Vdc
4	Storage temperature range	T_{stg}	-40 to +105	°C
5	Operating temperature range	T_{op}	-40 to +85	°C
6	Input RF level	P_{max}	+6	dBm
8	Reflow temperature	T_{Death}	Please refer to chapter 12	°C

Table 6: Absolute Maximum Ratings

The absolute maximum ratings given above should under no circumstances be violated. Exceeding one or more of the limiting values may cause permanent damage to the device.



Caution! ESD sensitive device. Precautions should be used when handling the device in order to prevent permanent damage.

6.1 Environmental Characteristics

No.	Item	Symbol	Absolute Maximum Ratings	Unit
1	ESD on any pad according to Human Body Model (HBM) circuit description	V_{THBM}	±2	kV
2	ESD on non-RF pads according to Charged Device Model (CDM) circuit description	V_{THCDM}	±400	V
3	ESD on RF terminal (HBM)	V_{THCDM}	1000	V
4	Moisture Sensitivity Level	MSL	MSL3, per J-STD-033	

Table 7: Absolute Maximum Ratings

6.2 Recommended Operating Conditions

No.	Item	Condition / Remark	Symbol	Value			Unit
				Min	Typ	Max	
1	Supply voltage		V_{CC}	2.1 or 2.3	3.0	3.6	Vdc
2	RF Input Frequency		f_c	2405		2480	MHz
3	RF Input Power		P_{IN}			0	dBm
4	Operating temperature range		T_{op}	-40		+85	°C

Table 8. Recommended Operating Conditions

7 DC Electrical Characteristics

$V_{CC} = 3.0V$, $T_{AMB} = 25^{\circ}C$, NORMAL MODE (non-Boost) unless otherwise stated

No.	Item	Condition / Remark	Symbol	Value			Unit
				Min	Typ	Max	
1	Module supply voltage	Without 8Mbit flash (non "8" suffix)	V_{CC}	2.1		3.6	Vdc
2	Module supply voltage	With 8Mbit optional flash ("8" variants)	V_{CC}	2.3		3.6	Vdc
Deep Sleep Current							
3	Quiescent current, internal RC oscillator disabled,		I_{SLEEP}		0.6		μA
4	Quiescent current, internal RC oscillator enabled		I_{SLEEP}		0.7		μA
5	Quiescent current, including 32.768kHz oscillator		I_{SLEEP}		1.5		μA
6	Additional Current in case flash chip is enabled, but in power-down on variants with "8" suffix		$I_{FlashSleep}$		1	5	μA
7	Additional Current in case flash chip is enabled, but in standby-on variants with "8" suffix		$I_{FlashSleep}$		25	50	μA
Reset Current							
8	Quiescent current nReset asserted		I_{RESET}		2	3	mA
Processor and Peripheral Currents							
9	ARM [®] Cortex [™] M3, RAM and flash memory	25 [°] C, 12MHz Core clock	I_{MCU}		6.5		mA
10	ARM [®] Cortex [™] M3, RAM and flash memory	25 [°] C, 24MHz Core clock	I_{MCU}		7.5		mA
11	Serial controller current	Per serial controller at max. clock rate	I_{SC}		0.2		mA
12	General purpose timer current	Per timer at max. clock rate	I_{TIM}		0.25		mA
13	General purpose ADC current	Max. Sample rate, DMA	I_{ADC}		1.1		mA
14	Flash Write current of 8Mbit flash ("8" suffix)		$I_{FLASHWRITE}$		20	25	mA
RX Current							
15	Receive current consumption	Total, 12MHz clock speed	I_{RX}		30		mA
16	Receive current consumption	Total, 24MHz clock speed	I_{RX}		31.5		mA
TX Current							
17	Transmit current consumption	at +20dBm module output power	I_{TXVCC}		140		mA
18	Transmit Current consumption	at min module output power	I_{TXVCC}		52		mA

Table 9: DC Electrical Characteristics

8 Digital I/O Specifications

The digital I/Os of the sETRX357-LRS module have the ratings shown below.

$V_{CC} = 3.0V$, $T_{AMB} = 25^{\circ}C$, NORMAL MODE unless otherwise stated

No.	Item	Condition / Remark	Symbol	Value			Unit
				Min	Typ	Max	
1	Low Schmitt switching threshold	Schmitt input threshold going from high to low	V_{SWIL}	$0.42 \times V_{CC}$		$0.5 \times V_{CC}$	Vdc
2	High Schmitt switching threshold	Schmitt input threshold going from low to high	V_{SWIH}	$0.62 \times V_{CC}$		$0.8 \times V_{CC}$	MHz
3	Input current for logic 0		I_{IL}			-0.5	μA
4	Input current for logic 1		I_{IH}			0.5	μA
5	Input Pull-up resistor value		R_{IPU}	24	29	34	k Ω
6	Input Pull-down resistor value		R_{IPD}	24	29	34	k Ω
7	Output voltage for logic 0	$I_{OL} = 4mA$ (8mA) for standard (high current) pads	V_{OL}	0		$0.18 \times V_{CC}$	V
8	Output voltage for logic 1	$I_{OH} = 4mA$ (8mA) for standard (high current) pads	V_{OH}	$0.82 \times V_{CC}$		V_{CC}	V
9	Output Source Current	Standard current pad	I_{OHS}			4	mA
10	Output Sink current	Standard current pad	I_{OLS}			4	mA
11	Output Source Current	High current pad (1)	I_{OHH}			8	mA
12	Output Sink current	High current pad (1)	I_{OLH}			8	mA
13	Total output current		$I_{OH} + I_{OL}$			40	mA

Table 10. Digital I/O Specifications

No.	Item	Condition / Remark	Symbol	Value			Unit
				Min	Typ	Max	
1	Low Schmitt switching threshold	Schmitt input threshold going from high to low	V_{SWIL}	$0.42 \times V_{CC}$		$0.5 \times V_{CC}$	Vdc
2	High Schmitt switching threshold	Schmitt input threshold going from low to high	V_{SWIH}	$0.62 \times V_{CC}$		$0.68 \times V_{CC}$	Vdc
3	Input current for logic 0		I_{IL}			-0.5	μA
4	Input current for logic 1		I_{IH}			0.5	μA
5	Input Pull-up resistor value	Chip not reset	R_{IPU}	24	29	34	k Ω
6	Input Pull-up resistor value	Chip reset	$R_{IPURESET}$	12	14.5	17	k Ω

Table 11. nReset Pin Specifications

Notes

1) High current pads are PA6, PA7, PB6, PB7, PC0

9 A/D Converter Characteristics

The ADC is a first-order sigma-delta converter. For additional information on the ADC please refer to the EM358x datasheet.

No.	Item	
1	A/D resolution	Up to 14 bits
2	A/D sample time for 7-bit conversion	5.33µs (188kHz)
3	A/D sample time for 14-bit conversion	682µs
4	Reference Voltage	1.2V

Table 12. A/D Converter Characteristics

10 AC Electrical Characteristics

$V_{CC} = 3.0V$, $T_{AMB} = 25^{\circ}C$, NORMAL MODE measured at 50Ω terminal load connected to the U.FL socket

No.	Receiver	Value			Unit
		Min	Typ	Max	
1	Frequency range	2400		2500	MHz
2	Sensitivity for 1% Packet Error Rate (PER)	-107	-106	-100	dBm
4	Saturation (maximum input level for correct operation)	-3	2		dBm
5	High-Side Adjacent Channel Rejection (1% PER and desired signal -82dBm acc. to [1])		41		dB
6	Low-Side Adjacent Channel Rejection (1% PER and desired signal -82dBm acc. to [1])		40		dB
7	2 nd High-Side Adjacent Channel Rejection (1% PER and desired signal -82dBm acc. to [1])		54		dB
8	2 nd Low-Side Adjacent Channel Rejection (1% PER and desired signal -82dBm acc. to [1])		52		dB
9	Channel Rejection for all other channels (1% PER and desired signal -82dBm acc. to [1])		tbd		dB
10	802.11g rejection centred at +12MHz or -13MHz (1% PER and desired signal -82dBm acc. to [1])		tbd		dB
11	Co-channel rejection (1% PER and desired signal -82dBm acc. to [1])		tbd		dBc
12	Relative frequency error (2x40ppm required by [1])	-120		120	ppm
13	Relative timing error (2x40ppm required by [1])	-120		120	ppm
14	Linear RSSI range	35			dB
15	Output power at highest power setting NORMAL MODE BOOST MODE	20 20	21 21	21.5 21.5	dBm
16	Output power at lowest power setting			-40	dBm
17	Error vector magnitude as per IEEE802.15.4		7	15	%

Table 13. AC Electrical Characteristics

Please Note: For the relationship between EM357 power settings and module output power please refer to chapter 10.1 of this document. When developing custom firmware the output power settings described in this document relate directly to the EM357 power settings accessible via the Ember stack API. When using the Telegesis AT Command-set firmware the settings

mentioned in this document directly relate to the settings in the S-Register S01 which is used for setting the output power.

No.	Synthesiser Characteristics	Limit			Unit
		Min	Typ	Max	
22	Frequency range	2400		2500	MHz
23	Frequency resolution		11.7		kHz
24	Lock time from off state, with correct VCO DAC settings			100	µs
25	Relock time, channel change or Rx/Tx turnaround			100	µs
26	Phase noise at 100kHz offset		-71dBc/Hz		
27	Phase noise at 1MHz offset		-91dBc/Hz		
28	Phase noise at 4MHz offset		-103dBc/Hz		
29	Phase noise at 10MHz offset		-111dBc/Hz		

Table 14. Synthesiser Characteristics

No.	Power On Reset (POR) Specifications	Limit			Unit
		Min	Typ	Max	
30	V _{CC} POR release	0.62	0.95	1.2	Vdc
31	V _{CC} POR assert	0.45	0.65	0.85	Vdc

Table 15. Power On Reset Specifications

No.	nRESET Specifications	Limit			Unit
		Min	Typ	Max	
32	Reset Filter Time constant	2.1	12	16	µs
33	Reset Pulse width to guarantee a reset	26			µs
34	Reset Pulse width guaranteed not to cause reset	0		1	µs

Table 16. nReset Specifications

10.1 TX Power Characteristics

The diagrams below show the typical output power and module current as a function of sETRX357-LRS power setting in NORMAL MODE at 3.6V and room temperature.

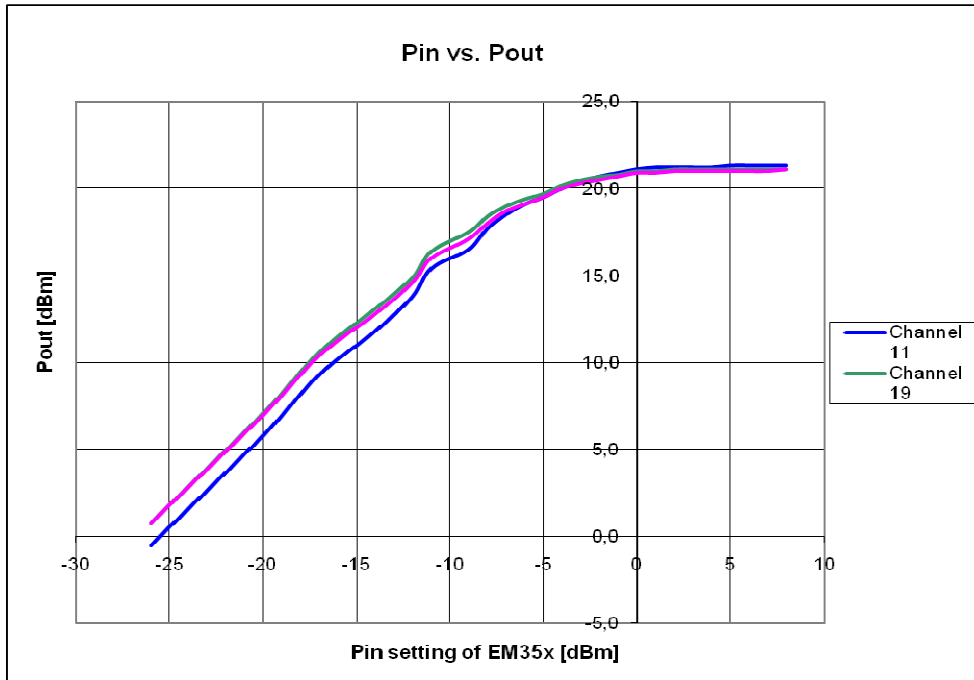


Figure 3. Output Power vs. Power Setting

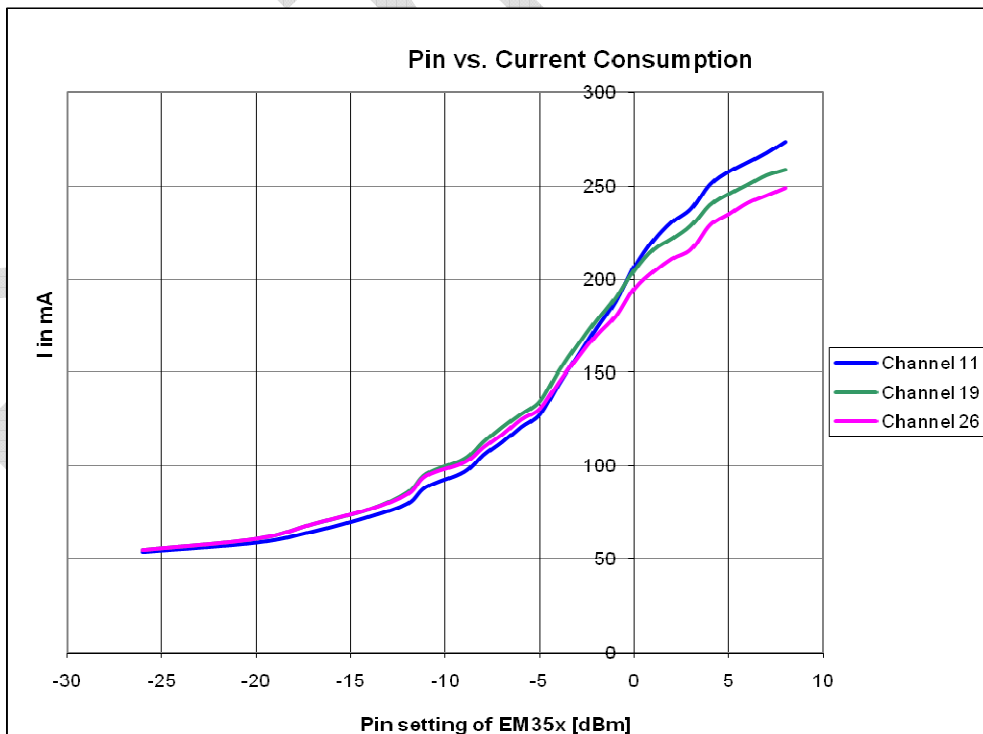


Figure 4. Module Current vs. Power Setting

10.2 Power Settings for Regulatory Compliance

Because of the high gain of the frontend module output power of up to 22dBm can be achieved. When the antenna gain is included the output power of the sETRX357-LRS transceivers needs to be reduced for regulatory compliance. The following tables list the maximum permitted power setting for the antenna types listed in Table 2. Note that this is the power out of the EM357 chip (set in register S01 when using Telegesis R3xx firmware), and the power delivered to the antenna will be higher by the gain of the RF power amplifier.

Antenna	Channels 11-18	Channels 19-24	Channel 25	Channel 26
1/2 Wave	-9	-9	-9	-43
1/4 Wave	-8	-8	-8	-26
On Board	-7	-7	-8	-26

Table 17: Maximum Power Settings for FCC, IC Compliance

Preliminary

11 Physical Dimensions

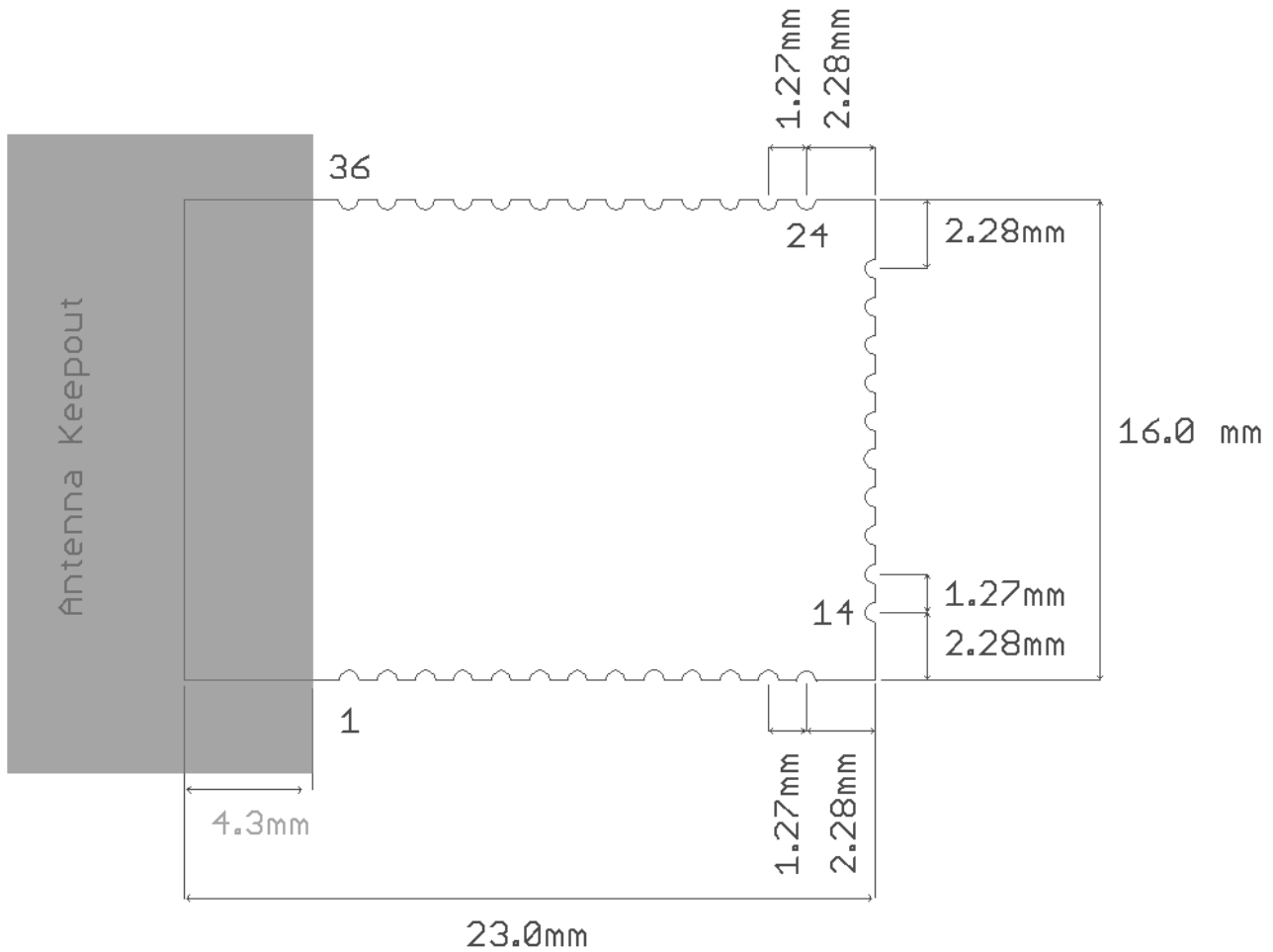


Figure 5. ETRX3 Physical Dimensions

For ideal RF performance when using the on-board antenna, the antenna should stick out from the carrier PCB. There should be no components, tracks or copper planes in the “keep-out” area which should be as large as possible. When using the U.FL RF connector or the Rf pad the “keep-out” area does not have to be kept. **NB:** The modules’ transmit/receive range will depend on the antenna used and also the housing of the finished product.

12 Recommended Reflow Profile

Recommended temperature profile for reflow soldering

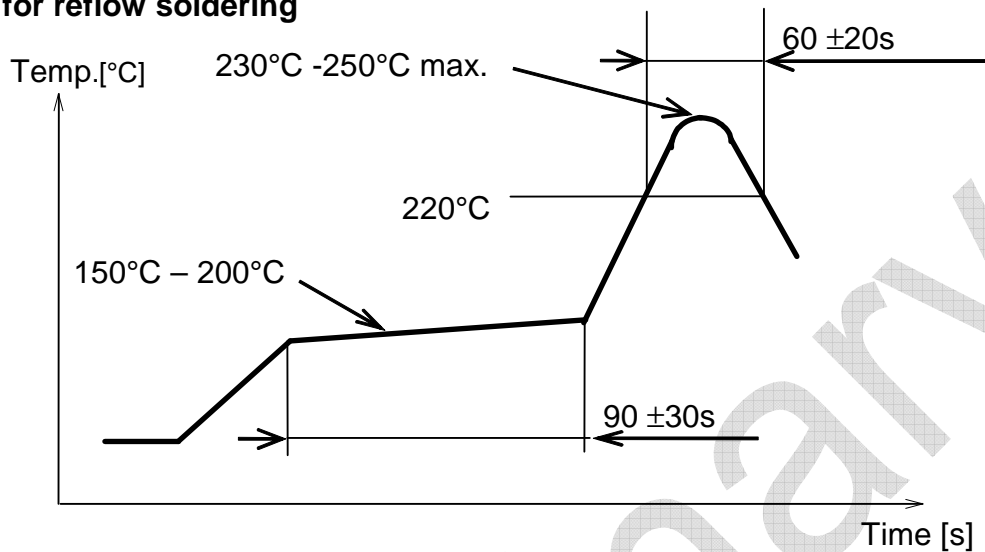


Figure 6. Recommended Reflow Profile

Use of “No-Clean” solder paste is recommended to avoid the requirement for a cleaning process. Cleaning the module is strongly discouraged because it will be difficult to ensure no cleaning agent and other residuals are remaining underneath the shielding can as well as in the gap between the module and the host board.

Please Note:

Maximum number of reflow cycles: 2

Opposite-side reflow is prohibited due to the module’s weight. (i.e. you must not place the module on the bottom / underside of your PCB and re-flow).

13 Product Label Drawing



Figure 7. Product Label

The label dimensions are 9.5mm x 9.5mm. The label will withstand temperatures used during reflow soldering.

Imprint	Description
sETRX357-LRS8	Module Order code Possible codes are: - sETRX357-LRS - sETRX357HR-LRS - sETRX357AP-LRS - sETRX357-LRS8 - sETRX357HR-LRS8 - sETRX357AP-LRS8
000D6F0012345678	Indication for the serial number.
E2	Production Date Code
01	Indication for factory ID
02	Indication for the hardware revision
2D-Barcode	Information in the 2D-Barcode are the serial number [16 characters], the Part-Order code, identifier for the batch number [2 characters], the identifier for the hardware release [2 characters] and the production date code [2 characters], all separated by a semicolon.

Table 18. sETRX357-LRS Label Details

Due to the limited space on the label the FCC and IC IDs are printed on the bottom side of the sETRX357-LRS module family.

13.1 Date Codes

The date codes are set up as follows:

Year 1st / Month 2nd char.

E1	01.01.2014
E2	01.02.2014
E3	01.03.2014
E4	01.04.2014
E5	01.05.2014
E6	01.06.2014
E7	01.07.2014
E8	01.08.2014
E9	01.09.2014
EO	01.10.2014
EN	01.11.2014
ED	01.12.2014
F1	01.01.2015
F2	01.02.2015
F3	01.03.2015
F4	01.04.2015
F5	01.05.2015
F6	01.06.2015
F7	01.07.2015

Preliminary

14 Recommended Footprint

In order to surface mount a sETRX357-LRS series module, we recommend that you use pads which are 0.86mm wide and 1.5mm high. Unless using the “HR” or “AP” variants it should be insured that the antenna area is not on top of the carrier PCB

For best RF performance it is required to provide good ground connections to the ground pads of the module. It is recommended to use multiple vias between each ground pad and a solid ground plane to minimize inductivity in the ground path.

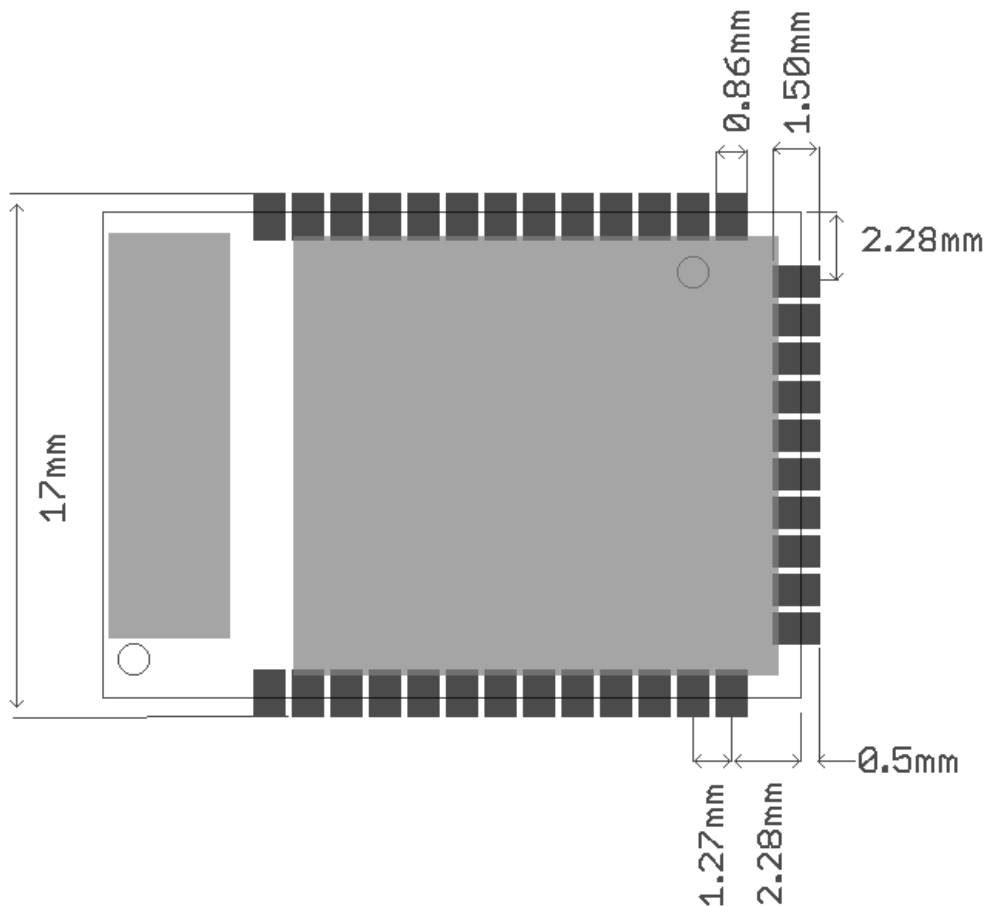


Figure 8. Recommended Footprint

The land pattern dimensions above serve as a guideline.

We recommend that you use the same pad dimensions for the solder paste screen as you have for the copper pads. However these sizes and shapes may need to be varied depending on your soldering processes and your individual production standards. We recommend a paste screen thickness of 120µm to 150µm.

Figure 11 shows the typical pad dimensions of the module and Figure -Figure in section 14.1 show examples of how to align the module on its host PCB.

Although the undersides of the sETRX357-LRS series modules are fully coated, no exposed copper, such as through-hole vias, planes or tracks on your board component layer, should be located below the sETRX357-LRS series module in order to avoid 'shorts'. All sETRX357-LRS series modules use a multilayer PCB containing an inner RF shielding ground plane, therefore there is no need to have an additional copper plane directly under the sETRX357-LRS series module.

tbd

Figure 95. Typical pad dimensions

Finally it is recommended to use no clean flux when soldering the sETRX357-LRS family of modules and to not use a washing process after reflow. If the process does require washing then care must be taken that no washing agent is trapped underneath the shielding can after the drying process has completed.

Preliminary

14.1 Recommended Placement

tbd

Figure 10. Typical placement

tbd

Figure 11. How to not place the Module

tbd

Figure 12. Adding a no copper / no component area

Preliminary

14.2 Example carrier board

Since the RF performance of the module with the on board antenna is strongly dependent on the proper location of the module on its carrier board, Figure 6 shows the reference carrier board which was used during testing by Telegesis.

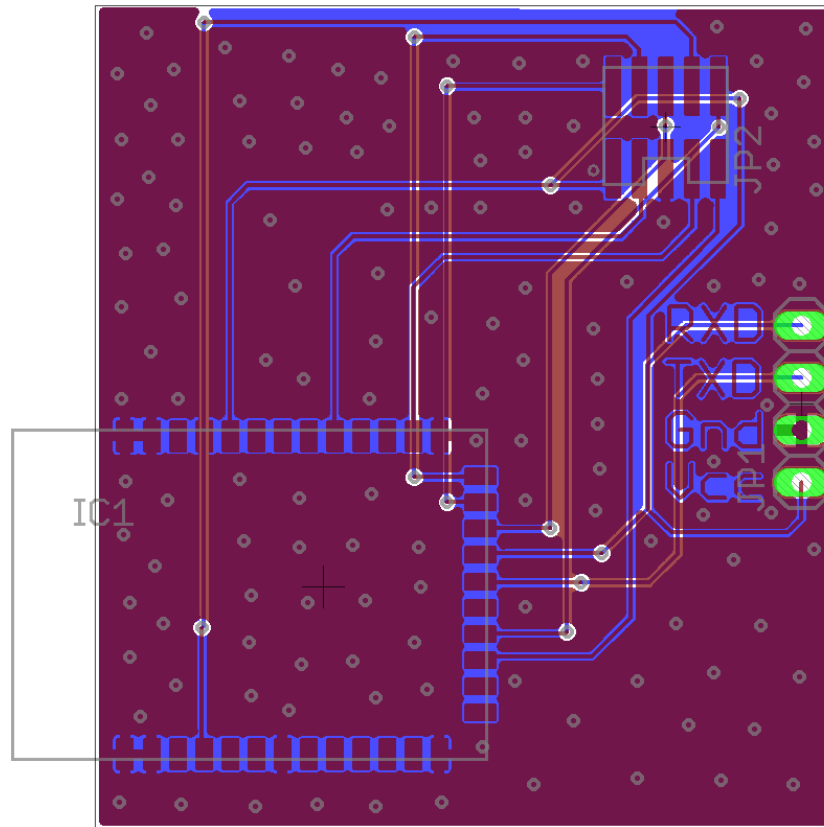


Figure 6: Reference Board

Finally to provide a good reference ground to the on board antenna, the carrier board should have a ground plane spanning no less than 40 x 40mm. In many cases a smaller ground plane will suffice, but a degradation in radio performance could be the result.

15 Reliability Tests

The following measurements have been conducted after the module has been exposed to standard room temperature and humidity for 1 hour.

No	Item	Limit	Condition
1	Vibration test	Electrical parameter should be in specification	Freq.:40Hz,Amplitude:1.5mm 20min. / cycle,1hrs. each of X and Y axis
2	Shock test	the same as the above	Dropped onto hard wood from height of 50cm for 10 times
3	Heat cycle test	the same as the above	-40°C for 30min. and +85°C for 30min.; each temperature 300 cycles
5	Low temp. test	the same as the above	-40°C, 300h
6	High temp. test	the same as the above	+85°C, 300h

Table 19: Reliability Tests

16 Application Notes

16.1 Safety Precautions

These specifications are intended to preserve the quality assurance of products as individual components.

Before use, check and evaluate their operation when mounted on your products. Abide by these specifications when using the products. These products may short-circuit. If electrical shocks, smoke, fire, and/or accidents involving human life are anticipated when a short circuit occurs, then provide the following failsafe functions as a minimum:

- (1) Ensure the safety of the whole system by installing a protection circuit and a protection device.
- (2) Ensure the safety of the whole system by installing a redundant circuit or another system to prevent a single fault causing an unsafe status.

16.2 Design Engineering Notes

- (1) Heat is the major cause of shortening the life of these products. Avoid assembly and use of the target equipment in conditions where the product's temperature may exceed the maximum allowable.
- (2) Failure to do so may result in degrading of the product's functions and damage to the product.
- (3) If pulses or other transient loads (a large load applied in a short time) are applied to the products, before use, check and evaluate their operation when assembled onto your products.
- (4) These products are not intended for other uses, other than under the special conditions shown below. Before using these products under such special conditions, check their performance and reliability under the said special conditions carefully, to determine whether or not they can be used in such a manner.

- (5) In liquid, such as water, salt water, oil, alkali, or organic solvent, or in places where liquid may splash.
- (6) In direct sunlight, outdoors, or in a dusty environment
- (7) In an environment where condensation occurs.
- (8) In an environment with a high concentration of harmful gas (e.g. salty air, HCl, Cl₂, SO₂, H₂S, NH₃, and NO_x)
- (9) If an abnormal voltage is applied due to a problem occurring in other components or circuits, replace these products with new products because they may not be able to provide normal performance even if their electronic characteristics and appearances appear satisfactory.
- (10) Mechanical stress during assembly of the board and operation has to be avoided.
- (11) Pressing on parts of the metal cover or fastening objects to the metal cover is not permitted.

16.3 Storage Conditions

- (1) The module must not be stressed mechanically during storage.
- (2) Do not store these products in the following conditions or the performance characteristics of the product, such as RF performance, may well be adversely affected:
 - (3) Storage in salty air or in an environment with a high concentration of corrosive gas, such as Cl₂, H₂S, NH₃, SO₂, or NO_x
 - (4) Storage (before assembly of the end product) of the modules for more than one year after the date of delivery at your company even if all the above conditions (1) to (3) have been met, should be avoided.

17 Packaging

The modules will be delivered on trays. Tbd.

18 Ordering Information

Ordering/Product Code	Description
sETRX357-LRS sETRX357-LRS8	Power amplified Telegesis Wireless Mesh Networking Module with Silicon Labs ZigBee Technology: <ul style="list-style-type: none"> • Based on Silicon Labs EM357 SoC • Telegesis AT Style Command Interpreter based on • EmberZNet meshing and self-healing ZigBee PRO stack • Integrated 2.4GHz Antenna
sETRX357HR-LRS sETRX357HR-LRS	Power amplified Telegesis Wireless Mesh Networking Module with Silicon Labs ZigBee Technology: <ul style="list-style-type: none"> • Based on Silicon Labs EM357 SoC • Telegesis AT Style Command Interpreter based on • EmberZNet meshing and self-healing ZigBee PRO stack • U.FL coaxial Antenna Connector
sETRX357AP-LRS sETRX357AP-LRS	Power amplified Telegesis Wireless Mesh Networking Module with Silicon Labs ZigBee Technology: <ul style="list-style-type: none"> • Based on Silicon Labs EM357 SoC • Telegesis AT Style Command Interpreter based on • EmberZNet meshing and self-healing ZigBee PRO stack • RF Pad
sETRX357DVK (to be announced)	Telegesis Development Kit with: <ul style="list-style-type: none"> • 3 x ETRX3DVK Development Boards • 3 x USB cables • 3 x sETRX357-LRS on carrier boards • 3 x sETRX357HR-LRS on carrier boards • 1 x ETRX3USB USB stick • 3 x ½-wave antennae • 3 x ¼-wave antennae

Notes:

- Customers' PO's must state the Ordering/Product Code.
- There are no un-programmed versions of the sETRX357-LRS modules available. All Modules are pre-programmed with the Telegesis AT style command interpreter based on the EmberZNet stack. (In case it is desired to program custom firmware the pre-programmed firmware can simply be overwritten).

19 Trademarks

All trademarks, registered trademarks and products names are the sole property of their respective owners.

20 Disclaimer

Product and company names and logos referenced may either be trademarks or registered trademarks of their respective companies. We reserve the right to make modifications and/or improvements without prior notification. All information is correct at time of issue. Telegesis (UK) Ltd does not convey any license under its patent rights or assume any responsibility for the use of the described product

21 RoHS Declaration

Declaration of environmental compatibility for supplied products:

Hereby we declare to our best present knowledge based on the declaration of our suppliers that this product does not contain any of the substances which are banned by Directive 2011/65/EU (RoHS)

22 Data Sheet Status

Telegesis (UK) Ltd. reserves the right to change the specification without notice, in order to improve the design and supply the best possible product. Please consult the most recently issued data sheet before initiating or completing a design.

23 Life Support Policy

This product is not designed for use in life support appliances, devices, or systems where malfunction can reasonably be expected to result in a significant personal injury to the user, or as a critical component in any life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness. Customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Telegesis (UK) Ltd. for any damages resulting.

24 Related Documents

- [1] IEEE Standard 802.15.4 –2003 Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (LR-WPANS)
- [2] Datasheet EM35x, Ember. (www.ember.com)
- [3] Datasheet U.FL-Series 2004.2 Hirose Ultra Small Surface Mount Coaxial Connectors - Low Profile 1.9mm or 2.4mm Mated Height
- [4] The ZigBee specification (www.zigbee.org)
- [5] Specification for Antenova Rufa Antenna (www.antenova.com)
- [6] Embedded Antenna design Ltd. (EAD Ltd.) (www.ead-ltd.com)

25 Contact Information

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