

# Cinterion<sup>®</sup> LTE Terminals

Hardware Interface Description

Version: 06  
DocId: ELSxT\_HID\_v06



Document Name: **Cinterion® LTE Terminals Hardware Interface Description**

Version: **06**

Date: **2019-02-26**

DocId: **ELSxT\_HID\_v06**

Status **Confidential / Preliminary**

**GENERAL NOTE**

THE USE OF THE PRODUCT INCLUDING THE SOFTWARE AND DOCUMENTATION (THE "PRODUCT") IS SUBJECT TO THE RELEASE NOTE PROVIDED TOGETHER WITH PRODUCT. IN ANY EVENT THE PROVISIONS OF THE RELEASE NOTE SHALL PREVAIL. THIS DOCUMENT CONTAINS INFORMATION ON GEMALTO M2M PRODUCTS. THE SPECIFICATIONS IN THIS DOCUMENT ARE SUBJECT TO CHANGE AT GEMALTO M2M'S DISCRETION. GEMALTO M2M GMBH GRANTS A NON-EXCLUSIVE RIGHT TO USE THE PRODUCT. THE RECIPIENT SHALL NOT TRANSFER, COPY, MODIFY, TRANSLATE, REVERSE ENGINEER, CREATE DERIVATIVE WORKS; DISASSEMBLE OR DECOMPILE THE PRODUCT OR OTHERWISE USE THE PRODUCT EXCEPT AS SPECIFICALLY AUTHORIZED. THE PRODUCT AND THIS DOCUMENT ARE PROVIDED ON AN "AS IS" BASIS ONLY AND MAY CONTAIN DEFICIENCIES OR INADEQUACIES. TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, GEMALTO M2M GMBH DISCLAIMS ALL WARRANTIES AND LIABILITIES. THE RECIPIENT UNDERTAKES FOR AN UNLIMITED PERIOD OF TIME TO OBSERVE SECRECY REGARDING ANY INFORMATION AND DATA PROVIDED TO HIM IN THE CONTEXT OF THE DELIVERY OF THE PRODUCT. THIS GENERAL NOTE SHALL BE GOVERNED AND CONSTRUED ACCORDING TO GERMAN LAW.

**Copyright**

Transmittal, reproduction, dissemination and/or editing of this document as well as utilization of its contents and communication thereof to others without express authorization are prohibited. Offenders will be held liable for payment of damages. All rights created by patent grant or registration of a utility model or design patent are reserved.

Copyright © 2019, Gemalto M2M GmbH, a Gemalto Company

**Trademark Notice**

Gemalto, the Gemalto logo, are trademarks and service marks of Gemalto and are registered in certain countries. Microsoft and Windows are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries. All other registered trademarks or trademarks mentioned in this document are property of their respective owners.

## Contents

|          |  |           |
|----------|--|-----------|
| <b>0</b> | <b>Document History .....</b>                  | <b>8</b>  |
| <b>1</b> | <b>Introduction .....</b>                      | <b>10</b> |
| 1.1      | Related Documents .....                        | 11        |
| 1.2      | Terms and Abbreviations .....                  | 11        |
| 1.3      | Regulatory and Type Approval Information ..... | 13        |
| 1.3.1    | Directives and Standards .....                 | 13        |
| 1.3.2    | Safety Precautions .....                       | 16        |
| 1.4      | Product Label .....                            | 18        |
| <b>2</b> | <b>Product Concept .....</b>                   | <b>20</b> |
| 2.1      | Key Features at a Glance .....                 | 20        |
| <b>3</b> | <b>Interface Description .....</b>             | <b>24</b> |
| 3.1      | Overview .....                                 | 24        |
| 3.2      | Block Diagram.....                             | 25        |
| 3.3      | Terminal Circuit.....                          | 26        |
| 3.4      | Operating Modes .....                          | 27        |
| 3.5      | RS-232 Interface.....                          | 28        |
| 3.5.1    | 9-Pole D-sub Connector .....                   | 28        |
| 3.6      | GPIO Interface .....                           | 29        |
| 3.6.1    | Serial Interface ASC1 .....                    | 32        |
| 3.6.2    | Digital Audio Interface (ELS61T-E2).....       | 33        |
| 3.6.3    | I <sup>2</sup> C Interface .....               | 37        |
| 3.6.4    | SPI Interface .....                            | 38        |
| 3.6.5    | PWM Interface .....                            | 39        |
| 3.6.6    | Pulse Counter .....                            | 39        |
| 3.6.7    | Analog-to-Digital Converter (ADC).....         | 39        |
| 3.6.8    | DSR0 signal .....                              | 39        |
| 3.7      | Ethernet Interface .....                       | 40        |
| 3.8      | Power Supply .....                             | 41        |
| 3.9      | Power Up/Power Down Scenarios .....            | 42        |
| 3.9.1    | Turn LTE Terminals on .....                    | 42        |
| 3.9.2    | Reset/Restart LTE Terminals.....               | 42        |
| 3.9.3    | Turn LTE Terminals off .....                   | 43        |
| 3.9.4    | Disconnecting power supply .....               | 43        |
| 3.10     | Automatic thermal shutdown.....                | 44        |
| 3.11     | Hardware Watchdog .....                        | 44        |
| 3.12     | RTC.....                                       | 44        |
| 3.13     | SIM Interface.....                             | 45        |
| 3.14     | Status LEDs .....                              | 46        |
| 3.15     | RF Antenna Interface.....                      | 47        |

---

|          |   |           |
|----------|---|-----------|
| <b>4</b> | <b>Electrical and Environmental Characteristics</b> .....   | <b>48</b> |
| 4.1      | Absolute Maximum Ratings .....                              | 48        |
| 4.2      | Electrical Specifications of the Application Interface..... | 49        |
| 4.2.1    | On/Off Control.....   | 49        |
| 4.2.2    | RS-232 Interface.....                                       | 49        |
| 4.2.3    | GPIO Interface .....  | 50        |
| 4.2.4    | Ethernet Interface .....                                    | 51        |
| 4.3      | Maximum Power Supply Ratings .....                          | 52        |
| 4.4      | Operating Temperatures .....                                | 56        |
| 4.5      | Antenna Interface.....                                      | 57        |
| 4.6      | Storage Conditions .....                                    | 60        |
| <b>5</b> | <b>Mechanics, Mounting and Packaging</b> .....              | <b>61</b> |
| 5.1      | Mechanical Dimensions .....                                 | 61        |
| 5.2      | Mounting the LTE Terminals.....                             | 64        |
| 5.3      | Packaging .....   | 65        |
| <b>6</b> | <b>Full Type Approval</b> .....                             | <b>66</b> |
| 6.1      | Gemalto M2M Reference Setup .....                           | 66        |
| 6.2      | Restrictions .....  | 67        |
| 6.3      | CE Conformity.....  | 67        |
| 6.4      | EMC.....  | 67        |
| 6.5      | Compliance with FCC and IC Rules and Regulations .....      | 68        |
| 6.6      | Compliance with Japanese Rules and Regulations.....         | 70        |
| <b>7</b> | <b>List of Parts and Accessories</b> .....                  | <b>71</b> |
| <b>8</b> | <b>Appendix A: (Hardware) Watchdog</b> .....                | <b>72</b> |
| 8.1      | Reset Conditions.....                                       | 73        |
| 8.1.1    | Reset stages .....  | 73        |
| 8.1.2    | Reset Delay .....   | 74        |
| 8.2      | Restart Conditions .....                                    | 74        |
| 8.3      | Complete Watchdog Configuration .....                       | 75        |
| 8.3.1    | Watchdog (WD) Command Specification .....                   | 75        |
| 8.4      | Qualified Watchdog Configuration .....                      | 85        |
| 8.4.1    | I <sup>2</sup> C Interface Command Specification .....      | 85        |
| 8.5      | Configuring GPIO Directions.....                            | 90        |
| 8.5.1    | Configuration using I <sup>2</sup> C Interface .....        | 91        |
| 8.5.2    | Configuration using TXD0 Line of ASC0 Interface.....        | 92        |

---

|          |   |           |
|----------|---|-----------|
| <b>9</b> | <b>Appendix B: Ethernet Setup and Usage .....</b> | <b>93</b> |
| 9.1      | Connection Setup .....                            | 93        |
| 9.2      | Connection Usage .....                            | 95        |
| 9.2.1    | Access LTE Terminal via Telnet (or SSH) .....     | 95        |
| 9.2.2    | Access LTE Terminal via FTP .....                 | 96        |
| 9.2.3    | Security Notes.....                               | 97        |
| 9.2.4    | Configure IP Address.....                         | 97        |
| 9.2.5    | Edit APN List.....                                | 97        |
| 9.2.6    | Enter SIM Pin.....                                | 98        |
| 9.2.7    | Transparent Data Exchange .....                   | 98        |
| 9.2.8    | Update LTE Module Firmware .....                  | 99        |
| 9.2.9    | Update Ethernet Sub-System Software .....         | 99        |

## Tables

|           |   |    |
|-----------|---|----|
| Table 1:  | Cinterion® LTE Terminals overview .....   | 10 |
| Table 2:  | Terms and abbreviations.....  | 11 |
| Table 3:  | Directives .....  | 13 |
| Table 4:  | Standards of North American type approval .....   | 13 |
| Table 5:  | Standards of European type approval.....  | 13 |
| Table 6:  | Standards of Japanese type approval.....  | 14 |
| Table 7:  | Requirements of quality .....   | 14 |
| Table 8:  | Standards of the Ministry of Information Industry of the People's Republic<br>of China..... | 15 |
| Table 9:  | Toxic or hazardous substances or elements with defined concentration<br>limits .....        | 15 |
| Table 10: | LTE Terminals label information .....   | 19 |
| Table 11: | LTE Terminals' interfaces .....   | 24 |
| Table 12: | Overview of operating modes .....   | 27 |
| Table 13: | 9-pole D-sub (female) RS-232 .....  | 28 |
| Table 14: | GPIO connector pin availability and alternate pin functionalities .....                     | 31 |
| Table 15: | Overview of DAI/PCM signals.....  | 33 |
| Table 16: | Female 8-pole RJ-45 Ethernet connector .....  | 40 |
| Table 17: | Female 6-pole Western plug for power supply, ignition, power down.....                      | 41 |
| Table 18: | Allowed maximum antenna gain (including cable loss).....                                    | 47 |
| Table 19: | Absolute maximum ratings.....   | 48 |
| Table 20: | Operating supply voltage for LTE Terminals.....   | 48 |
| Table 21: | On/Off control line specifications.....   | 49 |
| Table 22: | RS-232 interface specifications.....  | 49 |
| Table 23: | GPIO interface specifications (requirements) .....  | 50 |
| Table 24: | Power supply specifications .....   | 52 |
| Table 25: | Temperature characteristics.....  | 56 |
| Table 26: | RF Antenna interface GSM / UMTS / LTE .....   | 57 |
| Table 27: | Storage conditions .....  | 60 |
| Table 28: | List of parts and accessories.....  | 71 |
| Table 29: | Address register for I <sup>2</sup> C commands .....  | 86 |
| Table 30: | I <sup>2</sup> C status result codes .....  | 87 |

## Figures

|            |   |    |
|------------|---|----|
| Figure 1:  | Product label of ELS61T-E2.....   | 18 |
| Figure 2:  | Product Label of ELS61T-AUS .....   | 18 |
| Figure 3:  | Product label of ELS61T-US .....  | 19 |
| Figure 4:  | LTE Terminals 3D view .....   | 24 |
| Figure 5:  | Block diagram .....   | 25 |
| Figure 6:  | LTE Terminals circuit block diagram .....                                       | 26 |
| Figure 7:  | Pin assignment RS-232 (D-sub 9-pole female).....                                | 28 |
| Figure 8:  | ELS61T-US/AUS: GPIO connectors (8-pin and 12-pin).....                          | 29 |
| Figure 9:  | ELS61T-E2: GPIO connectors (8-pin and 12-pin).....                              | 30 |
| Figure 10: | ELS31T-V/J: GPIO connectors (8-pin and 12-pin).....                             | 30 |
| Figure 11: | Long frame PCM timing, 256kHz .....   | 33 |
| Figure 12: | Block circuit for DAI/PCM to analog converter .....                             | 34 |
| Figure 13: | Sample circuit for analog to DAI/PCM circuit .....                              | 34 |
| Figure 14: | Audio Codec Board .....   | 35 |
| Figure 15: | Characteristics of SPI modes .....  | 38 |
| Figure 16: | 8-pole RJ-45 Ethernet connector (female).....                                   | 40 |
| Figure 17: | 6-pole Western jack for power supply, ignition, reset, typical connection ..... | 41 |
| Figure 18: | SIM interface .....   | 45 |
| Figure 19: | Status LED .....  | 46 |
| Figure 20: | Antenna connectors .....  | 47 |
| Figure 21: | LTE Terminals 3D overview .....   | 61 |
| Figure 22: | LTE Terminals mechanical dimensions .....                                       | 62 |
| Figure 23: | LTE Terminals exploded view .....   | 63 |
| Figure 24: | Mounting the LTE Terminals .....  | 64 |
| Figure 25: | Reference equipment for approval .....  | 66 |
| Figure 26: | Hardware watchdog configuration.....  | 72 |
| Figure 27: | Write data to address register .....  | 88 |
| Figure 28: | Read data from address register.....  | 89 |
| Figure 29: | Setting GPIO direction to OUTPUT via I <sup>2</sup> C interface .....           | 91 |
| Figure 30: | Setting GPIO direction to INPUT via I <sup>2</sup> C interface .....            | 91 |
| Figure 31: | Setting GPIO direction to OUTPUT via TXD0 line (at 1200bps).....                | 92 |
| Figure 32: | Setting GPIO direction to INPUT via TXD0 line (at 1200bps).....                 | 92 |

## 0 Document History

Preceding document: "Cinterion® LTE Terminals Hardware Interface Description" Version 05

New document: "Cinterion® LTE Terminals Hardware Interface Description" Version **06**

| Chapter | What is new                  |
|---------|------------------------------|
| ---     | Product ELS61T-E LAN removed |

Preceding document: "Cinterion® LTE Terminals Hardware Interface Description" Version 04

New document: "Cinterion® LTE Terminals Hardware Interface Description" Version 05

| Chapter             | What is new  |
|---------------------|--|
| <a href="#">3.7</a> | Added remark on supported types of power supplies.   |
| <a href="#">4.1</a> | Added supply voltage range at RJ45.<br>Added footnote on maximum recommended operating supply voltage. |

Preceding document: "Cinterion® LTE Terminals Hardware Interface Description" Version 03a

New document: "Cinterion® LTE Terminals Hardware Interface Description" Version 04

| Chapter  | What is new  |
|--|--|
| ---  | Product ELS61T-E2 added and adapted document accordingly     |
| <a href="#">3.6.2.2</a> ,<br><a href="#">3.6.2.3</a> | Added description and configuration of the Audio Codec Board |
| <a href="#">4.3</a>                                  | <a href="#">Table 24</a> power consumption values added      |

Preceding document: "Cinterion® LTE Terminals Hardware Interface Description" Version 03

New document: "Cinterion® LTE Terminals Hardware Interface Description" Version 03a

| Chapter             | What is new  |
|---------------------|--|
| <a href="#">1.4</a> | <a href="#">Figure 2</a> Product label of ELS61T-AUS added |

Preceding document: "Cinterion® LTE Terminals Hardware Interface Description" Version 02

New document: "Cinterion® LTE Terminals Hardware Interface Description" Version 03

| Chapter                                   | What is new  |
|---|--|
| <a href="#">1</a>                         | Revised <a href="#">Table 1</a> for Module ELS61-E2 (remove DAI)                               |
| <a href="#">1.3.1</a>                     | Revised <a href="#">Table 4</a> and <a href="#">Table 5</a> according to the actual standards  |
| <a href="#">1.4</a>                       | <a href="#">Figure 1</a> Product label of ELS61T-E and manufacturer contact address added      |
| <a href="#">2.1</a>                       | Revised table for Module ELS61-E2  |
| <a href="#">3.6</a>                       | Revised <a href="#">Figure 9</a> and <a href="#">Table 14</a> for Module ELS61-E2 (remove DAI) |
| <a href="#">3.15</a>                      | <a href="#">Table 18</a> maximum antenna gain for ELS61T-E added                               |
| <a href="#">4.2.3</a> , <a href="#">8</a> | Revised <a href="#">Table 23</a> removing RS-485   |
| <a href="#">4.3</a>                       | Revised <a href="#">Table 24</a> removing UMTS Band III  |



|     |   |
|-----|---|
| 4.5 | Revised <a href="#">Table 26</a> adding LTE bands   |
| 6.3 | Terminal product names and included module information added<br>information regarding usage inside European Union added |
| 6.4 | Terminal product names and included module information added  |

Preceding document: "Cinterion® LTE Terminals Hardware Interface Description" Version 01

New document: "Cinterion® LTE Terminals Hardware Interface Description" Version 02

| Chapter                   | What is new  |
|---------------------------|--|
| 1                         | Revised <a href="#">Table 1</a> for ELS31 terminals, which not support SPI                                   |
| 1.3                       | Revised footnote 1.  |
| 2.1                       | Revised Table Feature of the glance regarding FW update, Power On and available memory for Java applications |
| 3.3                       | Revised <a href="#">Figure 6</a> regarding module ON signal  |
| 3.6                       | Revised <a href="#">Table 14</a> regarding digital audio signal names  |
| 3.8                       | Revised <a href="#">Table 17</a> regarding IGT_IN signal   |
| 3.9.1, 3.9.2, 3.9.3, 3.12 | Revised chapters regarding "auto ignition"   |
| 4.1                       | Removed IGT_IN from <a href="#">Table 19</a>   |
| 4.2.1                     | Removed IGT_IN from <a href="#">Table 21</a>   |
| 4.2.3                     | Revised comment for SPI in <a href="#">Table 23</a>  |
| 6.6                       | Added chapter for Japanese Rules and Regulations   |

New document: "Cinterion® LTE Terminals Hardware Interface Description" Version 01

| Chapter | What is new             |
|---------|-------------------------|
| --      | Initial document setup. |

# 1 Introduction

This document<sup>1</sup> describes the hardware of the Cinterion® LTE Terminals. The LTE Terminals come in five variants depending on the included Cinterion® module:

- **ELS61T-US LAN** for use in North America and countries with similar radio bands.
- **ELS61T-AUS LAN** for use in Australia.
- **ELS61T-E2 LAN** for use in Europe and countries with similar radio bands, supporting voice
- **ELS31T-V LAN** for use in North America in Verizon Wireless Network.
- **ELS31T-J LAN** for use in Japan.

All LTE Terminals implements an Ethernet interface with a RJ-45 8-pin connector and also a V.24 / V.28 RS-232 interface with a D-sub 9-pole female socket as well as a 6-pole Western jack as plug-in power supply connector.

Wherever necessary and appropriate this document distinguishes between these five variants.

[Table 1](#) gives a short overview of the available interfaces for the different LTE Terminals.

**Table 1:** Cinterion® LTE Terminals overview

| Module/Interface                | ELS61T-US LAN                      | ELS61T-AUS LAN                     | ELS61T-E2 LAN   | ELS31T-V LAN | ELS31T-J LAN |
|---------------------------------|------------------------------------|------------------------------------|---|--------------|--------------|
| Cinterion® module               | ELS61-US                           | ELS61-AUS                          | ELS61-E R2  | ELS31-V      | ELS31-J      |
| LTE                             | Cat. 1                             | Cat. 1                             | Cat. 1  | Cat. 1       | Cat. 1       |
| UMTS/HSPA+                      | HSDPA<br>Cat.8 /<br>HSUPA<br>Cat.6 | HSDPA<br>Cat.8 /<br>HSUPA<br>Cat.6 | HSDPA<br>Cat.8 /<br>HSUPA<br>Cat.6                                | -            | -            |
| GMS/GPRS/<br>EDGE               | -                                  | -                                  | GPRS:<br>Multislot<br>Class 12<br>EGPRS:<br>Multislot<br>Class 12 | -            | -            |
| RS232 / supports<br>autobauding | ✓/✓                                | ✓/✓                                | ✓/✓   | ✓/ -         | ✓/ -         |
| GPIO                            | ✓                                  | ✓                                  | ✓   | ✓            | ✓            |
| ASC1                            | ✓                                  | ✓                                  | ✓   | ✓            | ✓            |
| I2C/SPI                         | ✓/✓                                | ✓/✓                                | ✓/✓   | ✓/ -         | ✓/ -         |
| DAI                             | -                                  | -                                  | ✓   | -            | -            |
| Java                            | ✓                                  | ✓                                  | ✓   | -            | -            |

The scope of this document includes interface specifications, electrical as well as mechanical characteristics of the LTE Terminals. It specifies standards pertaining to wireless applications and outlines requirements that must be adhered to for successful product design. The LTE Ter-

1. The document is effective only if listed in the appropriate Release Notes as part of the technical documentation delivered with your Gemalto M2M product.

## 1.1 Related Documents

minals are compact GSM/UMTS/LTE modems for the transfer of data in GSM/UMTS/LTE networks. Industrial standard interfaces and an integrated SIM card reader allow using the LTE Terminals easily as GSM/GPRS/UMTS/LTE modems.

## 1.1 Related Documents

- [1] AT Command Set for your LTE Terminal product
- [2] Release Notes for your LTE Terminal product

To visit the Gemalto M2M GmbH Website please use the following link:

<http://www.gemalto.com/m2m/>

## 1.2 Terms and Abbreviations

**Table 2:** Terms and abbreviations

| Abbreviation     | Description                               |
|------------------|---|
| ARP              | Antenna Reference Point                   |
| ATC              | AT Command                                |
| BTS              | Base Transceiver Station                  |
| CB               | Cell Broadcast                            |
| CODEC            | Coder-Decoder                             |
| DAI              | Digital Audio Interface                   |
| DCE              | Data Circuit terminating Equipment        |
| DSR              | Data Set Ready                            |
| DTR              | Data Terminal Ready                       |
| EFR              | Enhanced Full Rate                        |
| EGSM             | Enhanced GSM                              |
| EMC              | Electromagnetic Compatibility             |
| ESD              | Electrostatic Discharge                   |
| ETS              | European Telecommunication Standard       |
| FDMA             | Frequency Division Multiple Access        |
| G.C.F.           | GSM Conformity Forum                      |
| GSM              | Global Standard for Mobile Communication  |
| HW               | Hardware                                  |
| I <sup>2</sup> C | Inter Integrated Circuit                  |
| IC               | Integrated Circuit                        |
| IF               | Intermediate Frequency                    |
| IMEI             | International Mobile Equipment Identifier |
| I/O              | Input/ Output                             |
| IGT              | Ignition                                  |

## 1.2 Terms and Abbreviations

**Table 2:** Terms and abbreviations

| Abbreviation | Description                                     |
|--------------|---|
| ISO          | International Standards Organization            |
| ITU          | International Telecommunications Union          |
| kbps         | kbits per second                                |
| LVD          | Low voltage Directive                           |
| Mbps         | Mbits per second                                |
| MCU          | Microprocessor Control Unit                     |
| MMI          | Machine Machine Interface                       |
| MO           | Mobile Originated                               |
| MS           | Mobile Station                                  |
| MT           | Mobile Terminated                               |
| NC           | Not Connected                                   |
| NTC          | Negative Temperature Coefficient                |
| PA           | Power Amplifier                                 |
| PCB          | Printed Circuit Board                           |
| PCM          | Pulse Code Modulation                           |
| PCS          | Personal Communication System                   |
| PD           | Power Down                                      |
| PDU          | Protocol Data Unit                              |
| PoE          | Power over Ethernet                             |
| RED          | Radio Equipment Directive                       |
| RF           | Radio frequency                                 |
| RI           | Ring Indication                                 |
| RX           | Receive direction                               |
| SIM          | Subscriber Identification Module                |
| SMS          | Short Message Service                           |
| SW           | Software  |
| TDD          | Time Division Duplex                            |
| TDMA         | Time Division Multiple Access                   |
| TX           | Transmit direction                              |
| UART         | Universal Asynchronous Receiver and Transmitter |


## 1.3 Regulatory and Type Approval Information

## 1.3 Regulatory and Type Approval Information

## 1.3.1 Directives and Standards

LTE Terminals have been designed to comply with the directives and standards listed below<sup>1</sup>.

**Table 3:** Directives

|  |   |
|--|---|
| 2014/53/EU                                 | Directive of the European Parliament and of the council of 16 April 2014 on the harmonization of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/ 05/EC.<br>The product is labeled with the CE conformity mark - see <a href="#">Section 6.3</a> . |
| 2002/95/EC (RoHS 1)<br>2011/65/EC (RoHS 2) | Directive of the European Parliament and of the Council of 27 January 2003 (and revised on 8 June 2011) on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)                          |
| 2002/96/EC                                 | Directive of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE)   |
| 2003/108/EC                                | Directive of the European Parliament and of the Council of 8 December 2003 amending directive 2002/96/ec on waste electrical and electronic equipment (WEEE)  |

**Table 4:** Standards of North American type approval

|                                    |   |
|------------------------------------|---|
| CFR Title 47                       | "Code of Federal Regulations, Part 15 B, Part 22 and Part 24 (Telecommunications, PCS)"; US Equipment Authorization FCC                               |
| OET Bulletin 65<br>(Edition 97-01) | Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields   |
| UL 60 950-1                        | Product Safety Certification (Safety requirements)  |
| NAPRD.03 V5.34                     | "Overview of PCS Type certification review board Mobile Equipment Type Certification and IMEI control"<br>PCS Type Certification Review board (PTCRB) |
| IEEE Std. C95.1-1999               | IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz                            |

**Table 5:** Standards of European type approval

|                                |   |
|--------------------------------|---|
| 3GPP TS 51.010-1               | "Digital cellular telecommunications system (Phase 2); Mobile Station (MS) conformance specification"   |
| ETSI EN 301 511 V12.5.1        | Global System for Mobile communications (GSM); Mobile Stations (MS) equipment; Harmonized Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU   |
| GCF-CC V3.68.1                 | Global Certification Forum - Certification Criteria   |
| Draft ETSI EN 301 489-1 V2.2.0 | ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU and the essential requirements of article 6 of Directive 2014/30/EU |

1. Standards of North American type approval do not apply to ELS61T-E and ELS31T-J . Standards of European Type approval do not apply to ELS61T-US and ELS31T-J. Standards of North American and European type approval apply partially to ELS61T-AUS and ELS31T-V

## 1.3 Regulatory and Type Approval Information

**Table 5:** Standards of European type approval

|   |  |
|---|--|
| Draft ETSI EN 301 489-52 V1.1.0                           | Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 52: Specific conditions for Cellular Communication Mobile and portable (UE) radio and ancillary equipment; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU |
| ETSI EN 301 908-1 V11.1.1                                 | IMT cellular networks; Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 1: Introduction and common requirements  |
| ETSI EN 301 908-2 V11.1.2                                 | IMT cellular networks; Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 2: CDMA Direct Spread (UTRA FDD) User Equipment (UE)   |
| EN 62311-2008   | Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)   |
| EN 60950-1:2006/<br>A11:2009+A1:2010+<br>A12:2011+A2:2013 | Safety of information technology equipment   |

**Table 6:** Standards of Japanese type approval


|   |
|---|
| ELS31T-J will be certified to meet the requirements of the Japanese "Telecommunications Business Law" and "Ordinance Concerning Technical Regulations Conformity Certification of Specified Radio Equipment" as well as the requirements of the Japanese "Radio Law" and "Ordinance Concerning Technical Conditions Compliance Approval and Certification of the Type for Terminal Equipment". For more information see <a href="#">Section 6.1</a> . |
|---|

**Table 7:** Requirements of quality

|              |   |
|--------------|---|
| IEC 60068    | Environmental testing                         |
| DIN EN 60529 | IP codes. The LTE Terminals comply with IP40. |

1.3 Regulatory and Type Approval Information

**Table 8:** Standards of the Ministry of Information Industry of the People’s Republic of China

|                 |  |
|-----------------|--|
| SJ/T 11363-2006 | “Requirements for Concentration Limits for Certain Hazardous Substances in Electronic Information Products” (2006-06).   |
| SJ/T 11364-2006 | <p>“Marking for Control of Pollution Caused by Electronic Information Products” (2006-06).</p> <p>According to the “Chinese Administration on the Control of Pollution caused by Electronic Information Products” (ACPEIP) the EPUP, i.e., Environmental Protection Use Period, of this product is 20 years as per the symbol shown here, unless otherwise marked. The EPUP is valid only as long as the product is operated within the operating limits described in the Hardware Interface Description.</p> <p>Please see <a href="#">Table 1.3.2</a> for an overview of toxic or hazardous substances or elements that might be contained in product parts in concentrations above the limits defined by SJ/T 11363-2006.</p>  |

**Table 9:** Toxic or hazardous substances or elements with defined concentration limits

| 部件名称<br>Name of the part                  | 有毒有害物质或元素 Hazardous substances |           |           |                 |               |                 |
|---|--------------------------------|-----------|-----------|-----------------|---------------|-----------------|
|   | 铅<br>(Pb)                      | 汞<br>(Hg) | 镉<br>(Cd) | 六价铬<br>(Cr(VI)) | 多溴联苯<br>(PBB) | 多溴二苯醚<br>(PBDE) |
| 金属部件<br>(Metal Parts)                     | ○                              | ○         | ○         | ○               | ○             | ○               |
| 电路模块<br>(Circuit Modules)                 | X                              | ○         | ○         | ○               | ○             | ○               |
| 电缆及电缆组件<br>(Cables and Cable Assemblies)  | ○                              | ○         | ○         | ○               | ○             | ○               |
| 塑料和聚合物部件<br>(Plastic and Polymeric parts) | ○                              | ○         | ○         | ○               | ○             | ○               |






O:  
表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T11363-2006 标准规定的限量要求以下。  
Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in SJ/T11363-2006.

X:  
表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T11363-2006标准规定的限量要求。  
Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part *might exceed* the limit requirement in SJ/T11363-2006.

## 1.3 Regulatory and Type Approval Information




## 1.3.2 Safety Precautions

The following safety precautions must be observed during all phases of the operation, usage, service or repair of any cellular terminal or mobile incorporating LTE Terminals. Manufacturers of the cellular terminal are advised to convey the following safety information to users and operating personnel and incorporate these guidelines into all manuals supplied with the product. Failure to comply with these precautions violates safety standards of design, manufacture and intended use of the product. Gemalto M2M GmbH assumes no liability for customer's failure to comply with these precautions.

|   |  |
|---|--|
|    | <p>When in hospitals or other health care facilities, observe the restrictions on the use of mobiles. Switch off the cellular terminal or mobile if to be instructed to do so by the guidelines posted in sensitive areas. Medical equipment may be sensitive to RF energy.</p> <p>The operation of cardiac pacemakers, other implanted medical equipment and hearing aids can be affected by interference from cellular terminals or mobiles placed close to the device. If in doubt about potential danger, contact the physician or the manufacturer of the device to verify that the equipment is properly shielded. Pacemaker patients are advised to keep their hand-held mobile away from the pacemaker, while it is on. This personal subgroup always should check the distance to the mobile.</p> |
|   | <p>Switch off the cellular terminal or mobile before boarding an aircraft. Make sure it cannot be switched on inadvertently. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communications systems. Failure to observe these instructions may lead to the suspension or denial of cellular services to the offender, legal action, or both.</p> <p>Check the local and actual laws about these themes.</p>  |
|  | <p>Do not operate the cellular terminal or mobile in the presence of flammable gases or fumes. Switch off the cellular terminal when you are near petrol stations, fuel depots, chemical plants or where blasting operations are in progress. Operation of any electrical equipment in potentially explosive atmospheres can constitute a safety hazard.</p>   |
|  | <p>Your cellular terminal or mobile receives and transmits radio frequency energy while switched on. Remember that interference can occur if it is used close to TV sets, radios, computers or inadequately shielded equipment. Follow any special regulations and always switch off the cellular terminal or mobile wherever forbidden, or when you suspect that it may cause interference or danger.</p>   |
|  | <p>Road safety comes first! Do not use a hand-held cellular terminal or mobile while driving a vehicle unless it is securely mounted in a holder for speakerphone operation. Before making a call with a hand-held terminal or mobile park the vehicle. Speakerphones must be installed by qualified personnel. Faulty installation or operation can constitute a safety hazard.</p> <p>Check the actual and local laws about these themes.</p>  |



1.3 Regulatory and Type Approval Information

|   |   |
|---|---|
|  | <p><b>IMPORTANT!</b><br/>Cellular terminals or mobiles operate using radio signals and cellular networks. In that case connections cannot be guaranteed at all times under all conditions. Therefore, you should never rely solely upon any wireless device for essential communications, for example emergency calls.</p> <p>Remember, in order to make calls or receive calls the cellular terminal or mobile must be switched on in a service area with adequate cellular signal strength.</p> <p>Some networks do not allow for emergency calls if certain network services or phone features are in use (e.g. lock functions, fixed dialing etc.). You may need to deactivate those features before you can make an emergency call.<br/>Some networks require a valid SIM card to be properly inserted in the cellular terminal or mobile.</p> |
|  | <p>If a power supply unit is used to supply the device it must meet the demands placed on SELV circuits in accordance with EN60950. The maximum permissible connection length between the device and the supply source should not exceed 3m.</p>  |
|  | <p>According to the guidelines for human exposure to radio frequency energy, an antenna connected to the FME jack of the device should be placed at least 20cm away from human bodies.</p>  |

### 1.4 Product Label

The label fixed to the bottom of a LTE Terminal comprises the following information.

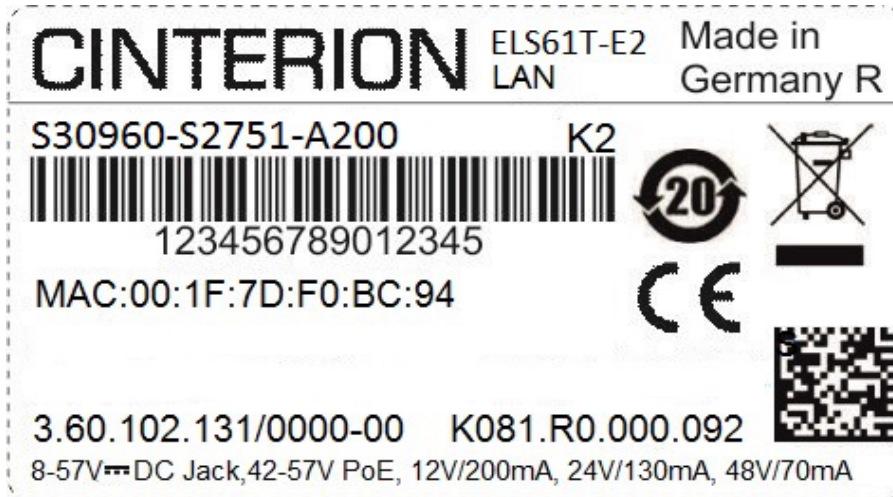


Figure 1: Product label of ELS61T-E2

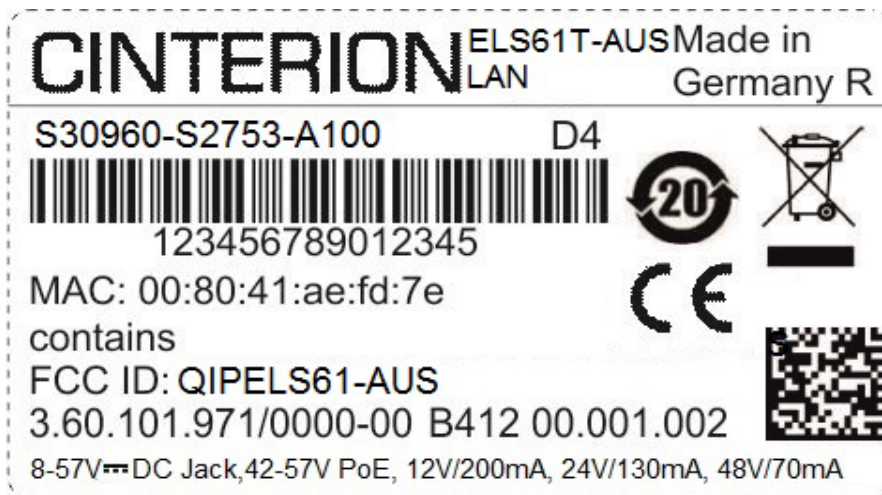


Figure 2: Product Label of ELS61T-AUS

1.4 Product Label

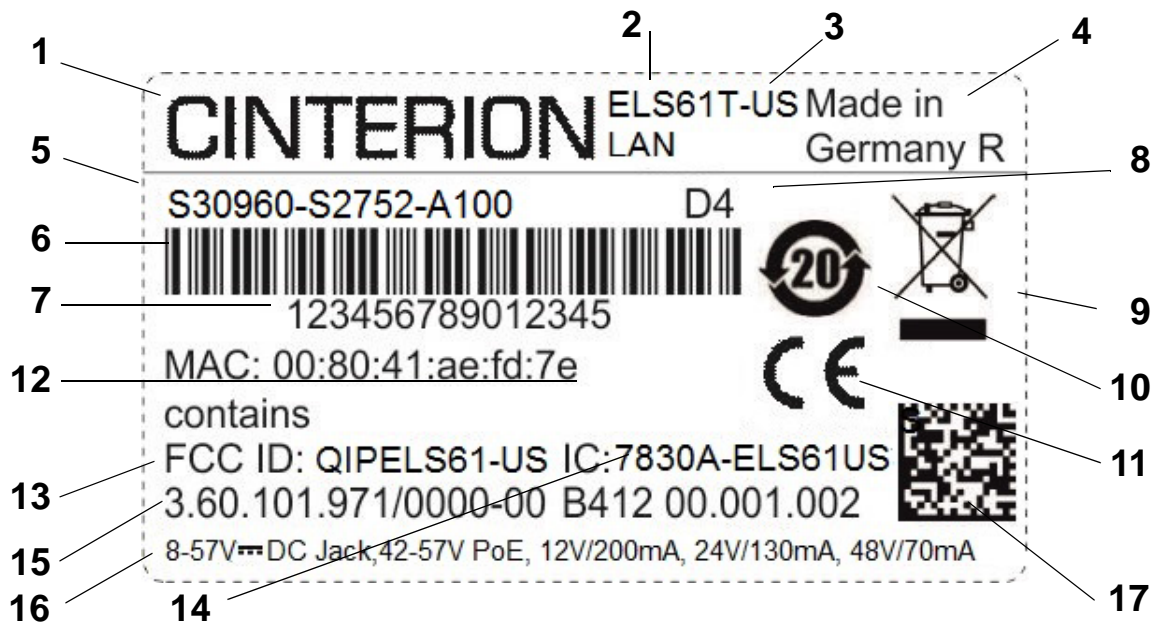


Figure 3: Product label of ELS61T-US

Table 10: LTE Terminals label information

| No. | Information   |
|-----|---|
| 1   | Cinterion logo  |
| 2   | Product name  |
| 3   | Product variant   |
| 4   | Marking "Made in Germany"   |
| 5   | Product ordering number   |
| 6   | Bar code (Code128)  |
| 7   | Product IMEI  |
| 8   | Date code   |
| 9   | WEEE symbol (see Table 3)   |
| 10  | Chinese RoHS symbol (see Table 8)   |
| 11  | CE logo. May be replaced for samples with "Not for sale" (see also Section 6.3) |
| 12  | MAC Address of the LAN Interface  |
| 13  | FCC ID for LTE module contained in LTE Terminal                                 |
| 14  | IC ID for LTE module contained in LTE Terminal                                  |
| 15  | Manufacturer code   |
| 16  | Power supply unit ratings   |
| 17  | Manufacturer code (2D)  |

Contact address: Gemalto M2M GmbH, Werinherstrasse 81, 81541 Munich, Germany.

## 2 Product Concept

### 2.1 Key Features at a Glance

| Feature                            | Implementation   |
|------------------------------------|--|
| General                            |  |
| Incorporates Cinterion® LTE module | The LTE module handles all signal and data processing within the LTE Terminals. Internal software runs the application interface and the complete GSM/UMTS/LTE protocol stack.   |
| Frequency bands                    | <p>ELS61T-US:<br/>UMTS/HSPA+: Triple band, 850 (BdV) / AWS (BdIV) / 1900MHz (BdII)<br/>LTE: Quad band, 700 (Bd12) / 850 (Bd5) / AWS (Bd4) / 1900MHz (Bd2)</p> <p>ELS61T-AUS:<br/>UMTS/HSPA+: Triple band, 850 (BdV) / 900 (BdVIII) / 2100 MHz (BdI)<br/>LTE: Quad band, 700 (Bd28) / 900 (Bd8) / 850 (Bd5) / 1800MHz (Bd3)</p> <p>ELS61T-E2<br/>GSM/GPRS/EDGE: Dual band 900/1800MHz<br/>UMTS/HSPA+: Dual band, 900 (BdVIII) / 2100MHz (BdI)<br/>LTE: Penta band, 700 (Bd28) / 800 (Bd20) / 900 (Bd8) / 1800 (Bd3) / 2100 MHz (Bd1)</p> <p>ELS31T-V:<br/>LTE: dualband, AWS (Bd4), 700MHz (Bd13)</p> <p>ELS31T-J:<br/>LTE: Triband, 2100 (Bd1), 850 MHz (Bd18, Bd19)</p> |
| GSM class                          | Small MS   |

## 2.1 Key Features at a Glance

| Feature  | Implementation   |
|--|--|
| Output power (according to Release 99, V5) depending on frequency band supported by module | <p>Class 4 (+33dBm ±2dB) for EGSM900<br/>           Class 1 (+30dBm ±2dB) for GSM1800<br/>           Class E2 (+27dBm ± 3dB) for GSM 900 8-PSK<br/>           Class E2 (+26dBm +3 /-4dB) for GSM 1800 8-PSK</p> <p>Class 3 (+24dBm +1/-3dB) for UMTS 2100, WCDMA FDD BdI<br/>           Class 3 (+24dBm +1/-3dB) for UMTS 1900, WCDMA FDD BdII<br/>           Class 3 (+24dBm +1/-3dB) for UMTS 850, WCDMA FDD BdV<br/>           Class 3 (+24dBm +1/-3dB) for UMTS 800, WCDMA FDD BdVI<br/>           Class 3 (+24dBm +1/-3dB) for UMTS 900, WCDMA FDD BdVIII</p> <p>Class 3 (+23dBm ±2dB) for LTE 2100, LTE FDD Bd1<br/>           Class 3 (+23dBm ±2dB) for LTE 1900, LTE FDD Bd2<br/>           Class 3 (+23dBm ±2dB) for LTE 1800, LTE FDD Bd3<br/>           Class 3 (+23dBm ±2dB) for LTE AWS, LTE FDD Bd4<br/>           Class 3 (+23dBm ±2dB) for LTE 850, LTE FDD Bd5<br/>           Class 3 (+23dBm ±2dB) for LTE 900, LTE FDD Bd8<br/>           Class 3 (+23dBm ±2dB) for LTE 700, LTE FDD Bd12<br/>           Class 3 (+23dBm ±2dB) for LTE 700, LTE FDD Bd13<br/>           Class 3 (+23dBm ±2dB) for LTE 800, LTE FDD B18<br/>           Class 3 (+23dBm ±2dB) for LTE 850, LTE FDD B19<br/>           Class 3 (+23dBm +1dB/-2dB) for LTE 800, LTE FDD Bd20<br/>           Class 3 (+23dBm ±2dB) for LTE 700, LTE FDD Bd28</p> <p>The values stated above are maximum limits. According to Release 99, the maximum output power in a multislot configuration may be lower. The nominal reduction of maximum output power varies with the number of uplink timeslots used and amounts to 3.0dB for 2Tx.</p> |
| Power supply   | Single supply voltage 8V to 57V<br>(Power-over-Ethernet support)   |
| Operating temperature (LTE module board temperature)                                       | Normal operation: -30°C to +85°C<br>Extended operation: -40°C to -30°C and +85°C to +90°C  |
| Physical   | Dimensions: 113.5mm x 75mm x 25.5mm<br>(excluding antenna and serial interface connectors)<br>Weight: 120g (approx.)   |
| RoHS, WEEE   | All hardware components are fully compliant with the EU RoHS and WEEE Directives   |
| LTE features   |  |
| 3GPP Release 9   | UE CAT 1 supported<br>DL 10.2Mbps, UL 5.2Mbps  |
| HSPA features  |  |
| 3GPP Release 8 (ELS61T-X only)   | DL 7.2Mbps, UL 5.7Mbps<br>HSDPA Cat.8 / HSUPA Cat.6 data rates<br>Compressed mode (CM) supported according to 3GPP TS25.212  |
| UMTS features  |  |
| 3GPP Release 4 (ELS61T-X only)   | PS data rate – 384 kbps DL / 384 kbps UL<br>CS data rate – 64 kbps DL / 64 kbps UL   |

## 2.1 Key Features at a Glance

| Feature                                     | Implementation   |
|---|--|
| GSM / GPRS / EDGE features                  |  |
| Data transfer (ELS61T-E and ELS61T-E2 only) | <p>GPRS:</p> <ul style="list-style-type: none"> <li>• Multislot Class 12</li> <li>• Full PBCCH support</li> <li>• Mobile Station Class B</li> <li>• Coding Scheme 1 – 4</li> </ul> <p>EGPRS (EHSxT only):</p> <ul style="list-style-type: none"> <li>• Multislot Class 12</li> <li>• EDGE E2 power class for 8 PSK</li> <li>• Downlink coding schemes – CS 1-4, MCS 1-9</li> <li>• Uplink coding schemes – CS 1-4, MCS 1-9</li> <li>• SRB loopback and test mode B</li> <li>• 8-bit, 11-bit RACH</li> <li>• PBCCH support</li> <li>• 1 phase/2 phase access procedures</li> <li>• Link adaptation and IR</li> <li>• NACC, extended UL TBF</li> <li>• Mobile Station Class B</li> </ul>         |
| SMS   | <ul style="list-style-type: none"> <li>• Point-to-point MT and MO</li> <li>• Cell broadcast</li> <li>• Text and PDU mode</li> </ul>  |
| Software                                    |  |
| AT commands                                 | Hayes 3GPP TS 27.007, TS 27.005, Gemalto M2M   |
| Java™ Open Platform (ESLS61-X only)         | <p>Java™ Open Platform with</p> <ul style="list-style-type: none"> <li>• Java™ profile IMP-NG &amp; CLDC 1.1 HI</li> <li>• Secure data transmission via HTTPS/SSL</li> <li>• Multi-threading programming and multi-application execution</li> </ul> <p>Major benefits: seamless integration into Java applications, ease of programming, no need for application micro-controller, extremely cost-efficient hardware and software design – ideal platform for industrial GSM applications.</p> <p>The memory space available for Java programs is around 30MB in the flash file system and around 18MB RAM. Application code and data share the space in the flash file system and in RAM.</p> |
| SIM Application Toolkit                     | SAT Release 99   |
| TCP/IP stack                                | Protocols: TCP server/client, UDP, HTTP, FTP, SMTP, POP3<br>Access by AT commands  |
| Firmware update                             | Upgradeable via serial ASC0 (RS-232) and LAN interface (see <a href="#">9.2.8</a> )  |
| Interfaces                                  |  |
| RS232                                       | <p>RS-232 interface for AT commands and data:</p> <ul style="list-style-type: none"> <li>• Supports RTS/CTS hardware handshake</li> <li>• Supports software XON/XOFF flow control</li> <li>• Multiplex ability according to GSM 07.10 Multiplexer protocol</li> <li>• Baud rates from 1200bps to 230400bps</li> <li>• Autobauding supported</li> </ul>   |

## 2.1 Key Features at a Glance

| Feature             | Implementation   |
|---------------------|--|
| GPIO connector      | 20-pin (8-pin and 12-pin) header with GPIO interface, external power supply, serial interface ASC1, ADC, DAI/PCM, SPI and I <sup>2</sup> C, depending on variant |
| Ethernet            | 8-pole RJ-45 Ethernet connector<br>Support for Power over Ethernet (PoE)   |
| Power connector     | 6-pole Western connector (female) for power supply, ignition, power down signal  |
| SIM card reader     | Supported SIM cards: 3V, 1.8V  |
| Antenna             | Main Antenna connected via female SMA connector<br>Diversity Antenna connected via female SMA connector  |
| Power on/off, Reset |  |
| Power on            | DTR line at RS-232 interface or by Power over Ethernet   |
| Power off           | Normal switch-off by AT^SMSO<br>Automatic switch-off in case of critical temperature conditions  |
| Reset               | Orderly shutdown and reset by AT command<br>Emergency restart via RST_IN line at power connector or via watchdog   |
| Special features    |  |
| Real time clock     | Timer functions via AT commands  |
| Phonebook           | SIM card and terminal  |
| (Hardware) Watchdog | Configurable watchdog to control module  |

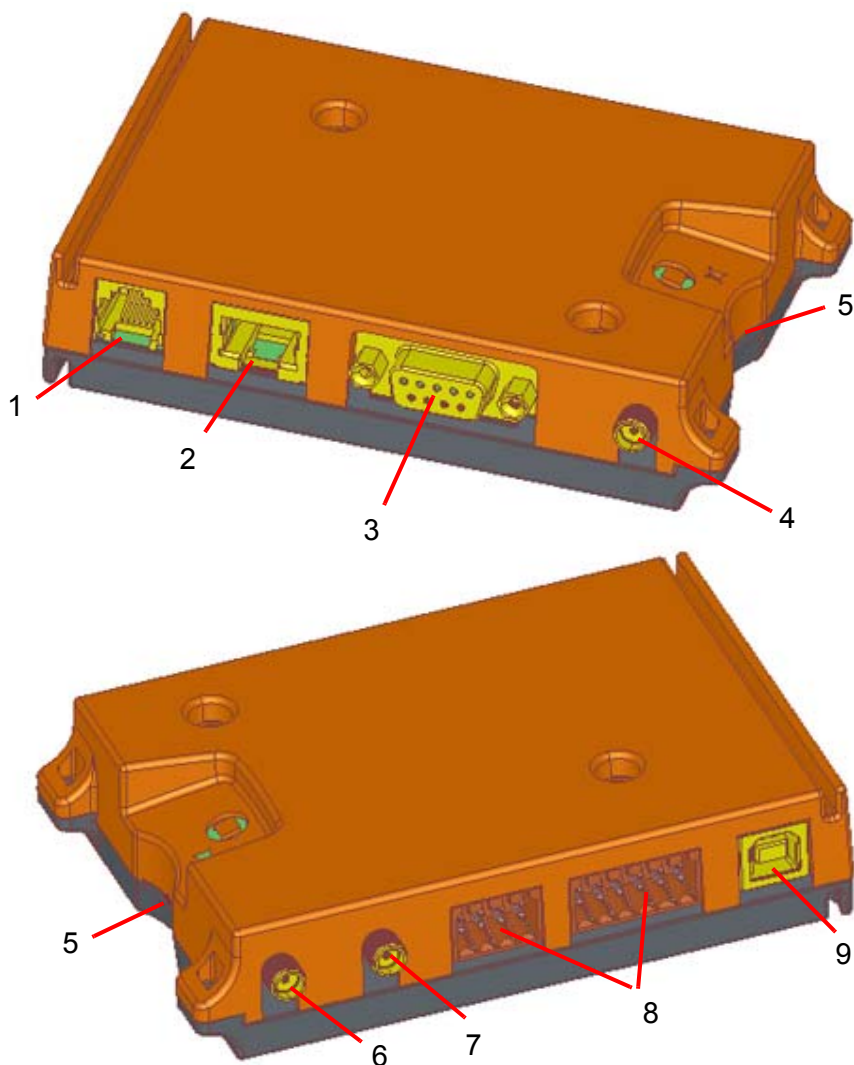
## 3 Interface Description

### 3.1 Overview

LTE Terminals provide the following interfaces for power supply, antenna, SIM card and data transfer:

**Table 11:** LTE Terminals' interfaces

| No. | Description   |
|-----|---|
| 1   | 6-pin Western connector (female) for power supply, ignition, power down signal    |
| 2   | 8-pin (female) RJ-45 Ethernet connector   |
| 3   | 9-pin (female) D-sub connector (RS-232 interface)                                 |
| 4   | SMA connector (female) for GPS antennas (for future use, currently not available) |
| 5   | SIM card reader   |
| 6   | SMA connector (female) for RF main antenna  |
| 7   | SMA connector (female) for Rx diversity antenna                                   |
| 8   | 12-pin and 8-pin GPIO connectors (male)   |
| 9   | 4-pin (female) USB-B connector (for future use, currently not available)          |



**Figure 4:** LTE Terminals 3D view



3.2 Block Diagram

### 3.2 Block Diagram

Figure 5 shows a block diagram of a sample configuration that incorporates a LTE Terminal and typical accessories.

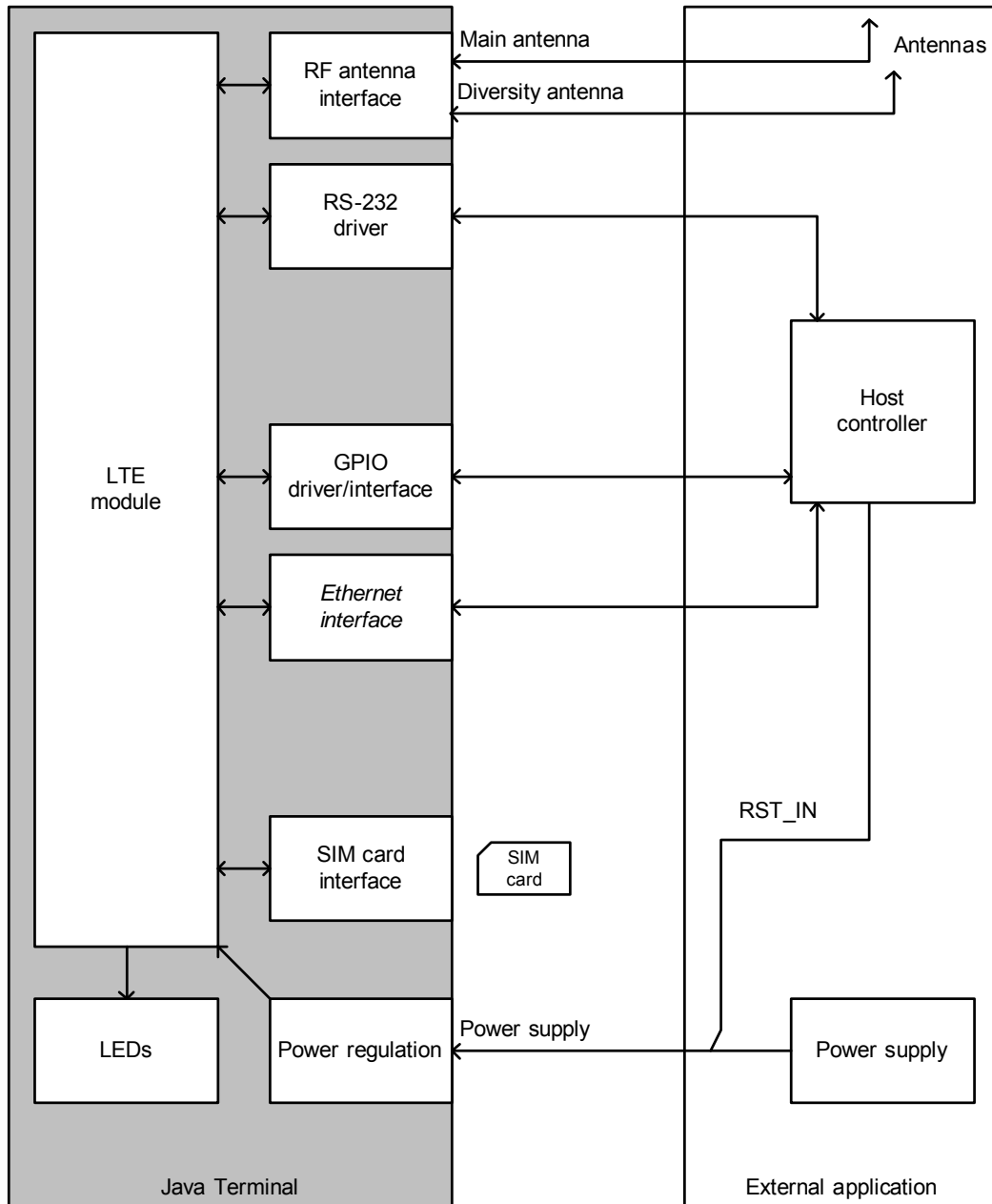


Figure 5: Block diagram

3.3 Terminal Circuit

### 3.3 Terminal Circuit

Figure 6 shows a general LTE Terminal block diagram that includes all variants.

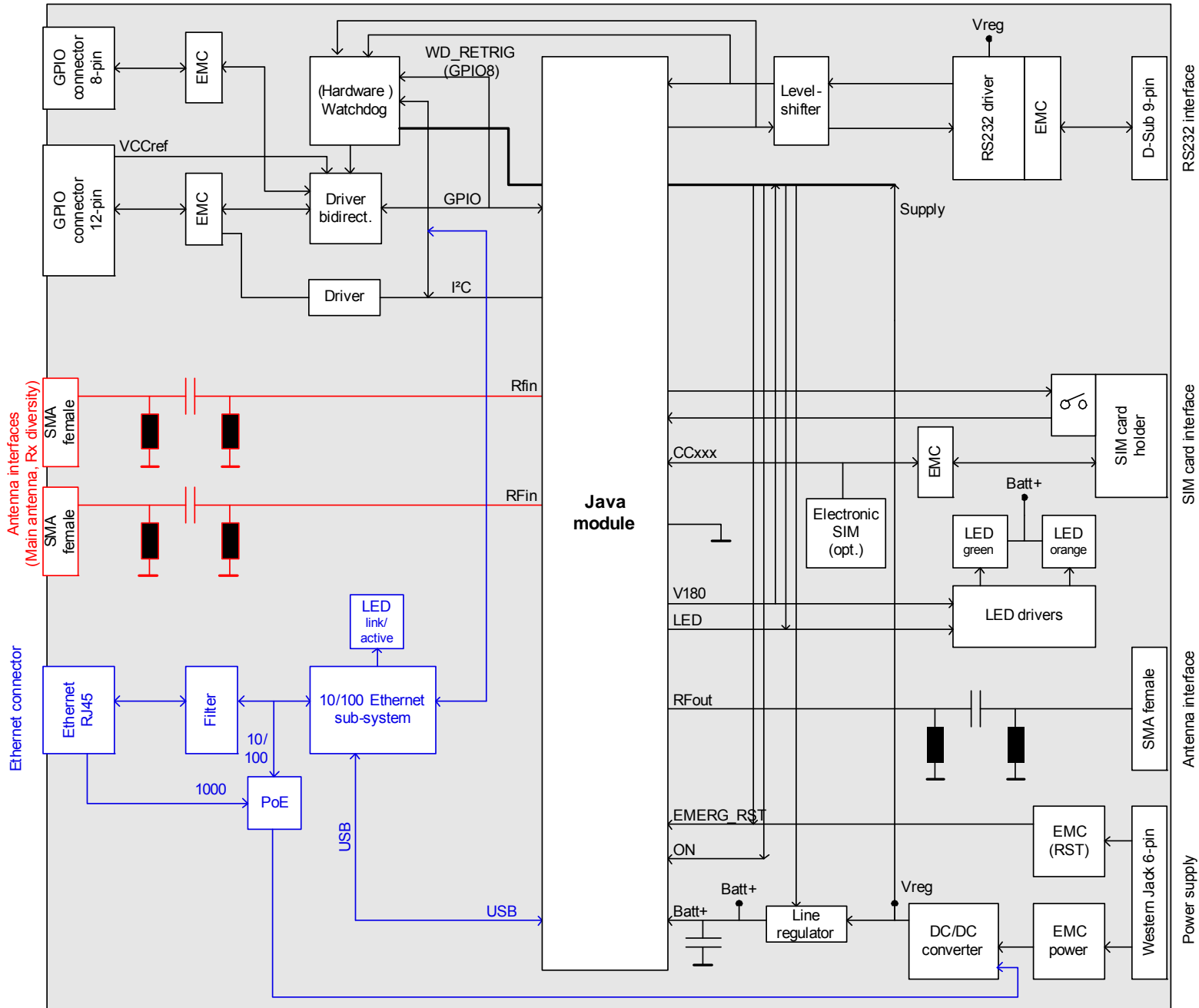


Figure 6: LTE Terminals circuit block diagram

## 3.4 Operating Modes

The table below briefly summarizes the various operating modes referred to in the following chapters.

**Table 12:** Overview of operating modes

| Mode             | Function   |
|------------------|--|
| Normal operation | UMTS / HSPA / LTE SLEEP<br>Power saving set automatically when no call is in progress and no active communication via ASC0.  |
|                  | UMTS / HSPA / LTE IDLE<br>Power saving disabled or active communication via ASC0, but no call in progress.   |
|                  | UMTS DATA (ELS61T-X only)<br>UMTS data transfer in progress. Power consumption depends on network settings (e.g. TPC Pattern) and data transfer rate.  |
|                  | HSPA DATA (ELS61T-X only)<br>HSPA data transfer in progress. Power consumption depends on network settings (e.g. TPC Pattern) and data transfer rate.  |
|                  | LTE DATA<br>LTE data transfer in progress. Power consumption depends on network settings (e.g. TPC Pattern) and data transfer rate.  |
| Power Down       | Normal shutdown after sending the power down command. Only a voltage regulator is active for powering the RTC. Software is not active. Interfaces are not accessible. Operating voltage remains applied.                                   |
| Airplane mode    | Airplane mode shuts down the radio part of the module, causes the module to log off from the network and disables all AT commands whose execution requires a radio connection.<br>Airplane mode can be controlled by AT command (see [1]). |
| Alarm mode       | Restricted operation launched by RTC alert function when the module is in Power Down mode. In Alarm mode, the module remains deregistered from the network. Limited number of AT commands is accessible.                                   |

## 3.5 RS-232 Interface

The interface is implemented as a serial asynchronous transmitter and receiver conforming to ITU-T V.24 Interchange Circuits DCE. It is configured for 8 data bits, no parity and 1 stop bit, and can be operated at bit rates from 1200bps to 921kbps. Autobauding supports bit rates from 1.2kbps to 230kbps.

For more information see also [Section 3.5.1](#).

### 3.5.1 9-Pole D-sub Connector

Via RS-232 interface, the host controller controls the LTE Terminals and transports data.

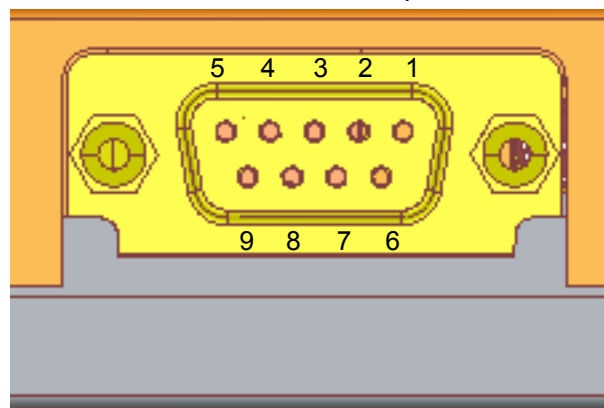


Figure 7: Pin assignment RS-232 (D-sub 9-pole female)

Table 13: 9-pole D-sub (female) RS-232

| Pin no. | Signal name       | I/O | Function  |
|---------|-------------------|-----|---|
| 1       | DCD0              | O   | Data Carrier Detected   |
| 2       | RXD0              | O   | Receive Data  |
| 3       | TXD0              | I   | Transmit Data   |
| 4       | DTR0              | I   | Data Terminal Ready<br>Attention: The ignition of LTE Terminals is activated via a rising edge of high potential (+3 ... +15 V) |
| 5       | GND               | -   | Ground  |
| 6       | DSR0 <sup>1</sup> | O   | Data Set Ready  |
| 7       | RTS0              | I   | Request To Send   |
| 8       | CTS0              | O   | Clear To Send   |
| 9       | RING0             | O   | Ring Indication   |

1. Note that DSR0 may also be available via GPIO connector pin - see [Section 3.6](#).

LTE Terminals are designed for use as a DCE. Based on the conventions for DCE-DTE connections it communicates with the customer application (DTE) using the following signals:

- Port TxD @ application sends data to TXD0 of the LTE Terminals
- Port RxD @ application receives data from RXD0 of the LTE Terminals

3.6 GPIO Interface

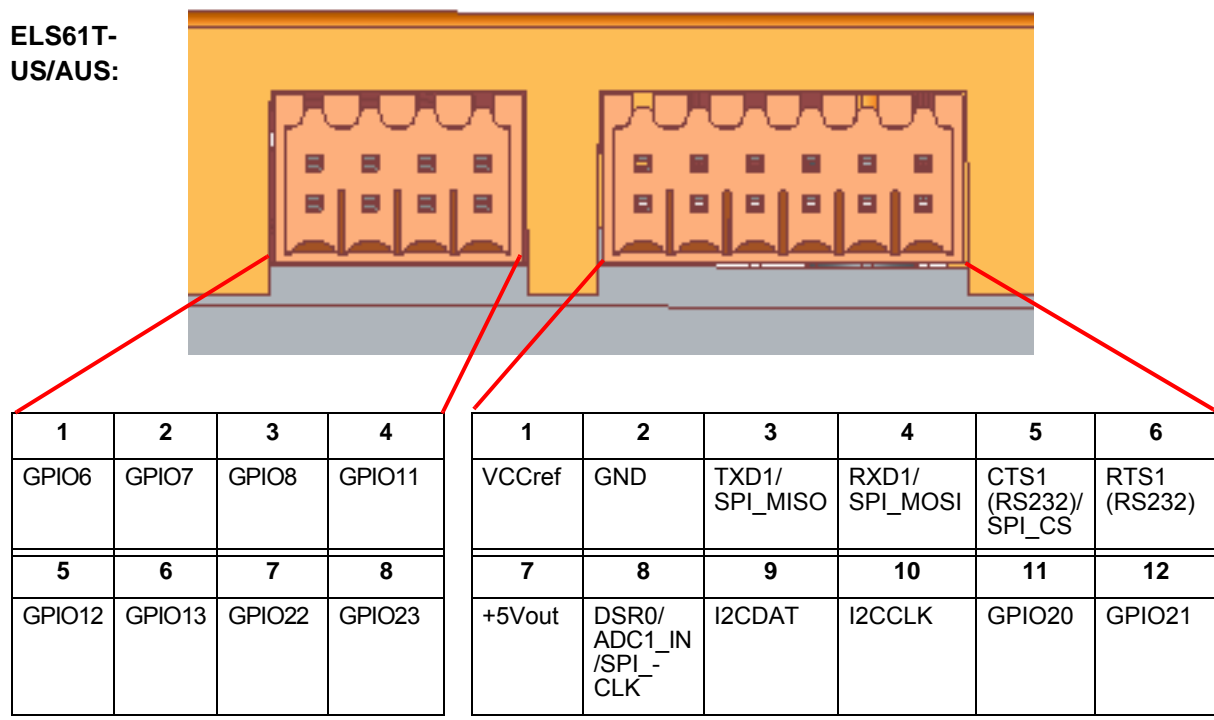
Hardware handshake using the RTS0 and CTS0 signals and XON/XOFF software flow control are supported.

In addition, the modem control signals DTR0, DSR0, DCD0 and RING0 are available. The modem control signal RING0 (Ring Indication) can be used to indicate, to the cellular device application, that a call or Unsolicited Result Code (URC) is received. There are different modes of operation, which can be set with AT commands.

**Note:** The DTR0 signal will only be polled once per second from the internal firmware of LTE Terminals.

### 3.6 GPIO Interface

The GPIO connectors (8-pin and 12-pin) provide access to various module signals including a number of configurable GPIOs. Note that not all of the pins are available for every LTE Terminal variant. The following figures show the available pins for the LTE Terminal variants and the below [Table 14](#) lists the overall availability of the pins.



n/a: not applicable

**Figure 8:** ELS61T-US/AUS: GPIO connectors (8-pin and 12-pin)

3.6 GPIO Interface

ELS61T-E2:

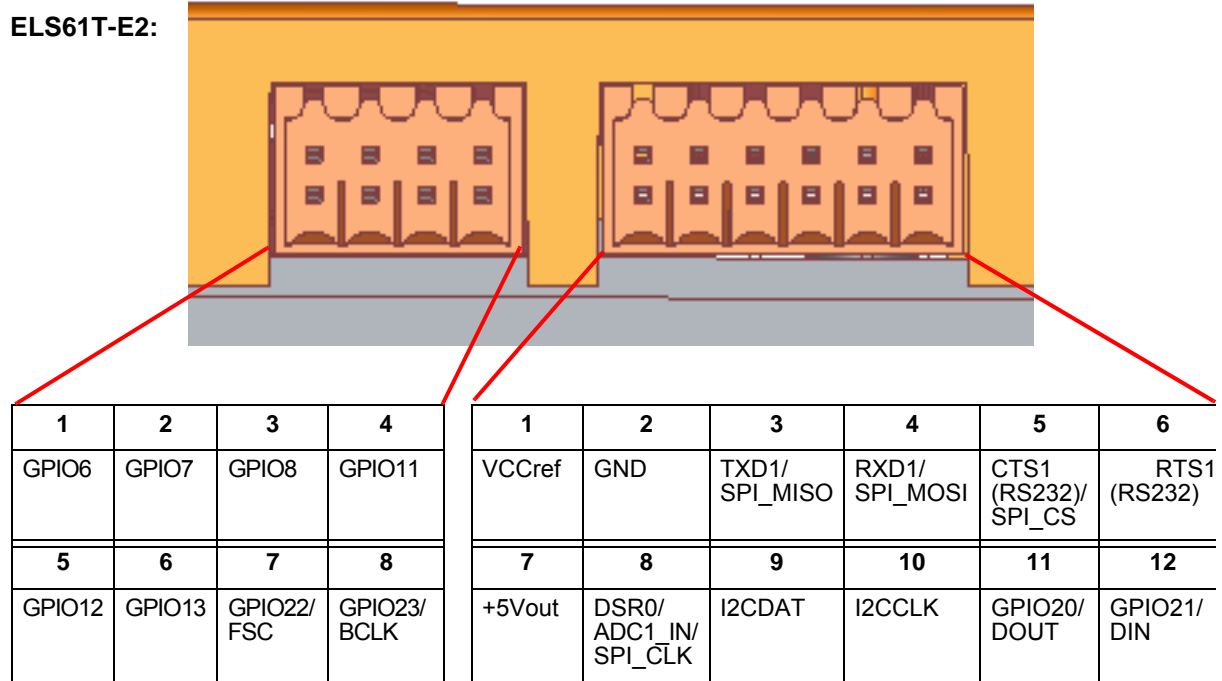
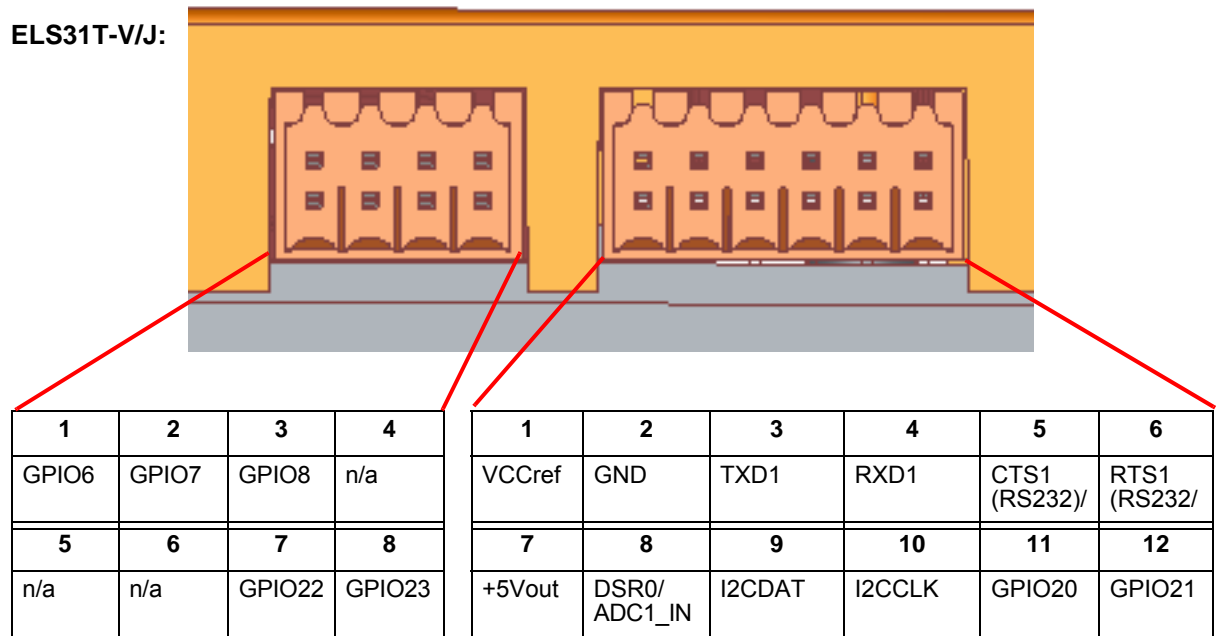


Figure 9: ELS61T-E2: GPIO connectors (8-pin and 12-pin)

ELS31T-V/J:



n/a: not applicable

Figure 10: ELS31T-V/J: GPIO connectors (8-pin and 12-pin)

## 3.6 GPIO Interface

The following [Table 14](#) shows the availability of the GPIO connector pins for various LTE Terminal variants.

**Table 14:** GPIO connector pin availability and alternate pin functionalities

| Pin              | Signal                     | Comment   | ELS61T-US       | ELS61T-AUS      | ELS61T-E2       | ELS31T-V/J     |
|------------------|----------------------------|---|-----------------|-----------------|-----------------|----------------|
| 8-pin connector  |                            |   |                 |                 |                 |                |
| 1                | GPIO6                      | Configurable via AT command, also as PWM2 signal                            | ✓               | ✓               | ✓               | ✓<br>no PWM    |
| 2                | GPIO7                      | Configurable via AT command, also as PWM1 signal                            | ✓               | ✓               | ✓               | ✓<br>no PWM    |
| 3                | GPIO8                      | Configurable via AT command, also as COUNTER signal                         | ✓               | ✓               | ✓               | ✓              |
| 4                | GPIO11                     | Configurable via AT command   | ✓               | ✓               | ✓               | -              |
| 5                | GPIO12                     | Configurable via AT command   | ✓               | ✓               | ✓               | -              |
| 6                | GPIO13                     | Configurable via AT command   | ✓               | ✓               | ✓               | -              |
| 7                | GPIO22                     | Configurable via AT command also as FSC                                     | ✓<br>no DAI     | ✓<br>no DAI     | ✓<br>FSC        | ✓<br>no DAI    |
| 8                | GPIO23                     | Configurable via AT command also as BCLK                                    | ✓<br>no DAI     | ✓<br>no DAI     | ✓<br>BCLK       | ✓<br>no DAI    |
| 12-pin connector |                            |   |                 |                 |                 |                |
| 1                | VCCref                     | Input supply for level adjustment. E.g., connect +5Vout for 5V IO operation | ✓               | ✓               | ✓               | ✓              |
| 2                | GND                        |   | ✓               | ✓               | ✓               | ✓              |
| 3                | TXD1 or SPI_MISO           | Configurable via AT command, also as SPI_MISO signal                        | TXD1 / SPI_MISO | TXD1 / SPI_MISO | TXD1 / SPI_MISO | TXD1           |
| 4                | RXD1 or SPI_MOSI           | Configurable via AT command, also as SPI_MOSI signal                        | RXD1 / SPI_MOSI | RXD1 / SPI_MOSI | RXD1 / SPI_MOSI | RXD1           |
| 5                | CTS1 or SPI_CS             | CTS1 (RS-232) or SPI_CS   | CTS1 / SPI_CS   | CTS1 / SPI_CS   | CTS1 / SPI_CS   | CTS1           |
| 6                | RTS1                       | RTS1 (RS-232)   | RTS1            | RTS1            | RTS1            | RTS1           |
| 7                | +5Vout                     | External power supply up to 100mA, usable as VCCref input                   | ✓               | ✓               | ✓               | ✓              |
| 8                | DSR0 or ADC1_IN or SPI_CLK | Configurable via AT command   | ✓               | ✓               | ✓               | DSR0 / ADC1_IN |
| 9                | I2CDAT                     | I <sup>2</sup> C interface  | ✓               | ✓               | ✓               | ✓              |
| 10               | I2CCLK                     | I <sup>2</sup> C interface  | ✓               | ✓               | ✓               | ✓              |
| 11               | GPIO20                     | Configurable via AT command also as DOUT                                    | ✓<br>no DAI     | ✓<br>no DAI     | ✓<br>DOUT       | ✓<br>no DAI    |
| 12               | GPIO21                     | Configurable via AT command also as DIN                                     | ✓<br>no DAI     | ✓<br>no DAI     | ✓<br>DIN        | ✓<br>no DAI    |

Please refer to the respective "AT Command Set" for details on how to configure the GPIO pins using AT commands.

Also, be sure not to activate SLEEP mode, e.g., by setting AT^SPOW with <mode>=2, for the ELS61 module, as the module may no longer be able to wake up from SLEEP mode, and will

then have to be reset.

### 3.6.1 Serial Interface ASC1

On all LTE Terminals four pins at the GPIO connector can be configured as ASC1 interface signals to provide a 4-wire serial modem interface ASC1. For electrical characteristics please refer to [Table 23](#).

The following pins at the GPIO connector can be configured as ASC1 interface signals: RXD1, TXD1, RTS1 and CTS1 (see also [Table 14](#)). The configuration is done by AT command AT^SCFG - see [\[1\]](#). It is non-volatile and becomes active after a LTE Terminal restart.

LTE Terminals are designed for use as a DCE. Based on the conventions for DCE-DTE connections they communicate with the customer application (DTE) using the following signals:

- Port TXD @ application sends data to LTE Terminal's TXD1 signal line
- Port RXD @ application receives data from the LTE Terminal's RXD1 signal line

Hardware handshake using the RTS1 and CTS1 signals is supported on all LTE Terminals.



### 3.6.2 Digital Audio Interface (ELS61T-E2)

Four pins at the LTE Terminals' GPIO connector can be configured as digital audio interface (DAI). The DAI can be used to connect audio devices capable of pulse code modulation (PCM). The PCM functionality allows for the use of an external codec like the W681360.

The DAI interface supports a 256kHz, long frame synchronization master mode with the following features:

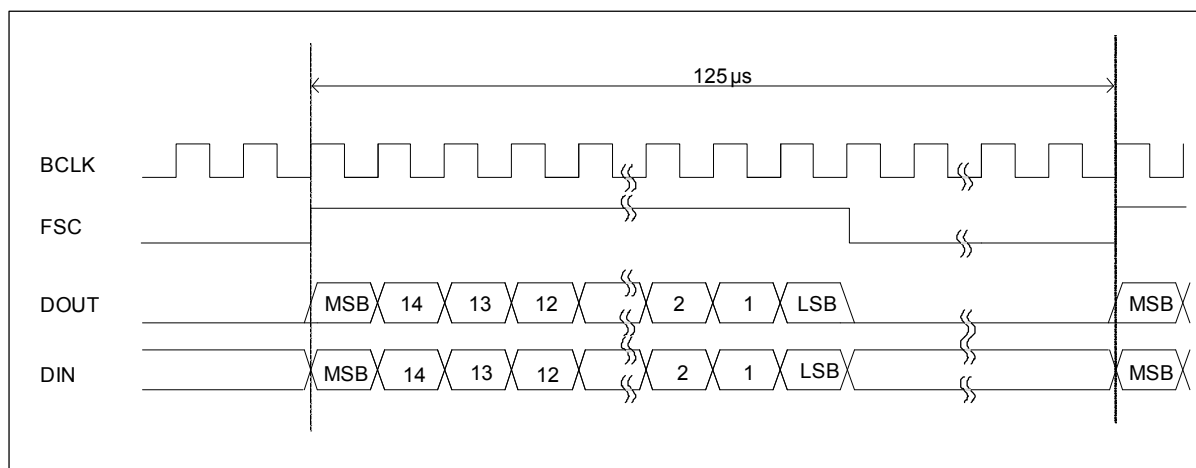
- 16 Bit linear
- 8kHz sample rate / 125µs frame duration
- The most significant bit MSB is transferred first
- Data write at rising edge / data read at falling edge
- Common frame sync signal for transmit and receive

The following pins at the GPIO connector can be configured as DAI/PCM interface signals: DOUT, DIN, FSC and BCLK (see also [Table 14](#)). The configuration is done by AT^SCFG command - see [\[1\]](#). It is non-volatile and becomes active after a module restart. DAI/PCM and GPIO functionalities for these lines are mutually exclusive. [Table 15](#) describes the available DAI/PCM lines at the digital audio interface<sup>1</sup>. For electrical details see [Table 23](#).

**Table 15:** Overview of DAI/PCM signals

| Signal name   | Input/Output | Description  |
|---------------|--------------|--|
| DOUT (GPIO20) | O            | PCM data from LTE Terminals to external codec.                       |
| DIN (GPIO21)  | I            | PCM data from external codec to LTE Terminals.                       |
| FSC (GPIO22)  | O            | Frame synchronization signal to external codec:<br>Long frame (8kHz) |
| BCLK (GPIO23) | O            | Bit clock to external codec: 256kHz                                  |

[Figure 11](#) shows the PCM timing for the master mode available with LTE Terminals.



**Figure 11:** Long frame PCM timing, 256kHz

[Section 3.6.2.1](#) gives an example of how the DAI can be employed.

1. **Note:** For the DAI interface to operate, the directions of the LTE Terminals' GPIO level shifters must be set according to the defined directions of the DAI signals. See [Section 8.3.1.11](#) and [Section 8.5](#) for more information on how to change level shifter directions.

### 3.6.2.1 Solutions for the Digital Audio Interface (DAI/PCM)

The Digital Audio Interface is only supported in ELS61T-E2. Figure 12 and Figure 13 show an example of using the digital audio interface of the LTE Terminal. The below mentioned sample Nuvoton codec W681360 can be replaced with a DSP. In the example, framesync and clock master is the module (FSC line) and thus the GSM network.

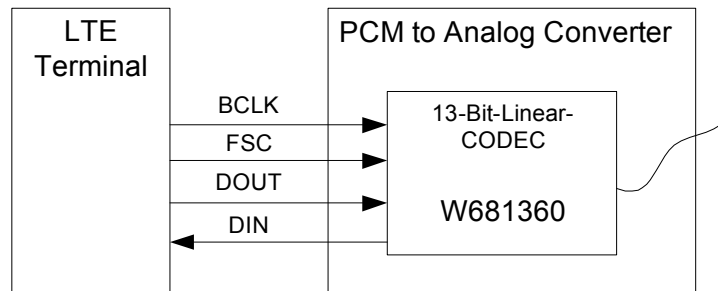


Figure 12: Block circuit for DAI/PCM to analog converter

This DAI/PCM analog converter is well suited for evaluating and testing a telephone handset.

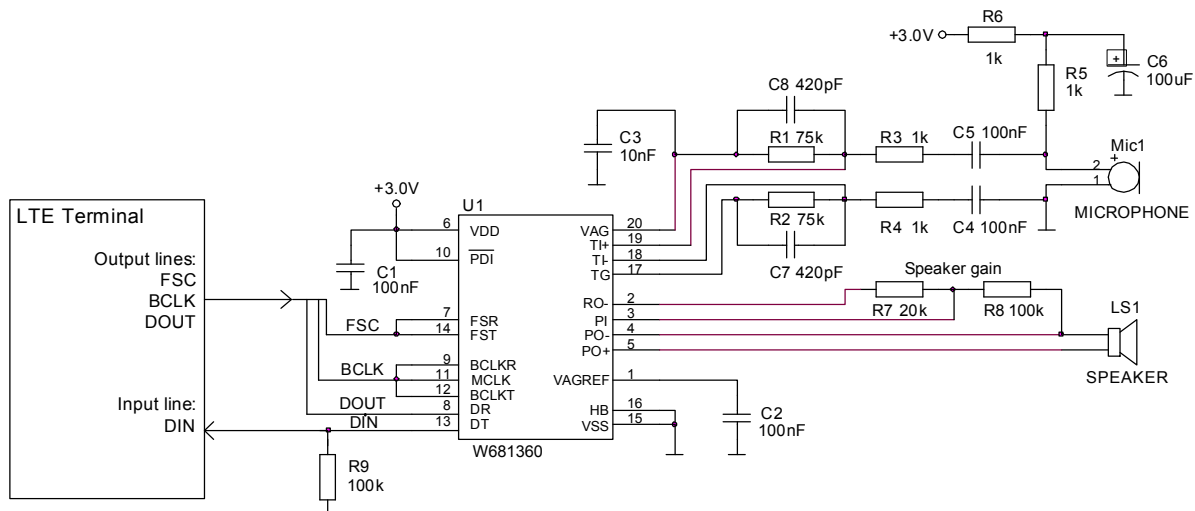


Figure 13: Sample circuit for analog to DAI/PCM circuit

On the module side, the PCM interface has to be enabled. This can be done by using the following AT command: `AT^SCFG="GPIO/mode/DAI", "std"`.

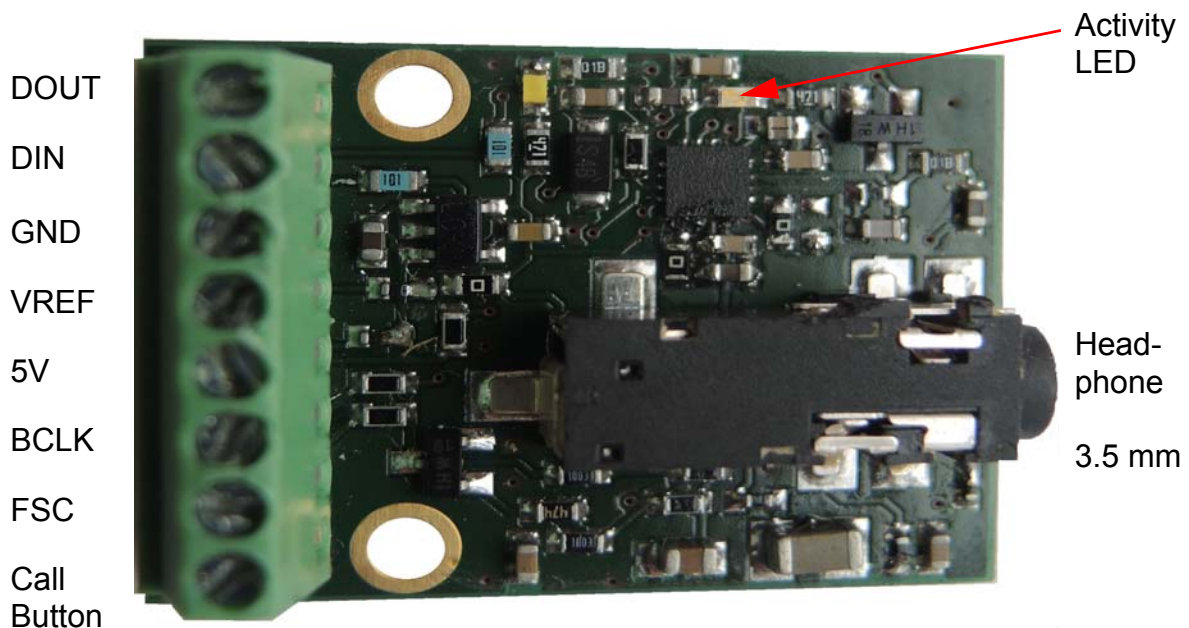
Please note that level converters may be required between the the 3.0V audio codec interface lines and the module's digital audio lines and - depending on VCCref settings for the GPIO interface lines.

### 3.6.2.2 Audio Codec Board

The Audio Codec Board (Figure 14) is small in its footprint (3cm x 2,3 cm). It integrates a 3.3V single channel PCM CODEC chip (AK2300), has a fixed terminal block (green connector) in order to connect easily to the Terminal ELS61T-E2 and a 3.5 mm plug connector for the head-phone.

The DAI Interface supports following configurations:

- 256 kHz long frame synchronization master mode
- 16 Bit linear
- 8 kHz sample rate



- The most significant bit MSB is transferred first
- Data write at rising edge / data read at falling edge
- Common frame sync signal for transmit and receive

**Figure 14:** Audio Codec Board

The signal “Call Button” indicates the state of the Call Button on the headphone and should be connected to GPIO.

### 3.6.2.3 Manual configuration via AT-Commands

Following steps have to be done:

- Connect the Terminal with the PC via RS-232 Interface.
- Open for instance an HTerm and open Port (115200, 8N1, no flowcontrol).
- enter following AT commands:
  - `at^scfg="Gpio/mode/DAI","std"` // set GPIOs in the module to DAI functionality
  - `at^sspi=` // open I2C connection
  - `<aD41601>` // set GPIO 22 to output (TFSDAI)
  - `<aD41701>` // set GPIO 23 to output (SCLK)
  - `<aD41800>` // set GPIO 21 to input (RXDDAI)
  - `<aD41901>` // set GPIO 20 to output (TXDDAI)
  - `#` // close I2C connection
  - `AT^SNFS=3` // configure
  -

The configuration is non-volatile and becomes active after a module restart.

If the DAI Interface is active, the Activity LED is on.

For more information and example Java Midlets, please visit Developer Community at <http://developer.gemalto.com>

### 3.6.3 I<sup>2</sup>C Interface

Two lines of the LTE Terminals' GPIO connector are I<sup>2</sup>C lines. I<sup>2</sup>C is a serial, 8-bit oriented data transfer bus for bit rates up to 400kbps in Fast mode. It consists of two lines, the serial data line I2CDAT and the serial clock line I2CCLK. The LTE Terminals' internal LTE module act as a single master device, e.g. the clock I2CCLK is driven by the LTE module. I2CDAT is a bi-directional line. Each device connected to the bus is software addressable by a unique 7-bit address, and simple master/slave relationships exist at all times. The LTE module operates as master-transmitter or as master-receiver. An external application transmits or receives data only on request of the module.

To configure and activate the I2C bus use the AT^SSPI command. Detailed information on the AT^SSPI command as well explanations on the protocol and syntax required for data transmission can be found in [\[1\]](#).

With the external application, I2CDAT and I2CCLK lines need to be connected to a positive supply voltage via a pull-up resistor. For electrical characteristics please refer to [Table 23](#).

Note: Good care should be taken when connecting the I2C lines to the external application: The wires of I2CCLK and I2CDAT should be equal in length and as short as possible.

### 3.6.4 SPI Interface

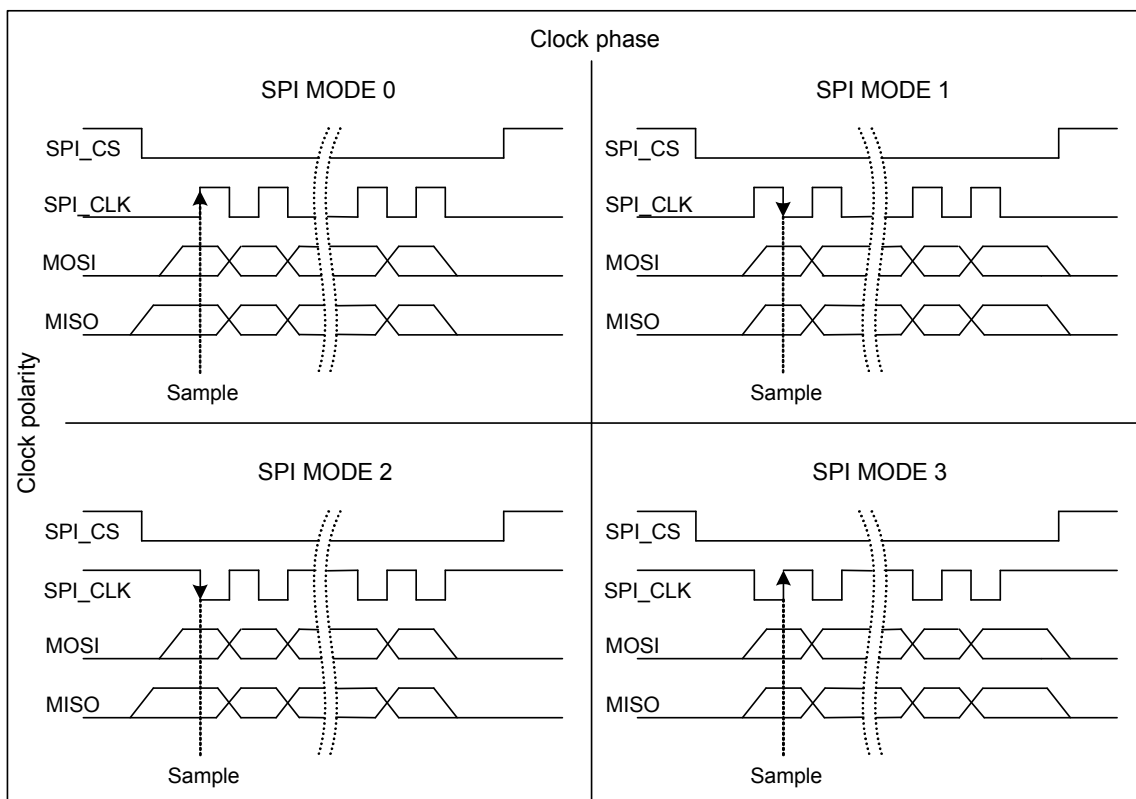
For ELS61T-X Terminals four dedicated pins of the GPIO connector can be configured as Serial Peripheral Interface (SPI). The SPI is a synchronous serial interface for control and data transfer between LTE Terminals and the external application. Only one application can be connected to the SPI and the interface supports only master mode. The transmission rates are up to 6.5Mbit/s. The SPI interface comprises the two data lines MOSI and MISO, the clock line SPI\_CLK a well as the chip select line SPI\_CS.

The following pins at the GPIO connector can be configured as SPI interface signals: SPI\_CLK, SPI\_MOSI, SPI\_MISO and SPI\_CS (see also [Table 14](#)). The configuration is done by AT command (see [\[1\]](#)). It is non-volatile and becomes active after a module restart. For electrical characteristics please refer to [Table 23](#).

To configure and activate the SPI interface use the AT<sup>^</sup>SSPI command. Detailed information on the AT<sup>^</sup>SSPI command as well explanations on the SPI modes required for data transmission can be found in [\[1\]](#). SPI, ADC1\_IN and DSR0 functionalities are mutually exclusive.

In general, SPI supports four operation modes. The modes are different in clock phase and clock polarity. The module's SPI mode can be configured by using the AT command AT<sup>^</sup>SSPI. Make sure the module and the connected slave device works with the same SPI mode.

[Figure 15](#) shows the characteristics of the four SPI modes. The SPI modes 0 and 3 are the most common used modes.



**Figure 15:** Characteristics of SPI modes

### 3.6.5 PWM Interface

The GPIO6 and GPIO7 pins at the GPIO connector can be configured as Pulse Width Modulation signals PWM1 and PWM2 by AT^SCFG command - see [1]. The PWM interface lines are output lines and can be used, for example, to connect buzzers. The PWM1 line is shared with GPIO7 and the PWM2 line is shared with GPIO6 (see also Table 14). GPIO and PWM functionalities are mutually exclusive<sup>1</sup>.

### 3.6.6 Pulse Counter

The GPIO8 pin at the GPIO connector can be configured as pulse counter line COUNTER by AT^SCFG command - see [1]. The pulse counter interface is an input line and can be used, for example, as a clock (see also Table 14). GPIO and COUNTER functionalities are mutually exclusive<sup>1</sup>.

### 3.6.7 Analog-to-Digital Converter (ADC)

ADC1\_IN can be used for general purpose voltage measurements. For electrical characteristics see Section 4.2.3. ADC1\_IN is configured and read by the AT^SRADC command - see [1]. ADC1\_IN, DSR0 and SPI functionalities are mutually exclusive.

### 3.6.8 DSR0 signal

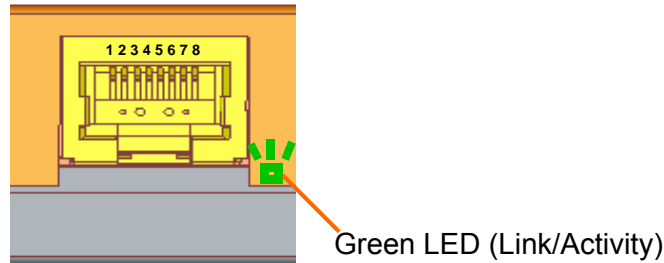
The DSR0 line available at the RS-232 interface is also routed to the GPIO connector and available as a separate pin. For electrical characteristics see Section 4.2.3. DSR0 can be configured by AT^SCFG command - see [1]. DSR0, ADC1\_IN and SPI functionalities are mutually exclusive.

---

1. **Note:** For the PWM interface and pulse counter to operate, the directions of the LTE Terminals' GPIO level shifters must be set according to the defined directions of the PWM and COUNTER signals. See Section 8.3.1.11 and Section 8.5 for more information on how to change level shifter directions.

### 3.7 Ethernet Interface

The Ethernet interface is available on all LTE Terminals. .



**Figure 16:** 8-pole RJ-45 Ethernet connector (female)

**Table 16:** Female 8-pole RJ-45 Ethernet connector

| Pin | Signal name | Use        | Comment   |
|-----|-------------|------------|---|
| 1   | TX+         | Transmit + | All lines available for Power over Ethernet (44V – 57V) |
| 2   | TX-         | Transmit - |   |
| 3   | RX+         | Receive +  |   |
| 4   | n/c         | Reserved   |   |
| 5   | n/c         | Reserved   |   |
| 6   | RX-         | Receive +  |   |
| 7   | n/c         | Reserved   |   |
| 8   | n/c         | Reserved   |   |

The Ethernet interface can be used as transparent data interface, for downloading new LTE Terminal firmware releases - module firmware as well as Ethernet sub-system software, and also to access the implemented LTE module via AT command interface.

The Ethernet interface supports Power over Ethernet (i.e., PoE+ (Class 0) according to IEEE 802.3at, and backward compatible to IEEE 802.3af.). This means that if connected to a PoE enabled router or PoE injector, the LTE Terminal does no longer need a separate power supply unit such as the mains adapter mentioned in [Section 3.8](#). The mains adapter and PoE may be connected in parallel, but one of the supplies suffices to operate the LTE Terminal (the other may be used a power supply backup). Power supplies shall be of type PS1, according to IEC 62368-1.

**Note:** The maximum cable length between LTE Terminal and the nearest network socket should be 10m, and it is recommended that the cable should be shielded.

Using the Ethernet interface it is also possible to maintain a database containing possible APNs for the LTE Terminal. Please refer to [Appendix B: Ethernet Setup and Usage](#) for details on how to setup and use LTE Terminals with Ethernet interface. For further characteristics of Ethernet interface refer to [Section 4.2.4](#).

A green LED near to the RJ-45 Ethernet connector shows the Link/Activity status of the Ethernet interface (refer to [Figure 16](#)).



### 3.8 Power Supply

The LTE Terminals power supply via Western jack has to be a single voltage source of  $V_{PLUS}=8V\dots57V$  capable of providing a peak current (pulsed  $2\times577ms$  at  $T=4.615ms$ ) of about  $1.2A$  at  $8V$  during an active transmission<sup>1</sup> in GSM mode. The uplink burst causes strong ripple (drop) on the power lines. The drop voltage should not exceed  $1V$ . The absolute minimum voltage during drops is given in [Section 4.1](#).

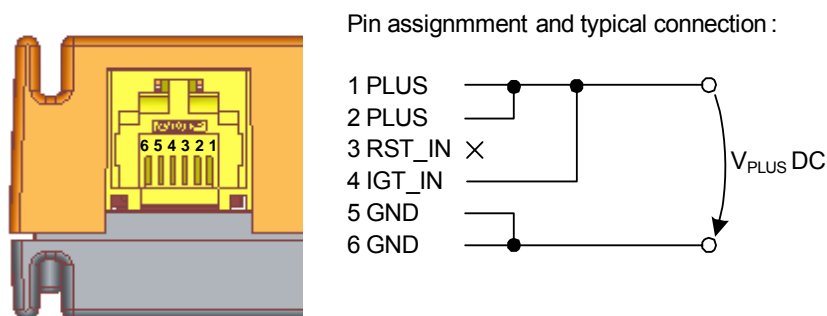
The LTE Terminals are protected from supply voltage reversal. An external fast acting fuse  $\geq 0.4A$  with melting integral  $I^2t$  ( $0.15 \dots 0.25$ ) $A^2s$  is necessary to use the LTE Terminals at a  $12V$  or  $24V$  unlimited power supply system.

The power supply must be compliant with the EN60950 guidelines. A switching regulator regulates the input voltage for the internal supply.

When power fails for  $>1ms$ , LTE Terminals reset or switch off. The watchdog can be configured to restart the LTE Terminals. When power fails for  $>15s$  the RTC will be reset.

**Table 17:** Female 6-pole Western plug for power supply, ignition, power down

| Pin | Signal name | Use                     | Parameters  |
|-----|-------------|-------------------------|---|
| 1   | PLUS        | Power supply            | $8V - 57V$ DC   |
| 2   | PLUS        | Power supply            | $8V - 57V$ DC   |
| 3   | RST_IN      | Signal for module reset | $U_{IH} \geq 8V$ for $t > 10ms$ resets the terminal.<br>$U_{IL} < 2V$ and low level for normal operation. |
| 4   | IGT_IN      | --                      | not supported on LTE Terminals  |
| 5   | GND         | Ground                  | $0V$  |
| 6   | GND         | Ground                  | $0V$  |



**Figure 17:** 6-pole Western jack for power supply, ignition, reset, typical connection

Mains adapter: If it fits into the design of your application we recommend the plug-in supply unit used with the type approved Gemalto M2M reference setup. Ordering information can be found in [Chapter 7](#). This  $12V$  mains adapter comes with a 6-pole Western plug and provides an inter-

1. As an alternative to the power supply via Western jack, Power over Ethernet (PoE) can be employed. The PoE feature complies with IEEE 802.3 standards, and can be made available in Ethernet networks via PoE enabled devices such as PoE routers or injectors.

nal connection between IGT\_IN pin and PLUS pin. LTE Terminals don't support the IGT\_IN function. Note that if employing PoE for LTE Terminals, the module will restart automatically after a normal shutdown. The module will also restart if Always On is configured (see [Section 8.3.1.8](#)).

## 3.9 Power Up/Power Down Scenarios

In general, be sure not to turn on the LTE Terminals while it is beyond the safety limits of voltage and temperature stated in [Section 4.1](#). LTE Terminals immediately switch off after having started and detected these inappropriate conditions. In extreme cases this can cause permanent damage to the LTE Terminals.

### 3.9.1 Turn LTE Terminals on

There are various possibilities to turn on LTE Terminals and start into normal mode, depending on connecting and/or operating states.

If powered off (i.e., if LTE Terminals' power supply is disconnected):

- LTE Terminals can simply be started up by plugging an appropriate power supply unit between PLUS and GND of the 6-pole Western jack. If using the PoE feature, LTE Terminal can also be started up by connecting simply the Ethernet interface

If switched off (i.e., while in Power Down mode):

- LTE Terminals can be started up by activating the RS-232 DTR line (as long as RST\_IN signal (pin 3) is not active (voltage <2V))
- LTE Terminals can be started up by configuring the watchdog appropriately. For details see [Chapter 8](#).

Note: If employing PoE (see [Section 3.8](#)), LTE Terminals will automatically restart into normal mode after switch off (see [Section 3.9.3](#)). The module will also restart if Always On is configured (see [Section 8.3.1.8](#))

### 3.9.2 Reset/Restart LTE Terminals

There are various possibilities to reset/restart LTE Terminals:

- LTE Terminals can be reset/restarted by entering the command AT+CFUN=x,1. For details on AT+CFUN please see [\[1\]](#).
- LTE Terminals can be reset/restarted by configuring the watchdog appropriately. For details see [Chapter 8](#).
- LTE Terminals can be reset/restarted by configuring a wake-up alarm (see [Section 3.12](#)) before using AT^SMSO to turn them off and send them into Power Down mode.
- LTE Terminals can be reset/restarted by simply shutting them down as described in [Section 3.9.3](#) and then restarting them as described in [Section 3.9.1](#). Note: If employing PoE (see [Section 3.8](#)), it is ensured that the module will automatically restart after a normal shutdown using AT^SMSO. The module will also restart if Always On is configured (see [Section 8.3.1.8](#))

Emergency restart:

- Finally, LTE Terminals can be reset/restarted in the event of software hang-ups etc. by applying a voltage >8V to the RST\_IN pin (pin 3) for more than 10ms. The RST\_IN signal then restarts the LTE Terminals.

Caution: Use the RST\_IN pin only when, due to serious problems, the software is not responding for more than 5 seconds. Pulling the RST\_IN pin causes the loss of all information stored in the volatile memory since power is cut off immediately. Therefore, this procedure is intended only for use in case of emergency, e.g. if LTE Terminals fails to shut down properly.

### 3.9.3 Turn LTE Terminals off

Normal shutdown:

- To turn off the LTE Terminals use the AT^SMSO command, rather than disconnecting the mains adapter. This switch off procedure lets the LTE Terminals log off from the network and allows the software to enter a secure state and save data before disconnecting the power supply. After AT^SMSO has been entered the LTE Terminals returns the following result codes:

```
^SMSO: MS OFF
OK
^SHUTDOWN
```

The "^SHUTDOWN" result code indicates that the LTE Terminals turns off in less than 1 second. After the shutdown procedure is complete the LTE Terminals enters the Power Down mode. The yellow LED stops flashing (see [Section 3.14](#) for a detailed LED description). The RTC is still fed from the voltage regulator in the power supply ASIC. Please note that if employing PoE (see [Section 3.8](#)), the module will restart automatically after a normal shutdown. The module will also restart if Always On is configured (see [Section 8.3.1.8](#))

### 3.9.4 Disconnecting power supply

Before disconnecting the power supply from the PLUS pin, make sure that the LTE Terminals are in a safe condition. The best way is to wait 1s after the "^SHUTDOWN" result code has been indicated.

### 3.10 Automatic thermal shutdown

An on-board NTC measures the temperature of the built-in LTE module. If over- or under-temperature is detected on the module the LTE Terminals automatically shut down to avoid thermal damage to the system. [Table 25](#) specifies the ambient temperature threshold for the LTE Terminals.

The automatic shutdown procedure is equivalent to the power-down initiated with the AT^SM-SO command, i.e. LTE Terminals log off from the network and the software enters a secure state avoiding loss of data.

Alert messages transmitted before the LTE Terminals switch off are implemented as Unsolicited Result codes (URCs). For details see the description of AT^SCTM command provided in [\[1\]](#).

The watchdog can be configured to restart the LTE Terminals after a defined period of time.

### 3.11 Hardware Watchdog

The LTE Terminals feature a programmable hardware watchdog that permanently monitors the terminals hardware and can be configured to react to various hardware states. The watchdog may for example be configured to periodically restart the terminal, independent of its current operating state. [Figure 6](#) shows how the watchdog is integrated into the LTE Terminals.

Please refer to [Chapter 8](#) for details on how to control and configure the hardware watchdog.

### 3.12 RTC

The internal Real Time Clock (RTC) of the LTE Terminals retains the time and date and handles the alarm function. The AT+CCLK command serves to set the time and date, and AT+CALA specifies a reminder message or sets an alarm for the LTE Terminals to wake up. See [\[1\]](#) for details.

A dedicated voltage regulator backs up the RTC even in Power Down mode and enables LTE Terminals to keep track of time and date.

However, please note that the Alarm function described in [\[1\]](#), Section AT+CALA, will only work if Always On is not configured (see [Section 8.3.1.8](#)). Otherwise, the AT+CALA command can only be used to set a reminder message, but not to configure the LTE Terminals to wake up from Power Down mode.

### 3.13 SIM Interface

The SIM interface is intended for 1.8V and 3V SIM cards in accordance with GSM 11.12 Phase 2. The card holder is a five wire interface according to GSM 11.11. A sixth pin has been added to detect whether or not a SIM card is inserted.

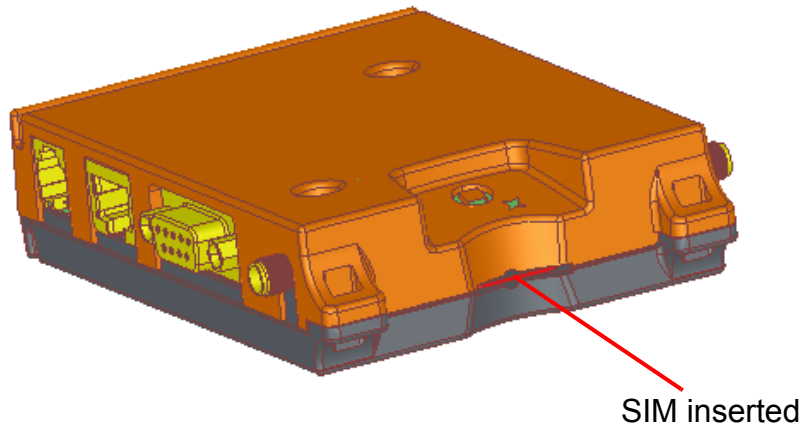


Figure 18: SIM interface

The SIM - with the circuit side facing upwards - is inserted by gently pushing it into the SIM card holder until it snaps hold. It is now protected from accidental removal. The SIM can be removed from the card holder by using a flat object such as a screwdriver to carefully press the inserted SIM until it snaps out again.

All signals of the SIM interface are protected from electrostatic discharge.

Removing and inserting the SIM card during operation requires the software to be reinitialized. Therefore, after reinserting the SIM card it is necessary to restart LTE Terminals.

**Note:** No guarantee can be given, nor any liability accepted, if loss of data is encountered after removing the SIM card during operation. Also, no guarantee can be given for properly initializing any SIM card that the user inserts after having removed a SIM card during operation. In this case, the application must restart the LTE Terminals.

### 3.14 Status LEDs

LTE Terminals have two LEDs indicating its operating states through the semitransparent casing:

- A green LED indicates whether the LTE Terminals are ready to operate and reports certain watchdog operations.
- An orange LED indicates the network registration state of the LTE Terminals.

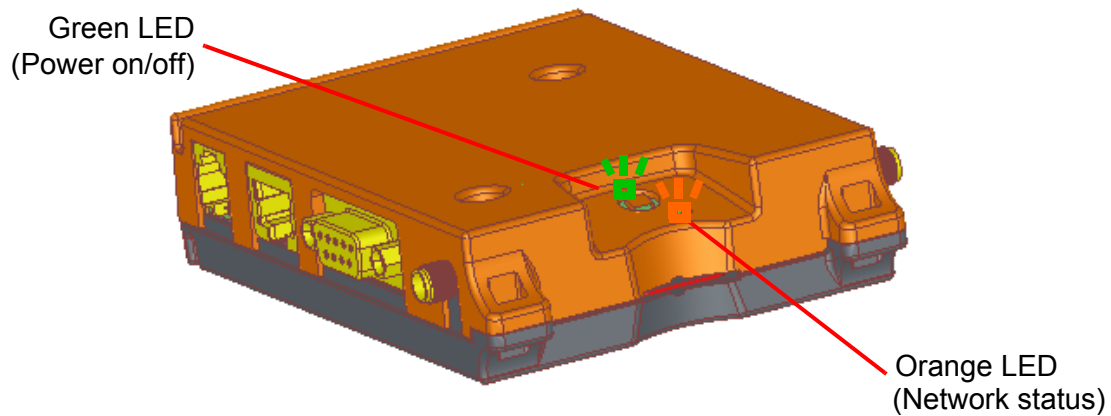


Figure 19: Status LED

The orange LED can be configured by using the `AT^SLED` command to either light permanently or to flash. For details on the AT command please refer to [\[1\]](#).

### 3.15 RF Antenna Interface

The external RF antennas are connected via the LTE Terminals's female SMA connectors that is also the antenna reference point (ARP).

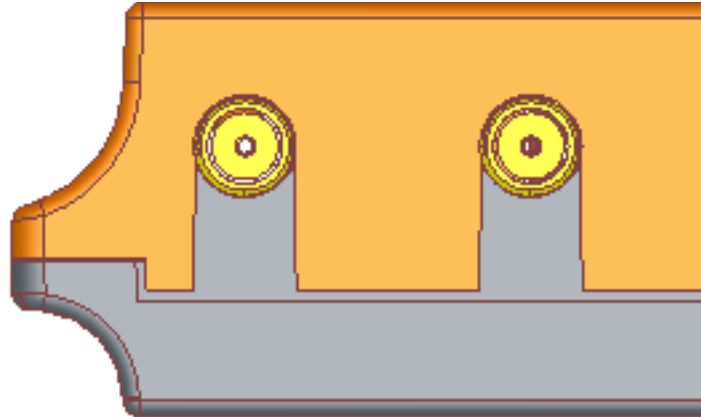


Figure 20: Antenna connectors

The system impedance is  $50\Omega$ . In any case, for good RF performance, the return loss of the customer application's antenna should be better than 10dB (VSWR < 2). LTE Terminals withstand a total mismatch at this connector when transmitting with maximum RF power.

Additional ESD protection to the antenna connector is provided. No DC voltage must be applied to the antenna circuit to protect it from damage.

Please note that the terminal should be installed and operated with a minimum distance of 20cm between the antenna connected to the terminal and any human bodies. Also, the transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. The allowed maximum antenna gain (including cable loss) for stand-alone situation is given below in [Table 18](#).

Table 18: Allowed maximum antenna gain (including cable loss)

| Terminal   | 700 MHz | 800 MHz | 850 MHz | 900 MHz | 1700 MHz | 1800 MHz | 1900 MHz | 2100 MHz |
|------------|---------|---------|---------|---------|----------|----------|----------|----------|
| ELS61T-E2  | 2.15dBi | 2.15dBi | -       | 2.15dBi | -        | 2.15dBi  | -        | 2.15dBi  |
| ELS61T-AUS | 2.15dBi | -       | 2.15dBi | 2.15dBi | -        | 2.15dBi  | -        | 2.15dBi  |
| ELS61T-US  | 2.15dBi | -       | 2.15dBi | -       | 2.15dBi  | -        | 2.15dBi  | -        |
| ELS31T-J   | -       | t.b.d.  | -       | -       | -        | -        | -        | t.b.d.   |
| ELS31T-V   | 7.4dBi  | -       | -       | -       | 6.5dBi   | -        | -        | -        |

## 4 Electrical and Environmental Characteristics

### 4.1 Absolute Maximum Ratings

**Table 19:** Absolute maximum ratings

| Parameter  | Port / Description  | Min. | Max.                              | Unit |
|--|---|------|-----------------------------------|------|
| Supply voltage                                   | PLUS  | -40  | 57 <sup>1</sup>                   | V    |
| Input voltage for on/off control lines           | RST_IN  | -5   | 30                                | V    |
| RS-232 input voltage                             | TXD0, DTR0, RTS0  | -25  | +25                               | V    |
| GPIO connector pins input voltage (incl. VCCref) | 8-pin and 12-pin connectors (if pins specified/configured as input pins)  | -0.3 | 6                                 | V    |
| GPIO connector pins output current               | 8-pin and 12-pin connectors (if pins specified/configured as output pins) | 0    | 50mA drawn @each pin <sup>2</sup> | --   |
| Immunity against discharge of static electricity | All interfaces (lines)<br>Contact discharge<br>Air discharge              | -4   | +4                                | kV   |
|  |   | -8   | +8                                | kV   |

1. Maximum 50V recommended.

2. Please note that if the VCCref pin is connected to the +5Vout pin, no more than 100mA should be drawn by **all** pins. In this case it is no longer allowed to draw a maximum of 50mA for each pin.

**Table 20:** Operating supply voltage for LTE Terminals

| Parameter   | Min | Typ | Max             | Unit |
|---|-----|-----|-----------------|------|
| Supply voltage PLUS measured at (6-pole) western jack plug (1 to 6)   | 8   | 12  | 57 <sup>1</sup> | V    |
| Minimum supply voltage PLUS measured at (6-pole) western jack plug (1 to 6) @any time, incl. all ripple, drops and temperature fluctuations | 7.6 |     |                 | V    |
| Supply voltage at RJ-45 for PoE according to IEEE 802.3at via PoE enabled router or injector  | 44  | 48  | 57 <sup>1</sup> | V    |

1. Maximum 50V recommended.



## 4.2 Electrical Specifications of the Application Interface

## 4.2 Electrical Specifications of the Application Interface

## 4.2.1 On/Off Control

Table 21: On/Off control line specifications

| Parameter  | Description                   | Conditions  | Min. | Typ | Max. | Unit      |
|------------|-------------------------------|-------------|------|-----|------|-----------|
| $V_{high}$ | Input voltage<br>RST_IN       | active high | 8    |     | 30   | V         |
| $V_{low}$  |                               |             | 0    |     | 2    | V         |
| $R_{IN}$   | Input resistance of<br>RST_IN |             | 1    |     |      | $M\Omega$ |
| $V_{high}$ | Input voltage<br>DTR          | active high | 2.4  |     | +25  | V         |
| $V_{low}$  |                               |             | -25  |     | 0.8  | V         |
| $R_{IN}$   | Input resistance of<br>DTR    |             | 3    | 5   | 7    | $k\Omega$ |

## 4.2.2 RS-232 Interface

Table 22: RS-232 interface specifications

| Parameter    | Description  | Conditions         | Min.    | Typ       | Max. | Unit      |
|--------------|--|--------------------|---------|-----------|------|-----------|
| $V_{OUT}$    | Transmitter output voltage swing for<br>RXD0, CTS0, DSR0,<br>DCD0, RING0 | @ 3k $\Omega$ load | $\pm 5$ | $\pm 5.4$ |      | V         |
| $R_{OUT}$    | Transmitter output resistance<br>RXD0, CTS0, DSR0,<br>DCD0, RING0        |                    | 300     |           |      | $\Omega$  |
| $V_{in}$     | Receiver input voltage range<br>TXD0, RTS0, DTR0                         |                    | -25     |           | +25  | V         |
| $R_{IN}$     | Receiver input resistance<br>TXD0, RTS0, DTR0                            |                    | 3       | 5         | 7    | $k\Omega$ |
| $V_{low}$    | Input threshold low  |                    | 0.8     | 1.5       |      | V         |
| $V_{high}$   | Input threshold high   |                    |         | 1.8       | 2.4  | V         |
| Baudrate     |  | Autobauding        | 1.2     |           | 960  | kbps      |
|              |  | Fixed range        | 1.2     |           | 960  | kbps      |
| $LE_{Cable}$ | Length of RS-232 cable   |                    |         | 1.8       | 2    | m         |

## 4.2 Electrical Specifications of the Application Interface

## 4.2.3 GPIO Interface

Table 23: GPIO interface specifications (requirements)

| Function  | Signal name   | IO | Signal form and level  | Comment  |
|---|---|----|--|--|
| 8-pin, 12-pin connectors for:<br>GPIO,<br>Power,<br>DAI,<br>I <sup>2</sup> C and<br>ASC1, SPI | GPIO 6-8<br>GPIO 11-13<br>GPIO 20-21<br>GPIO 22-23              | IO | $V_{OLmax} = 0.1V$ at $I = 100\mu A$<br>$V_{OLmax} = 0.55V$ at $I = 32mA$<br>$V_{OHmin} = VCCref - 0.1V$ at $I = 100\mu A$<br>$V_{OHmin} = VCCref - 0.4V$ at $I < 12mA$<br>$V_{OHmin} = VCCref - 0.7V$ at $I < 32mA$<br>$V_{ILmax} = 0.3 * VCCref$<br>$V_{IHmin} = 0.7 * VCCref$ | <p>If unused keep lines open.</p> <p>Please note that some GPIO lines can be configured for functions other than GPIO:<br/>           GPIO6/GPIO7: PWM<br/>           GPIO8: Pulse Counter/<br/>           WD_RETRIG<br/>           GPIO20-23: PCM/DAI</p> |
|   | VCCref  | I  | $V_{imax} = 5.5V$<br>$V_{imin} = 1.8V$<br><br>Input current has to at least match the positive output current required by all configured and used GPIO lines.  | <p>For level adjustment. E.g., connect 5Vout for 5V IO operation.</p> <p>Must be connected to 1.8...5.5V if employing signals from GPIO connector.</p>   |
|   | GND   | -- | --   |  |
|   | TXD1/<br>SPI_MISO   | I  | $V_{OLmax} = 0.1V$ at $I = 100\mu A$<br>$V_{OLmax} = 0.55V$ at $I = 32mA$<br>$V_{OHmin} = VCCref - 0.1V$ at $I = 100\mu A$<br>$V_{OHmin} = VCCref - 0.4V$ at $I < 12mA$<br>$V_{OHmin} = VCCref - 0.7V$ at $I < 32mA$   | If unused keep lines open.   |
|   | RXD1/ SPI_-<br>MOSI   | O  | $V_{OHmin} = VCCref - 0.1V$ at $I = 100\mu A$<br>$V_{OHmin} = VCCref - 0.4V$ at $I < 12mA$<br>$V_{OHmin} = VCCref - 0.7V$ at $I < 32mA$  | SPI interface is not available for ELS31T-V/J.   |
|   | CTS1/<br>SPI_CS   | O  | $V_{ILmax} = 0.3 * VCCref$<br>$V_{IHmin} = 0.7 * VCCref$   |  |
|   | RTS1  | I  |  |  |
|   | +5Vout  | O  | $5V, +0.05V, -0.2V$<br>$I_{outmax} = 100mA$  | <p>Regulated output for external supply. Can be connected to VCCref.</p> <p>If unused, keep open.</p>  |
|   | DSR0/<br>ADC1_IN<br>(Analog-to-Digital converter)/ SPI_-<br>CLK | I  | $R_I = 1M\Omega$<br>$V_{Imax} = 0V...VCCref + 0.3V$<br>Valid range 0V...5V<br><br>Resolution 1024 steps<br>Tolerance 0.3%  | <p>ADC1_IN can be used as input for external measurements.</p> <p>If unused keep line open.</p>  |

## 4.2 Electrical Specifications of the Application Interface

**Table 23:** GPIO interface specifications (requirements)

| Function  | Signal name | IO | Signal form and level   | Comment  |
|---|-------------|----|---|--|
| 8-pin, 12-pin connectors for: GPIO, Power, I <sup>2</sup> C and ASC1, SPI | I2CDAT      | IO | Open drain IO<br>$V_{OLmin} = 0.3V$ at $I = -3mA$<br>$V_{OHmax} = VCCref$<br>$R_{pullup} = 2.2k\Omega$<br><br>$V_{ILmax} = 0.35V$<br>$V_{IHmin} = 1.3V$<br>$V_{IHmax} = VCCref$ | According to the I <sup>2</sup> C Bus Specification Version 2.1 for the fast mode a rise time of max. 300ns is permitted. There is also a maximum $V_{OL}=0.4V$ at 3mA specified.<br>The value of the pull-up depends on the capacitive load of the whole system (I <sup>2</sup> C Slave + lines). The maximum sink current of I2CDAT and I2CCLK is 4mA.<br><br>If unused keep lines open. |
|   | I2CCLK      | IO |   |  |

#### 4.2.4 Ethernet Interface

The Ethernet interface is implemented as 10/100 Base-T RJ-45 Ethernet according to the IEEE 802.3 Ethernet standards, including PoE+ (IEEE 802.3at, backward compatible to IEEE 802.3af). For further characteristics see also [Section 3.7](#).

Please refer to [Appendix B: Ethernet Setup and Usage](#) for details on how to setup and use the LTE Terminals with Ethernet interface.

## 4.3 Maximum Power Supply Ratings

## 4.3 Maximum Power Supply Ratings

Table 24: Power supply specifications

| Parameter                           | Description   | Conditions  |      | Typical      |            |             |           |           | Unit |
|-------------------------------------|---|---|------|--------------|------------|-------------|-----------|-----------|------|
|                                     |   |   |      | ELS61 T-E/E2 | ELS61 T-US | ELS61 T-AUS | ELS31 T-J | ELS31 T-V |      |
| V <sub>PLUS</sub>                   | Allowed voltage ripple (peak-peak), drop during transmit burst peak current | Power control level for P <sub>out</sub> max <sup>1</sup> |      | 0.3          | 0.3        | 0.3         | 0.3       | 0.3       | V    |
| I <sub>PLUS</sub> <sup>2</sup>      | Average supply current (average time 3 min.)                                | Power Down mode   | @8V  |              |            |             |           |           | mA   |
|                                     |   |   | @30V |              |            |             |           |           |      |
|                                     |   |   | @57V |              |            |             |           |           |      |
|                                     | Average GSM supply current (average time 3 min.)                            | IDLE mode (GSM/GPRS, / 900/1800MHz)                       | @8V  | 150          | -          | -           | -         | -         | mA   |
|                                     |   |   | @30V | 45           | -          | -           | -         | -         |      |
|                                     |   |   | @57V | 34           | -          | -           | -         | -         |      |
|                                     | GPRS DATA mode(1 Tx, 4 Rx, 900MHz)  |   | @8V  | 360          | -          | -           | -         | -         | mA   |
|                                     |   |   | @30V | 90           | -          | -           | -         | -         |      |
|                                     |   |   | @57V | 60           | -          | -           | -         | -         |      |
|                                     | GPRS DATA mode(1 Tx, 4 Rx, 1800MHz)   |   | @8V  |              | -          | -           | -         | -         | mA   |
|                                     |   |   | @30V |              | -          | -           | -         | -         |      |
|                                     |   |   | @57V |              | -          | -           | -         | -         |      |
|                                     | GPRS DATA mode(4 Tx, 1 Rx, 900MHz)  |   | @8V  | 530          | -          | -           | -         | -         | mA   |
|                                     |   |   | @30V | 140          | -          | -           | -         | -         |      |
|                                     |   |   | @57V | 82           | -          | -           | -         | -         |      |
|                                     | GPRS DATA mode(4 Tx, 1 Rx, 1800MHz)   |   | @8V  |              | -          | -           | -         | -         | mA   |
|                                     |   |   | @30V |              | -          | -           | -         | -         |      |
|                                     |   |   | @57V |              | -          | -           | -         | -         |      |
|                                     | EDGE DATA mode(1 Tx, 4 Rx, 900MHz)  |   | @8V  |              | -          | -           | -         | -         | mA   |
|                                     |   |   | @30V |              | -          | -           | -         | -         |      |
| @57V                                |   |   |      | -            | -          | -           | -         |           |      |
| EDGE DATA mode(1 Tx, 4 Rx, 1800MHz) |   | @8V   |      | -            | -          | -           | -         | mA        |      |
|                                     |   | @30V  |      | -            | -          | -           | -         |           |      |
|                                     |   | @57V  |      | -            | -          | -           | -         |           |      |
| EDGE DATA mode(4 Tx, 1 Rx, 900MHz)  |   | @8V   |      | -            | -          | -           | -         | mA        |      |
|                                     |   | @30V  |      | -            | -          | -           | -         |           |      |
|                                     |   | @57V  |      | -            | -          | -           | -         |           |      |
| EDGE DATA mode(4 Tx, 1 Rx, 1800MHz) |   | @8V   |      | -            | -          | -           | -         | mA        |      |
|                                     |   | @30V  |      | -            | -          | -           | -         |           |      |
|                                     |   | @57V  |      | -            | -          | -           | -         |           |      |

## 4.3 Maximum Power Supply Ratings

Table 24: Power supply specifications

| Parameter         | Description  | Conditions                                 |      | Typical      |            |             |           |           | Unit |
|-------------------|--|--|------|--------------|------------|-------------|-----------|-----------|------|
|                   |  |  |      | ELS61 T-E/E2 | ELS61 T-US | ELS61 T-AUS | ELS31 T-J | ELS31 T-V |      |
| I <sub>PLUS</sub> | Peak supply current (during 577µs transmission slot every 4.6ms) | Power control level for Pout max (900MHz)  | @8V  | 1830         | -          | -           | -         | -         | mA   |
|                   |  |  | @30V | 375          | -          | -           | -         | -         |      |
|                   |  |  | @57V | 240          | -          | -           | -         | -         |      |
|                   |  | Power control level for Pout max (1800MHz) | @8V  |              | -          | -           | -         | -         | mA   |
|                   |  |  | @30V |              | -          | -           | -         | -         |      |
|                   |  |  | @57V |              | -          | -           | -         | -         |      |
| I <sub>PLUS</sub> | Average UMTS supply current (average time 3 min.)                | IDLE mode                                  | @8V  |              | 152        | 154         |           |           | mA   |
|                   |  |  | @30V |              | 46         | 46          |           |           |      |
|                   |  |  | @57V |              | 35         | 35          |           |           |      |
|                   |  | UMTS DATA (Band I; 23dBm)                  | @8V  |              | -          | 650         | -         | -         | mA   |
|                   |  |  | @30V |              | -          | 180         | -         | -         |      |
|                   |  |  | @57V |              | -          | 106         | -         | -         |      |
|                   |  | UMTS DATA Band II; 23dBm                   | @8V  | -            |            | -           | -         | -         | mA   |
|                   |  |  | @30V | -            |            | -           | -         | -         |      |
|                   |  |  | @57V | -            |            | -           | -         | -         |      |
|                   |  | UMTS DATA Band IV; 23dBm                   | @8V  | -            | 568        | -           | -         | -         | mA   |
|                   |  |  | @30V | -            | 158        | -           | -         | -         |      |
|                   |  |  | @57V | -            | 112        | -           | -         | -         |      |
|                   |  | UMTS DATA Band V; 23dBm                    | @8V  | -            |            |             | -         | -         | mA   |
|                   |  |  | @30V | -            |            |             | -         | -         |      |
|                   |  |  | @57V | -            |            |             | -         | -         |      |
|                   |  | UMTS DATA Band VIII; 23dBm                 | @8V  |              | -          |             | -         | -         | mA   |
|                   |  |  | @30V |              | -          |             | -         | -         |      |
|                   |  |  | @57V |              | -          |             | -         | -         |      |
|                   |  | HSPA DATA (Band I; 23dBm)                  | @8V  |              | -          | 650         | -         | -         | mA   |
|                   |  |  | @30V |              | -          | 180         | -         | -         |      |
|                   |  |  | @57V |              | -          | 105         | -         | -         |      |
|                   |  | HSPA DATA Band II; 23dBm                   | @8V  | -            |            | -           | -         | -         | mA   |
|                   |  |  | @30V | -            |            | -           | -         | -         |      |
|                   |  |  | @57V | -            |            | -           | -         | -         |      |

## 4.3 Maximum Power Supply Ratings

Table 24: Power supply specifications

| Parameter         | Description  | Conditions                       |      | Typical      |            |             |           |           | Unit |
|-------------------|--|----------------------------------|------|--------------|------------|-------------|-----------|-----------|------|
|                   |  |                                  |      | ELS61 T-E/E2 | ELS61 T-US | ELS61 T-AUS | ELS31 T-J | ELS31 T-V |      |
| I <sub>PLUS</sub> |  | HSPA DATA<br>Band IV; 23dBm      | @8V  | -            | -          | -           | -         | -         | mA   |
|                   |  |                                  | @30V | -            | -          | -           | -         |           |      |
|                   |  |                                  | @57V | -            | -          | -           | -         |           |      |
|                   |  | HSPA DATA<br>Band V; 23dBm       | @8V  | -            | -          | -           | -         | -         | mA   |
|                   |  |                                  | @30V | -            | -          | -           | -         |           |      |
|                   |  |                                  | @57V | -            | -          | -           | -         |           |      |
|                   |  | HSPA DATA<br>Band VIII;<br>23dBm | @8V  | -            | -          | -           | -         | -         | mA   |
|                   |  |                                  | @30V | -            | -          | -           | -         |           |      |
|                   |  |                                  | @57V | -            | -          | -           | -         |           |      |
| I <sub>PLUS</sub> | Average LTE supply<br>current (average time 3<br>min.) | IDLE                             | @8V  | 210          | 208        | 210         | 230       | 220       | mA   |
|                   |  |                                  | @30V | 70           | 70         | 71          | 75        | 75        |      |
|                   |  |                                  | @57V | 45           | 45         | 45          | 50        | 50        |      |
|                   |  | LTE DATA<br>Band 1, 23dBm        | @8V  | 590          | -          | -           | 800       | -         | mA   |
|                   |  |                                  | @30V | 165          | -          | -           | 220       | -         |      |
|                   |  |                                  | @57V | 100          | -          | -           | 130       | -         |      |
|                   |  | LTE DATA<br>Band 2, 23dBm        | @8V  | -            | 570        | -           | -         | -         | mA   |
|                   |  |                                  | @30V | -            | 160        | -           | -         | -         |      |
|                   |  |                                  | @57V | -            | 115        | -           | -         | -         |      |
|                   |  | LTE DATA<br>Band 3, 23dBm        | @8V  | -            | -          | 690         | -         | -         | mA   |
|                   |  |                                  | @30V | -            | -          | 190         | -         | -         |      |
|                   |  |                                  | @57V | -            | -          | 117         | -         | -         |      |
|                   |  | LTE DATA<br>Band 4, 23dBm        | @8V  | -            | 572        | -           | -         | -         | mA   |
|                   |  |                                  | @30V | -            | 161        | -           | -         | -         |      |
|                   |  |                                  | @57V | -            | 115        | -           | -         | -         |      |
|                   |  | LTE DATA<br>Band 5, 23dBm        | @8V  | -            | -          | -           | -         | -         | mA   |
|                   |  |                                  | @30V | -            | -          | -           | -         | -         |      |
|                   |  |                                  | @57V | -            | -          | -           | -         | -         |      |
|                   |  | LTE DATA<br>Band 8, 23dBm        | @8V  | -            | -          | -           | -         | -         | mA   |
|                   |  |                                  | @30V | -            | -          | -           | -         | -         |      |
|                   |  |                                  | @57V | -            | -          | -           | -         | -         |      |
|                   |  | LTE DATA<br>Band 12, 23dBm       | @8V  | -            | -          | -           | -         | -         | mA   |
|                   |  |                                  | @30V | -            | -          | -           | -         | -         |      |
|                   |  |                                  | @57V | -            | -          | -           | -         | -         |      |
|                   |  | LTE DATA<br>Band 13, 23dBm       | @8V  | -            | -          | -           | -         | 600       | mA   |
|                   |  |                                  | @30V | -            | -          | -           | -         | 162       |      |
|                   |  |                                  | @57V | -            | -          | -           | -         | 99        |      |

## 4.3 Maximum Power Supply Ratings

Table 24: Power supply specifications

| Parameter         | Description | Conditions                 |      | Typical      |            |             |           |           | Unit |
|-------------------|-------------|----------------------------|------|--------------|------------|-------------|-----------|-----------|------|
|                   |             |                            |      | ELS61 T-E/E2 | ELS61 T-US | ELS61 T-AUS | ELS31 T-J | ELS31 T-V |      |
| I <sub>PLUS</sub> |             | LTE DATA<br>Band 18, 23dBm | @8V  | -            | -          | -           | 760       | -         | mA   |
|                   |             |                            | @30V | -            | -          | -           | 210       | -         |      |
|                   |             |                            | @57V | -            | -          | -           | 120       | -         |      |
|                   |             | LTE DATA<br>Band 19, 23dBm | @8V  | -            | -          | -           | 740       | -         | mA   |
|                   |             |                            | @30V | -            | -          | -           | 200       | -         |      |
|                   |             |                            | @57V | -            | -          | -           | 115       | -         |      |
|                   |             | LTE DATA<br>Band 20, 23dBm | @8V  | -            | -          | -           | -         | -         | mA   |
|                   |             |                            | @30V | -            | -          | -           | -         | -         |      |
|                   |             |                            | @57V | -            | -          | -           | -         | -         |      |
|                   |             | LTE DATA<br>Band 28, 23dBm | @8V  | -            | -          | -           | -         | -         | mA   |
|                   |             |                            | @30V | -            | -          | -           | -         | -         |      |
|                   |             |                            | @57V | -            | -          | -           | -         | -         |      |

1. Lowest voltage (minimum peak) incl. all ripple and drops >7.6V including voltage drop, ripple and spikes, measured at western jack (6-pole) pins.
2. Typical values measured with antenna impedance = 50 Ohm (return loss >20dB).

## 4.4 Operating Temperatures

**Table 25:** Temperature characteristics

| Parameter  | Min        | Typical    | Max        | Unit |
|--|------------|------------|------------|------|
| Normal operation <sup>1</sup>  | -30        |            | +85        | °C   |
| Extended operation <sup>1, 2</sup>   | -40 to -30 |            | +85 to +90 | °C   |
| Automatic thermal shutdown <sup>1, 3</sup>   | <-40       |            | >+90       | °C   |
| Thermal resistance ( $R_{th}$ ) <sup>4</sup><br>2G operation (with $P_{th} = 1.5W$ )<br>3G operation (with $P_{th} = 3.5W$ ) |            | 10<br>11.5 |            | K/W  |

1. Board temperature of LTE module.
2. Extended operation allows normal mode speech calls or data transmission for limited time until automatic thermal shutdown takes effect. Within the extended temperature range (outside the normal operating temperature range) the specified electrical characteristics may be in- or decreased.
3. Due to temperature measurement uncertainty, a tolerance of  $\pm 3^{\circ}C$  on these switching thresholds may occur.
4. Thermal resistance ( $R_{th}$ ) of the LTE Terminals at the highest possible thermal power ( $P_{th}$ ) dissipation, i.e., at the worst possible network conditions. Measured in still air with an air gap of at least 100mm between the LTE Terminals and other objects.

Note: Within the specified operating temperature ranges the board temperature may vary to a great extent depending on operating mode, used frequency band, radio output power and current supply voltage. Note also the differences and dependencies that usually exist between board (PCB) temperature of the LTE module and its ambient temperature.



## 4.5 Antenna Interface

Table 26 lists RF antenna interface specifications for the LTE Terminals. Please note that the specified conditions may not apply to or be supported by all terminals.

**Table 26:** RF Antenna interface GSM / UMTS / LTE

| Parameter  | Conditions  | Min.  | Typical | Max. | Unit |
|--|---|---|---------|------|------|
| LTE connectivity   | Band 1, 2, 3, 4, 5, 8, 12, 13, 18, 19, 20, 28 (not every module variant supports all bands) |   |         |      |      |
| Receiver Input Sensitivity @ ARP, dual antenna (main+ diversity) | LTE 700 Band 12 (ch. bandwidth 5MHz)  |   | -99     |      | dBm  |
|  | LTE 700 Band 13 (ch. bandwidth 5MHz)  | -99.3   | -101    |      | dBm  |
|  | LTE 700 Band 28 (ch. bandwidth 5MHz)  |   | -98.5   |      | dBm  |
|  | LTE 800 Band 20(ch. bandwidth 5MHz)   |   | -97     |      | dBm  |
|  | LTE 850 Band 5 (ch. bandwidth 10MHz)  |   | -98     |      | dBm  |
|  | LTE 850 Band 18 (ch. bandwidth 5MHz)  | -99.3   | -103    |      | dBm  |
|  | LTE 850 Band 19 (ch. bandwidth 5MHz)  | -99.3   | -103    |      | dBm  |
|  | LTE 900 Band 8 (ch. bandwidth 5MHz)   |   | -97     |      | dBm  |
|  | LTE AWS Band 4 (ch. bandwidth 10MHz)  |   | -100    |      | dBm  |
|  | LTE 1800 Band 3 (ch. bandwidth 5MHz)  |   | -97     |      | dBm  |
|  | LTE 1900 Band 2 (ch. bandwidth 10MHz)   |   | -100    |      | dBm  |
|  | LTE 2100 Band 1 (ch. bandwidth 5MHz)  |   | -100    |      | dBm  |
|  | RF Power @ ARP with 50Ω Load (power supply: 3.8/4V, temperature 25°C)                       | LTE 700 Band 12 (ch. bandwidth 5MHz; 1RB, position low) |         | +23  |      |
| LTE 700 Band 13  |   |   | +23     |      | dBm  |
| LTE 700 Band 28  |   |   | +23     |      | dBm  |
| LTE 800 Band 20  |   |   | +23     |      | dBm  |
| LTE 850 Band 5 (ch. bandwidth 5MHz; 1RB, position low)           |   |   | +23     |      | dBm  |
| LTE 850 Band 18  |   |   | +23     |      | dBm  |
| LTE 850 Band 19  |   |   | +23     |      | dBm  |
| LTE 900 Band 8   |   |   | +23     |      | dBm  |

## 4.5 Antenna Interface

Table 26: RF Antenna interface GSM / UMTS / LTE

| Parameter   | Conditions  | Min.              | Typical | Max. | Unit |
|---|---|-------------------|---------|------|------|
| RF Power @ ARP with 50Ω Load (power supply: 3.8/4V, temperature 25°C) | LTE AWS Band 4 (ch. bandwidth 5MHz; 1RB, position low)                    |                   | +23     |      | dBm  |
|   | LTE 1800 Band 3   |                   | +23     |      | dBm  |
|   | LTE 1900 Band 2 (ch. bandwidth 5MHz; 1RB, position low)                   |                   | +23     |      | dBm  |
|   | LTE 2100 Band 1   |                   | +23     |      | dBm  |
| UMTS/HSPA connectivity  | Band I, II, IV, V, VI, VIII (not every module variant supports all bands) |                   |         |      |      |
| Receiver Input Sensitivity @ ARP                                      | UMTS 800/850 Band VI/V  | -104.7/<br>-106.7 | -110    |      | dBm  |
|   | UMTS 900 Band VIII  | -103.7            | -110    |      | dBm  |
|   | UMTS 1900 Band II   | -104.7            | -109    |      | dBm  |
|   | UMTS 2100 Band I, IV  | -106.7            | -110    |      | dBm  |
| RF Power @ ARP with 50Ω Load Board temperature <85°C                  | UMTS 800/850 Band VI/V  | +21               | +24     | +25  | dBm  |
|   | UMTS 900 Band VIII  | +21               | +24     | +25  | dBm  |
|   | UMTS AWS Band IV  | +21               | +24     | +25  | dBm  |
|   | UMTS 1900 Band II   | +21               | +24     | +25  | dBm  |
|   | UMTS 2100 Band I  | +21               | +24     | +25  | dBm  |
| GPRS coding schemes   | Class 12, CS1 to CS4  |                   |         |      |      |
| EGPRS   | Class 12, MCS1 to MCS9  |                   |         |      |      |
| GSM Class   | Small MS  |                   |         |      |      |
| Static Receiver input Sensitivity @ ARP                               | GSM 850 / E-GSM 900   | -102              | -109    |      | dBm  |
|   | GSM 1800 / GSM 1900   | -102              | -108    |      | dBm  |
| RF Power @ ARP with 50Ω Load  | GSM   |                   | 33      |      | dBm  |
|   |   |                   | 30      |      | dBm  |

## 4.5 Antenna Interface

**Table 26:** RF Antenna interface GSM / UMTS / LTE

| Parameter  | Conditions | Min.                | Typical | Max. | Unit |     |
|--|------------|---------------------|---------|------|------|-----|
| RF Power @ ARP with 50Ohm Load, (with maximum power reduction) | GPRS, 1 TX | GSM 850 / E-GSM 900 |         | 33   |      | dBm |
|  |            | GSM 1800 / GSM 1900 |         | 30   |      | dBm |
|  | EDGE, 1 TX | GSM 850 / E-GSM 900 |         | 27   |      | dBm |
|  |            | GSM 1800 / GSM 1900 |         | 26   |      | dBm |
|  | GPRS, 2 TX | GSM 850 / E-GSM 900 |         | 30   |      | dBm |
|  |            | GSM 1800 / GSM 1900 |         | 27   |      | dBm |
|  | EDGE, 2 TX | GSM 850 / E-GSM 900 |         | 24   |      | dBm |
|  |            | GSM 1800 / GSM 1900 |         | 23   |      | dBm |
|  | GPRS, 3 TX | GSM 850 / E-GSM 900 |         | 28.2 |      | dBm |
|  |            | GSM 1800 / GSM 1900 |         | 25.2 |      | dBm |
|  | EDGE, 3 TX | GSM 850 / E-GSM 900 |         | 22.2 |      | dBm |
|  |            | GSM 1800 / GSM 1900 |         | 21.2 |      | dBm |
|  | GPRS, 4 TX | GSM 850 / E-GSM 900 |         | 27   |      | dBm |
|  |            | GSM 1800 / GSM 1900 |         | 24   |      | dBm |
|  | EDGE, 4 TX | GSM 850 / E-GSM 900 |         | 21   |      | dBm |
|  |            | GSM 1800 / GSM 1900 |         | 20   |      | dBm |

## 4.6 Storage Conditions

## 4.6 Storage Conditions

Table 27: Storage conditions

| Type   | Condition                       | Unit                         | Reference   |
|--|---------------------------------|------------------------------|---|
| Air temperature: Low<br>High   | -30<br>+75                      | °C                           | ETS 300 019-2-1: T1.2, IEC 60068-2-1 Ab<br>ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb          |
| Humidity relative: Low<br>High<br>Condens.                               | 10<br>90 at 30°C<br>not allowed | %                            | ---<br>ETS 300 019-2-1: T1.2, IEC 60068-2-56 Cb<br>ETS 300 019-2-1: T1.2, IEC 60068-2-30 Db |
| Air pressure: Low<br>High  | 70<br>106                       | kPa                          | IEC TR 60271-3-1: 1K4<br>IEC TR 60271-3-1: 1K4  |
| Movement of surrounding air  | 1.0                             | m/s                          | IEC TR 60271-3-1: 1K4   |
| Water: rain, dripping, icing and frosting                                | Not allowed                     | ---                          | ---   |
| Radiation: Solar<br>Heat   | 1120<br>600                     | W/m <sup>2</sup>             | ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb<br>ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb          |
| Chemically active substances   | Not recommended                 |                              | IEC TR 60271-3-1: 1C1L  |
| Mechanically active substances   | Not recommended                 |                              | IEC TR 60271-3-1: 1S1   |
| Vibration sinusoidal:<br>Displacement<br>Acceleration<br>Frequency range | 1.5<br>5<br>2-9 9-200           | mm<br>m/s <sup>2</sup><br>Hz | IEC TR 60271-3-1: 1M2   |
| Shocks:<br>Shock spectrum<br>Duration<br>Acceleration                    | semi-sinusoidal<br>1<br>50      | ms<br>m/s <sup>2</sup>       | IEC 60068-2-27 Ea   |

The conditions stated above are only valid for devices in their original packed state in weather protected, non-temperature-controlled storage locations. Normal storage time under these conditions is 12 months maximum.

## 5 Mechanics, Mounting and Packaging

### 5.1 Mechanical Dimensions

Figure 21 shows a 3D view of the LTE Terminal and provides an overview of the mechanical dimensions of the board. For further details see Figure 22 and Figure 23. To allow for an easier mechanical implementation into an external application 3D STP data for the LTE Terminals is attached to this PDF. Please open the [Attachments](#) navigation panel to view and save this information.

Length: 113.5mm (including fixtures for cable straps)  
Width: 75mm (excluding antenna and serial interface connectors)  
Height: 25.5mm  
  
Weight: 120g

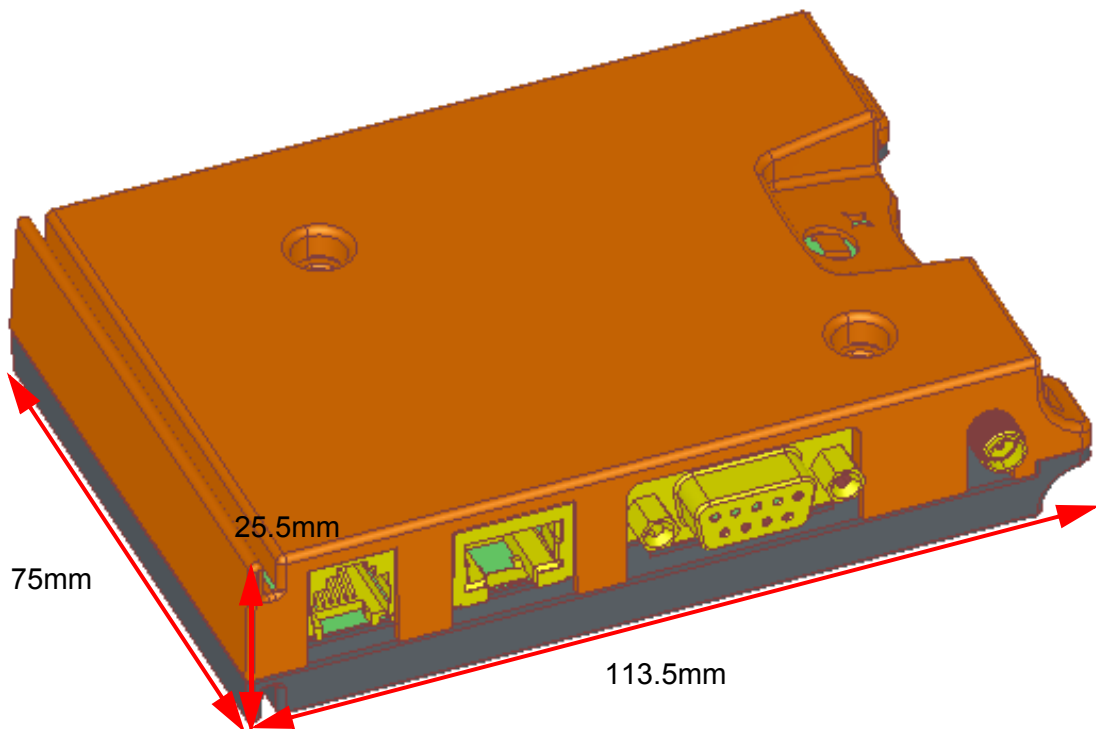


Figure 21: LTE Terminals 3D overview

5.1 Mechanical Dimensions

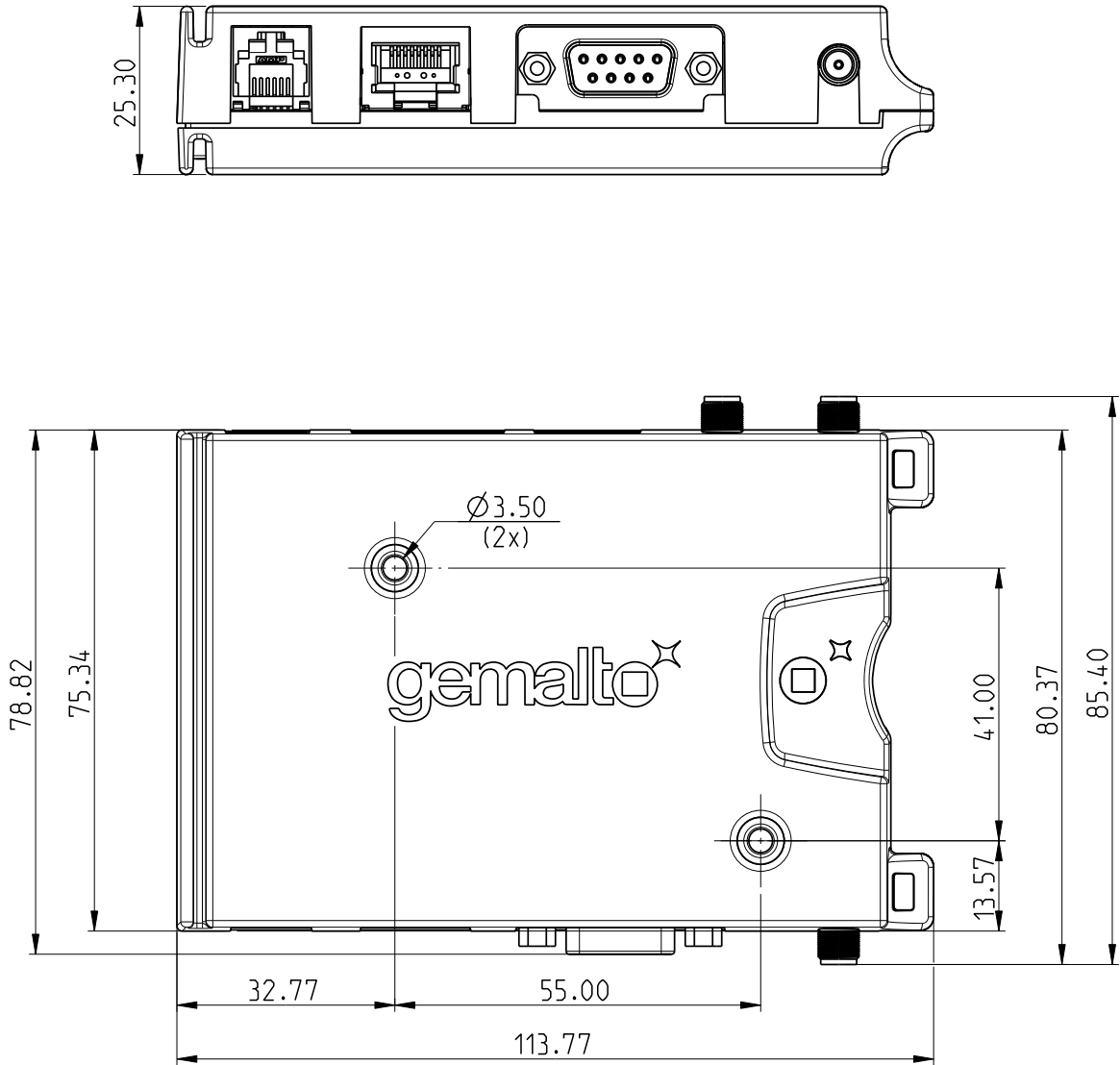


Figure 22: LTE Terminals mechanical dimensions

5.1 Mechanical Dimensions

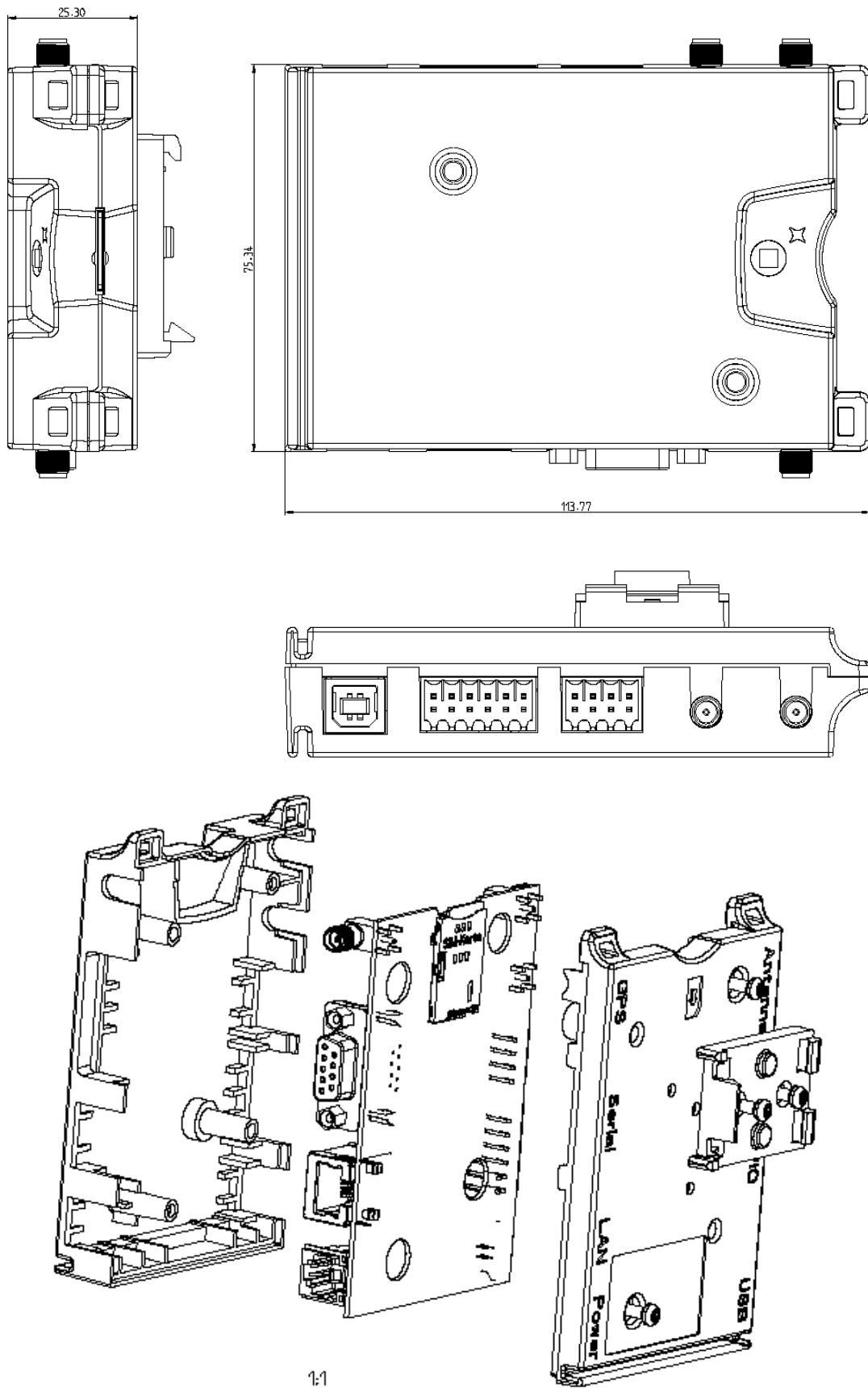


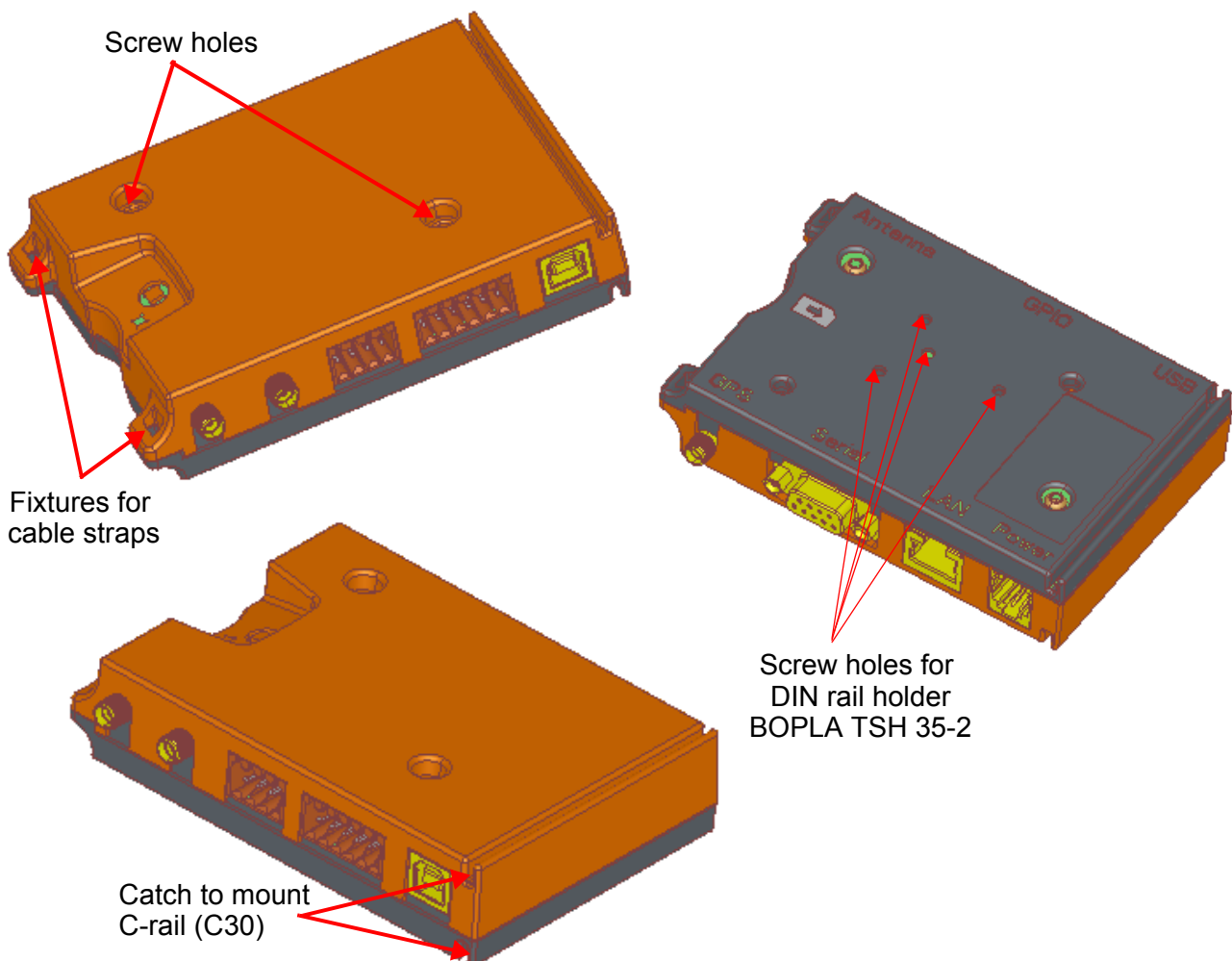
Figure 23: LTE Terminals exploded view

## 5.2 Mounting the LTE Terminals

There are a number of ways to mount the LTE Terminals:

- LTE Terminals can be attached to a rail installation or other surface using the two provided screw holes for screws, e.g., size M3.
- LTE Terminals can be fastened to a rack or holding using the two provided fixtures for cable straps.
- LTE Terminals can be slid onto a specific DIN rail made according to DIN EN 60715 - C section, C30 format. A catch at the terminal's bottom side will have to be removed to slide multiple terminals onto a single rail.
- Using a BOPLA TSH 35-2 universal DIN rail holder the LTE Terminals can be fitted onto another special type of DIN rail made according to DIN EN 60715 - Top hat section, 35mm (e.g., Wago 210-113 steel carrier rail).

The following figure shows the various possibilities provided to mount the LTE Terminals.



**Figure 24:** Mounting the LTE Terminals

The various ways to mount the LTE Terminals may be combined where appropriate. It is for example possible to slide the terminal onto a DIN rail and in addition use cable straps to fasten it to a holding.



## 5.3 Packaging

LTE Terminals come in terminal boxes:

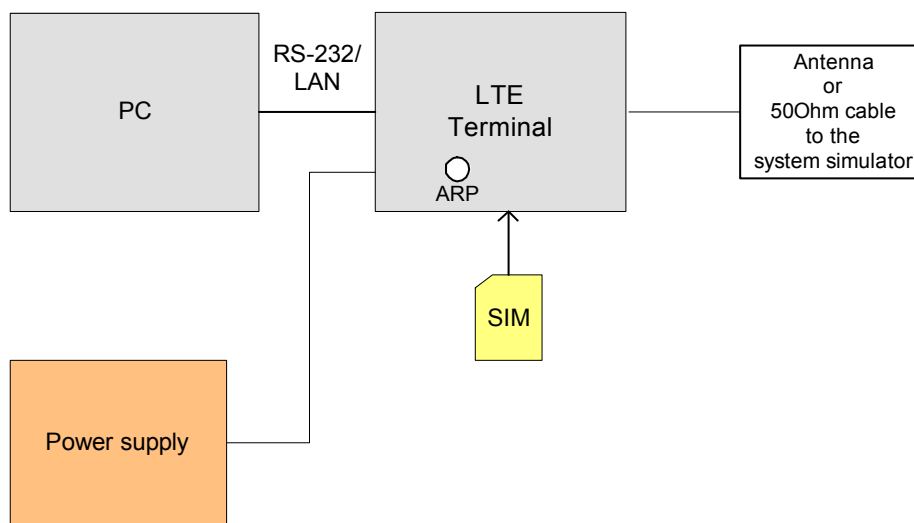
- Terminal box size: 191mm x 143mm x 44mm.

## 6 Full Type Approval

### 6.1 Gemalto M2M Reference Setup

The Gemalto M2M reference setup submitted to type approve LTE Terminals consists of the following components:

- LTE Terminal with approved LTE module
- PC as MMI
- Power Supply



**Figure 25:** Reference equipment for approval

For ordering information please refer to [Chapter 7](#).

## 6.2 Restrictions

Later enhancements and modifications beyond the certified configuration require extra approvals. Each supplementary approval process includes submittal of the technical documentation as well as testing of the changes made.

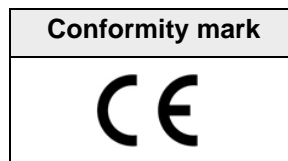
- No further approvals are required for customer applications that comply with the approved LTE Terminals configuration.
- Extra approval must be obtained for applications using other accessories than those included in the approved LTE Terminals configuration (power supply, MMI implementation supported by AT commands).

## 6.3 CE Conformity

The LTE Terminals ELS61T-E2 (contains the module ELS61-E R2) and ELS61T-AUS (contains the module ELS61-AUS) meet the requirements of the EU directives listed below:

- RED Directive 2014/53/EU

The LTE Terminals are marked with the CE conformity mark (without a notified body number):



The terminal can be used in all countries of the European Union. The Terminal will send only on frequency bands, which are assigned by the network.

## 6.4 EMC

The LTE Terminals ELS61T-E2 (contains the module ELS61-E R2) and ELS61T-AUS (contains the module ELS61-AUS) comply with the equipment requirements specified in EN 301489-1, and -52 are covered by the RED Directive. For details see [Section 1.3](#).

## 6.5 Compliance with FCC and IC Rules and Regulations

As an integrated product, the LTE Terminals are fully compliant with the grant of the FCC Equipment Authorization and the Industry Canada Certificates issued for the built-in LTE modules, and therefore, bear the labels “Contains FCC ID: QIPELS61-US” or “Contains FCC ID: QIPELS61-AUS” or “Contains FCC ID: QIPELS31-V”.

The Equipment Authorization Certification for the Cinterion® LTE modules is listed under the following identifiers:

FCC Identifier: QIPELS61-US or QIPELS61-AUS or QIPELS31-V  
Industry Canada Certification Number: 7830A-ELS61US or 7830A-ELS31V  
Granted to Gemalto M2M GmbH

### Notes (FCC):

Radiofrequency radiation exposure information:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 20 cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

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.

This terminal equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Changes or modifications made to this equipment not expressly approved by Gemalto M2M may void the FCC authorization to operate this equipment.

This device contains LTE, UMTS, GSM and GPRS class functions in the 700 (Bd28), 800/850 (Bd6, Bd18, Bd19), 900, 1800 and 2100MHz bands that are not operational in U.S. Territories. This device is to be used only for mobile and fixed applications.

Users and installers must be provided with antenna installation instructions and transmitter operating conditions for satisfying RF exposure compliance: For more information on the RF antenna interface please refer to [Section 3.15](#) and [Section 4.5](#).

**Notes (IC):**

(EN) This Class B digital apparatus complies with Canadian ICES-003 and RSS-210. 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.

(FR) Cet appareil numérique de classe B est conforme aux normes canadiennes ICES-003 et RSS-210. Son fonctionnement est soumis aux deux conditions suivantes: (1) cet appareil ne doit pas causer d'interférence et (2) cet appareil doit accepter toute interférence, notamment les interférences qui peuvent affecter son fonctionnement.

**(EN) Radio frequency (RF) Exposure Information**

The radiated output power of the Wireless Device is below the Industry Canada (IC) radio frequency exposure limits. The Wireless Device should be used in such a manner such that the potential for human contact during normal operation is minimized.

This device has also been evaluated and shown compliant with the IC RF Exposure limits under mobile exposure conditions. (antennas are greater than 20cm from a person's body).

**(FR) Informations concernant l'exposition aux fréquences radio (RF)**

La puissance de sortie émise par l'appareil de sans fil est inférieure à la limite d'exposition aux fréquences radio d'Industry Canada (IC). Utilisez l'appareil de sans fil de façon à minimiser les contacts humains lors du fonctionnement normal.

Ce périphérique a également été évalué et démontré conforme aux limites d'exposition aux RF d'IC dans des conditions d'exposition à des appareils mobiles (les antennes se situent à moins de 20cm du corps d'une personne).




## 6.6 Compliance with Japanese Rules and Regulations

The ELS31T-J reference application described in [Section 6.1](#) complies with the requirements of the Japanese "Telecommunications Business Law" and "Ordinance Concerning Technical Regulations Conformity Certification of Specified Radio Equipment" as well as with the requirements of the Japanese "Radio Law" and "Ordinance Concerning Technical Conditions Compliance Approval and Certification of the Type for Terminal Equipment".

- The certificates granted in accordance with the "Telecommunications Business Law" have the identifiers of the module ELS31-J:  
ELS31T-J: D150192003
- The certificates granted in accordance with the "Radio Law" have the identifiers of the module ELS31-J:  
ELS31T-J: 003-150276

## 7 List of Parts and Accessories

**Table 28:** List of parts and accessories

| Description  | Supplier                      | Ordering information   |
|--|-------------------------------|--|
| LTE Terminals  | Gemalto M2M                   | Ordering number<br>ELS61T-E2: L30960-N2751-A200<br>ELS61T-AUS: L30960-N2753-A100<br>ELS61T-US: L30960-N2752-A100<br>ELS31T-J: L30960-N2755-A100<br>ELS31T-V: L30960-N2754-A100   |
| Power supply unit<br>Input: 100-240V / 47-63Hz / 400mA<br>Output: 12V / 1,25A<br>   | Gemalto M2M                   | Terminal Power Supply (incl. EU adapter)<br>Ordering number: L36880-N8490-A12<br><br>UK adapter for above Terminal Power Supply<br>Ordering number: L36880-N8490-A13<br><br>US adapter for above Terminal Power Supply<br>Ordering number: L36880-N8490-A14<br><br>AU adapter for above Terminal Power Supply<br>Ordering number: L36880-N8490-A15                   |
| DIN rail holder - BOPLA TSH 35-2<br>  | BOPLA                         | Ordering number: 20035000<br>BOPLA Gehäuse Systeme GmbH<br>Borsigstr. 17-25<br>D-32257 Bünde<br>Phone: +49 (0)5223 / 969 - 0<br>Fax: +49 (0)5223 / 969 - 100<br>Email: <a href="mailto:info@bopla.de">info@bopla.de</a><br>Web: <a href="http://www.bopla.de">http://www.bopla.de</a>  |
| Antenna - SMARTEQ-MiniMAG<br>Dualband, 0dBd, 2.6m RG174, SMA<br>(m)  | KÖBEL Mobile<br>Communication | Ordering number: 1140.26 with crimped SMA<br>connector<br>KÖBEL Mobile Communication<br>Sesamstrasse 12<br>D-24632 Lentföhrden   |
| RS-232 cable with 9-pin D-sub con-<br>nector (male)  | Tecline                       | Tecline GmbH<br>Behrener Straße 8<br>D-66117 Saarbrücken<br>Phone: +49-681-926-78-70<br>Fax: +49-681-926-78-555<br>Web: <a href="http://www.tecline-edv.de/">http://www.tecline-edv.de/</a>  |
| 8-pin and 12-pin header GPIO con-<br>nector (female plug) for GPIO inter-<br>face<br>Type:<br>8-pin: B2CF 3.50/08/180 SN BK BX<br>12-pin: B2CF 3.50/12/180 SN BK BX<br> | Weidmueller                   | Ordering number (12-pin): 1277510000<br>Ordering number (8-pin): 1277480000<br>Weidmüller Interface GmbH & Co. KG<br>Klingenbergstraße 16<br>D-32758 Detmold<br><br>Phone: +49 5231 14-0<br>Fax: +49 5231 14-2083<br>Email: <a href="mailto:info@weidmueller.de">info@weidmueller.de</a><br>Web: <a href="http://www.weidmueller.com">http://www.weidmueller.com</a> |

## 8 Appendix A: (Hardware) Watchdog

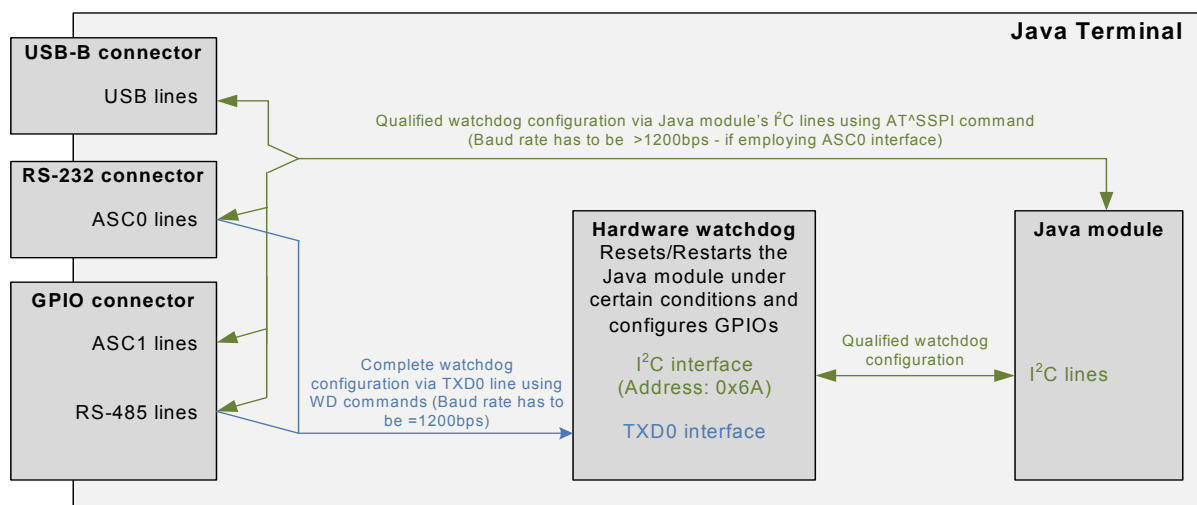
The watchdog is part of the LTE Terminals and connected to the LTE module itself (see also [Figure 6](#)). It can be used to

- Safely reset the module in certain conditions
- Restart the module when it has turned off
- Configure level shifter's GPIO directions and DSR0/ADC1\_IN availability at the GPIO connector

The complete watchdog functionality can be configured by means of special watchdog configuration commands (i.e., WD commands) that are passed to the watchdog via the serial TXD0 line. For details on how to configure the complete watchdog functionality see [Section 8.3](#).

A qualified set of configuration commands - level shifter's GPIO directions, DSR0/ADC1\_IN usage, trigger delay and firmware infos - can be specified by means of a special write/read protocol handled by the watchdog's I<sup>2</sup>C interface. For details on how to configure the watchdog via I<sup>2</sup>C interface see [Section 8.4](#).

The below [Figure 26](#) illustrates the various ways the watchdog may be accessed and configured.



**Figure 26:** Hardware watchdog configuration

Note: Unless the complete configuration scope is required, the qualified watchdog configuration via I<sup>2</sup>C interface should be used.



## 8.1 Reset Conditions

The watchdog implements three conditions, under which a reset of the module is automatically performed:

- **Repetitive:** A module reset is performed frequently and repetitive. This reset condition can be used to force the module to reconnect to the mobile network once in a while. Typical frequencies can be 24h or longer. This feature can be configured via the RST\_REP timeout.
- **UART activity:** The watchdog can be used to reset the module, when no response from the module on AT commands is recognized for a specified amount of time. To prevent the reset, the module has to be active frequently on the UART interface. This reset condition can be configured via the RST\_UART timeout, it is deactivated when timeout parameter = 0.
- **GPIO activity:** The watchdog can be used to reset the module, when no activity on the designated GPIO signal is recognized for a specified amount of time. To prevent the reset, the module has to be active frequently by toggling this GPIO signal. This reset condition can be configured via the RST\_GPIO timeout, it is deactivated when timeout parameter = 0.

When the watchdog is enabled, it will observe the activities on the UART and GPIO interfaces as well as the LTE module status, depending on timeout parameter settings and perform frequent resets, if it is configured to do so.

### 8.1.1 Reset stages

Basically, there are up to two escalation stages during a module reset:

- **First stage (regular fast shutdown):** The watchdog shuts down the module via an internal fast shutdown signal. The fast shutdown procedure will then still finish any data activities on the LTE module's flash file system, thus ensuring data integrity, but will no longer deregister gracefully from the network, thus saving the time required for network deregistration. Afterwards, i.e. after an internal signaling has gone low, the module is regularly restarted.
- **Second stage (emergency restart):** If the module can for some reasons not be switched off successfully during the first stage, the watchdog resets the module via an internal EMERG\_RST signal. The emergency restart procedure includes disconnecting the power supply lines, and causes the loss of all information stored in the LTE module's volatile memory.

During the first stage the watchdog waits for up to three seconds for the internal signaling to go low. If the internal signaling does not change, the watchdog escalates to the second stage in order to switch off and restart the module.

The watchdog can also be configured to automatically switch on resp. power up the module following a shutdown and a configured delay time (always-on mode).

### 8.1.2 Reset Delay

The watchdog implements a protection mechanism to prevent too frequent module resets. When the delayed reset mechanism is enabled, the watchdog will start its activity only after the specified amount of time, MIN\_START\_TIME. A reasonable value for this timeout is 30 minutes. After the watchdog startup, after a module reset and also after enabling the watchdog, no reset of the module is performed before the timeout of MIN\_START\_TIME. The reset delay mechanism may be useful for software updates.

When the watchdog is enabled, resets can be prevented once for a certain amount of time. This timeout, TRG\_DEL, can be configured via the I<sup>2</sup>C interface. It can be particularly useful when a software update is performed. Using the TRG\_DEL timeout will prevent the watchdog from resetting the module during the running TRG\_DEL timeout, so that the update can be performed safely. An upcoming reset event will be shifted and catch up after the TRG\_DEL timeout.

## 8.2 Restart Conditions

When the watchdog is enabled, it will observe the modules on/off state. When it is configured to keep the module "always on", it will restart the module after the specified amount of time after it has discovered that the module has turned off. This important feature is useful in rough environments with often power losses and out-of-temperature conditions where it secures a safe module operation. The timeout condition for the restart feature is called ALWAYS\_ON.

## 8.3 Complete Watchdog Configuration

The complete hardware watchdog functionality can be configured via the TXD0 line of the serial interface ASC0 as described in this section.

The watchdog listens on the TXD0 line exclusively at the low baudrate 1200bps. This means that if using the watchdog this low baud rate is reserved and should not be configured for the module's asynchronous serial interface ASC0. The TXD0 line can be accessed either via RS-232 interface. Note that in this case the watchdog gives no feedback via an output line. Commands are acknowledged by green ON LED - see [Section 8.3.1](#).

So, to control and configure the watchdog, a terminal program MUST be set to 1200bps, before a command can be sent to the watchdog. See [Section 8.3.1](#) for the watchdog's configuration command specification. Once completed, the terminal program should be changed to higher baud rates again to enable proper communication with the module. Note that the LTE module has to be up and running for this type of configuration.

Please note that a qualified set of configuration commands can also be configured via I<sup>2</sup>C interface. See [Section 8.4](#) for details.

### 8.3.1 Watchdog (WD) Command Specification

The general watchdog command syntax is as follows:

```
WD=<command>,<argument>,<checksum><NL>
```

Where

- <command> specifies the command name
- <argument> gives the numeric argument
- <checksum> is the sum of the digits of the argument. (e.g. the argument 124 produces a checksum 7, because 1+2+4=7).

Whenever a non-volatile command is executed, it is saved in the watchdog's flash memory. At watchdog start, the last state is loaded from flash memory.

If a config command was successfully executed by the watchdog, the green ON LED flashes two times. The watchdog commands are implemented as text commands. In case a command error occurs - e.g., a checksum failure - the green ON LED flashes 4 times.

## 8.3 Complete Watchdog Configuration

The following watchdog configuration commands are available:

- Watchdog on/off - see [Section 8.3.1.1](#)
- Test mode - see [Section 8.3.1.2](#)
- Repetitive module reset - see [Section 8.3.1.3](#)
- UART reset - see [Section 8.3.1.4](#)
- GPIO reset - see [Section 8.3.1.5](#)
- I<sup>2</sup>C reset - see [Section 8.3.1.6](#)
- Restart delay - see [Section 8.3.1.7](#)
- Always on - see [Section 8.3.1.8](#)
- Load default values - see [Section 8.3.1.9](#)
- Change the Watchdogs I<sup>2</sup>C Address - see [Section 8.3.1.10](#)
- Set GPIO Direction - see [Section 8.3.1.11](#)
- Configure ADC1\_IN/DSR0/SPI\_CLK Line - see [Section 8.3.1.12](#)

Note: Changing the watchdog configuration using any of the following commands disables the watchdog: Repetitive module reset, UART reset, GPIO reset, Restart delay and Always on. With these commands the new configuration setting becomes effective only after the hardware watchdog is enabled again.

### 8.3.1.1 Watchdog On/Off

|              |   |
|--------------|---|
| Command      | ON  |
| Parameter    | <on off>  |
| Type         | Boolean   |
| Range        | 0: Off (watchdog disabled)<br>1: On (watchdog enabled)                  |
| Default      | 0: Off  |
| Non-volatile | Yes   |
| Example      | WD=ON,0,0 // disables the watchdog<br>WD=ON,1,1 // enables the watchdog |

This command is used to enable or disable the watchdog function. When disabled, all timers are stopped and the watchdog doesn't perform a module reset. When enabled, all configured timers start after a delay time of MIN\_START\_TIME. If MIN\_START\_TIME=0, all reset timers start immediately. Also, when the watchdog is enabled and ALWAYS\_ON>0, the watchdog observes the modules on/off state, and starts the module in case it detects that the module is off.

## 8.3 Complete Watchdog Configuration

**8.3.1.2 Test Mode**

|              |   |
|--------------|---|
| Command      | TEST_MODE   |
| Parameter    | <on off>  |
| Type         | Boolean   |
| Range        | 0: Off (Exit test mode)<br>1: On (Enter test mode)                        |
| Default      | 0: Off  |
| Non-volatile | Yes   |
| Example      | WD=TEST_MODE,0,0 // Exit test mode<br>WD=TEST_MODE,1,1 // Enter test mode |

This commands configures the watchdog's test mode. In test mode the watchdog operates normally, but does not actually perform a module reset. Instead, it signals the (simulated) reset via the LED by flashing the green ON LED two times to visualize the watchdog trigger. Entering the test mode disables the actual watchdog functionality.

**8.3.1.3 Repetitive Module Reset**

|              |  |
|--------------|--|
| Command      | RST_REP  |
| Parameter    | <timeout>                                      |
| Type         | Milliseconds                                   |
| Range        | 0 .. $2^{32}-1$                                |
| Default      | 0: Feature is disabled                         |
| Non-volatile | Yes  |
| Example      | WD=RST_REP,1800000,9 // Reset every 30 minutes |

This command configures a repetitive module resets, if the watchdog is enabled. The parameter sets the RST\_REP timeout value. If the watchdog is enabled, an unconditional module reset every RST\_REP milliseconds is performed.

Changing this configuration disables the watchdog. The feature becomes active, if the watchdog is enabled again, and after the MIN\_START\_TIME has passed.

For normal operation, this value should be set to a value greater than 30 minutes, some use cases may even require a setting > 24h.

## 8.3 Complete Watchdog Configuration

**8.3.1.4 UART Reset**

|              |  |
|--------------|--|
| Command      | RST_UART   |
| Parameter    | <timeout>  |
| Type         | Milliseconds   |
| Range        | 0 .. $2^{32}-1$  |
| Default      | 0: Feature is disabled   |
| Non-volatile | Yes  |
| Example      | WD=RST_UART,600000,6 // Resets the module if there was no activity on the RXD0 line for 10 minutes |

This command configures a module reset, if no UART activity from the module was observed for the specified amount of time - RST\_UART. The module has to be active on the RXD0 signal within the specified time period; otherwise the watchdog will reset the module.

Changing this configuration disables the watchdog. The feature becomes active, if the watchdog is enabled again, and after the MIN\_START\_TIME has passed.

For normal operation, this value should be set to a value greater than 10 minutes (600000).

**8.3.1.5 GPIO Reset**

|              |   |
|--------------|---|
| Command      | RST_GPIO  |
| Parameter    | <timeout>   |
| Type         | Milliseconds  |
| Range        | 0 .. $2^{32}-1$   |
| Default      | 0: Feature is disabled  |
| Non-volatile | Yes   |
| Example      | WD=RST_GPIO,600000,6 // Resets the module if there was no activity on the WD_RETRIG line for 10 minutes |

This command configures a module reset, if no activity from the module was observed on the signal WD\_RETRIG for the specified amount of time (see [Figure 6](#) for WD\_RETRIG (GPIO8) line). The module has activate the WD\_RETRIG signal by toggling the GPIO8 module output within the specified time period. Otherwise the watchdog will reset the module. If enabled, each GPIO8 toggling resets the timer to its configured value. Note that for this feature to work, GPIO8 has to be available and enabled, and its direction must be set to output. Please refer to [Section 8.3.1.11](#), [Section 8.4](#) and [Section 8.5](#) for details on how to configure GPIO directions. If configured as WD\_RETRIG signal, GPIO8 cannot be used for any other purpose.

Changing this configuration disables the watchdog. The feature becomes active, if the watchdog is enabled again, and after the MIN\_START\_TIME has passed.

For normal operation, this value should be set to a value greater than 10 minutes (600000).

### 8.3.1.6 I<sup>2</sup>C Reset

|              |  |
|--------------|--|
| Command      | RST_I2C  |
| Parameter    | <timeout>  |
| Type         | Milliseconds   |
| Range        | 0 .. 2 <sup>32</sup> -1  |
| Default      | 0: Feature is disabled   |
| Non-volatile | Yes  |
| Example      | WD=RST_I2C,600000,6 // Resets the module if there was no keep alive signal received at the I <sup>2</sup> C bus address 0x09 for 10 minutes. |

This command configures an Ethernet sub-system reset, if no activity from the Ethernet sub-system or a possible external application also connected to the I<sup>2</sup>C bus was observed for the specified amount of time (see [Figure 6](#) and [Section 3.6](#) for I<sup>2</sup>C lines). If enabled, the Ethernet sub-system or an external application will have to send keep alive signals to the I<sup>2</sup>C bus address 0x09 within the specified time period. If the keep alive signals are not regularly received at this address, the watchdog will reset the Ethernet sub-system.

Changing this configuration disables the watchdog. The feature becomes active, if the watchdog is enabled again, and after the MIN\_START\_TIME has passed.

For normal operation, this value should be set to a value greater than 10 minutes (600000).

### 8.3.1.7 Restart Delay

|              |  |
|--------------|--|
| Command      | MIN_START_TIME   |
| Parameter    | <timeout>  |
| Type         | Milliseconds   |
| Range        | 0 .. $2^{32}-1$  |
| Default      | 18000000ms (30 minutes)  |
| Non-volatile | Yes  |
| Example      | WD=MIN_START_TIME,18000000,9 // Prevents module resets for 30 minutes after each module startup, and after the watchdog becomes active |

This command configures the MIN\_START\_TIME timeout value. By setting the MIN\_START\_TIME, the watchdog no longer performs a module reset for the given amount of time, after module startup. Whenever the module has been reset and restarted, as well as after the watchdog has been enabled, the watchdog will wait for MIN\_START\_TIME before performing any (further) resets. The watchdog's reset timer only starts after the MIN\_START\_TIME has expired.

Changing this configuration disables the watchdog. The feature becomes active, if the watchdog is enabled again.

It is strongly recommended to set this value to a time period of more than 30 minutes for normal operation. During development it may be set to values of less than 30 minutes, but should always be greater than the time the module needs for a complete start up including LTE. Also, a LTE module firmware or userware update right after startup should be taken into account which may take up to 15 min.



### 8.3.1.8 Always On

|              |  |
|--------------|--|
| Command      | ALWAYS_ON  |
| Parameter    | <timeout>  |
| Type         | Milliseconds   |
| Range        | 0 .. $2^{32}-1$  |
| Default      | 0: Feature is disabled   |
| Non-volatile | Yes  |
| Example      | WD= ALWAYS_ON,60000,6 // Observes the module and restarts it 60 seconds after it has been turned off |

This command configures the on/off-state observation of the module by specifying a timeout value for ALWAYS\_ON. If enabled, the watchdog observes the module's internal signalling. If the watchdog detects that the module is OFF, it will restart the module after the timeout of ALWAYS\_ON milliseconds.

Changing this configuration disables the watchdog. The feature becomes active, if the watchdog is enabled.

It is strongly recommended to set this value to a time period of more than 1 minute for normal operation to avoid oscillation in e.g. out-of-temperature events. In case of over/under temperature shut down it can be expected that the temperature does not change significantly within a minute. During development the timeout may be set to a period of less than 1 minute.

### 8.3.1.9 Load Default Values

|              |   |
|--------------|---|
| Command      | DFT_VAL                                     |
| Parameter    | <1>   |
| Type         | Fixed                                       |
| Range        | 1   |
| Default      | ---   |
| Non-volatile | No  |
| Example      | WD= DFT_VAL,1,1 // Loads the default values |

This command loads the default configuration values. This disables the watchdog. If the watchdog is enabled, the reset timeout values, the MIN\_START\_TIME timeout and the ALWAYS\_ON timeout become active. Other configuration values become active immediately. The loaded default values are also persistent, i.e. written to the flash memory.

### 8.3.1.10 Change the Watchdog's I<sup>2</sup>C Address

|              |  |
|--------------|--|
| Command      | I2C_ADDR   |
| Parameter    | <address>  |
| Type         | Number   |
| Range        | 1-127  |
| Default      | 106 (0x6A)   |
| Non-volatile | Yes  |
| Example      | WD= I2C_ADDR,87,15 // Changes the I <sup>2</sup> C address to 87d (0x57) |

The watchdog's I<sup>2</sup>C slave address can be changed to any 7-bit address. This may become necessary to avoid address conflicts on the I<sup>2</sup>C bus, if used in an environment, where the default I<sup>2</sup>C address "0x6A" is already in use by other slave devices connected to the LTE Terminals.

Changing the I<sup>2</sup>C address takes effect immediately and has no impact on the watchdog's enabled/disabled state.

## 8.3 Complete Watchdog Configuration

## 8.3.1.11 Set GPIO Direction

|              |   |  |
|--------------|---|--|
| Command      | GPIO_DIR  |  |
| Parameter    | <pin-config>  |  |
| Type         | Number  |  |
| Range        | 0-1023  |  |
| Default      | 0 (0x000, 0000000000b)  |  |
| Non-volatile | Yes   |  |
| Example      | WD= GPIO_DIR,682,16 // Sets the GPIOs alternating to output and input (binary value: 1010101010b) |  |

This command configures the input/output direction of level-shifters to the module's externally available GPIO pins. The argument is a 10-bit number, representing the 10 adjustable directions of the GPIO level-shifters. A set bit (value 1) sets the respective level-shifter to the output direction. A cleared bit changes the respective level-shifter to input direction. The following table describes the connection between the 10-bit argument number, the modules GPIO pins, and the LTE Terminals GPIO connectors 8-pin and 12-pin:

| 10-Bit number | GPIO   | 8-pin connector | 12-pin connector | Default |
|---------------|--------|-----------------|------------------|---------|
| 0             | GPIO6  | 1               | -                | Input   |
| 1             | GPIO7  | 2               | -                | Input   |
| 2             | GPIO8  | 3               | -                | Input   |
| 3             | GPIO11 | 4               | -                | Input   |
| 4             | GPIO12 | 5               | -                | Input   |
| 5             | GPIO13 | 6               | -                | Input   |
| 6             | GPIO22 | 7               | -                | Input   |
| 7             | GPIO23 | 8               | -                | Input   |
| 8             | GPIO21 | -               | 12               | Input   |
| 9             | GPIO20 | -               | 11               | Input   |

Changing the directions of the level-shifters must be executed with great care. They may only be set in accordance with the LTE modules' GPIO input/output configuration. Special care must be taken that no outputs are cross-connected during the switching phase.

Configuring a LTE Terminal output, the level shifter output should be set first, followed by the module output configuration. Configuring an input, the module input should be set first, followed by the level shifter input. Please refer to [Section 8.5](#) for more information on how to configure GPIO directions.

Please note that the GPIO direction can also be configured via I<sup>2</sup>C interface (see [Section 8.4](#)). It is recommended to use the I<sup>2</sup>C interface to configure the GPIO direction.

Note: Not every GPIO is supported by every LTE Terminal variant - see [Section 3.6](#).

### 8.3.1.12 Configure ADC1\_IN/DSR0/SPI\_CLK Line

|              |  |  |
|--------------|--|--|
| Command      | ADC_DSR0   |  |
| Parameter    | <input/output>   |  |
| Type         | Boolean  |  |
| Range        | 0: Analog input (ADC1_IN)<br>1: Digital output (DSR0/SPI_CLK)  |  |
| Default      | 0: Analog input (ADC1_IN)  |  |
| Non-volatile | Yes  |  |
| Example      | WD= ADC_DSR0,0,0 // Configures the line to be analog input<br>WD= ADC_DSR0,1,1 // Configures the line to be digital output |  |

This command configures the the ADC/DSR0/SPI\_CLK signal on the GPIO connector to be either an analog input line (ADC) or a digital output line (DSR0/SPI\_CLK). If configured as analog input, the signal is connected to the LTE module's ADC1\_IN line. If configured as digital output, the signal is connected to the LTE module's DSR0/SPI\_CLK line that can be configured to be either DSR0 or SPI\_CLK.

Note: If configuring the ADC1\_IN/DSR0/SPI\_CLK line please take great care to be in accordance with the LTE module's current configuration of the ADC1\_IN and DSR0/SPI\_CLK signals.

## 8.4 Qualified Watchdog Configuration

While the complete watchdog functionality may be configured via TXD0 line of the ASC0 interface (for details see [Section 8.3](#)), a qualified set of configuration commands can also be specified via the watchdog's I<sup>2</sup>C interface as described in this section. The LTE module has to be up and running for this type of configuration.

The watchdog's I<sup>2</sup>C interface is accessible by means of the LTE module's I<sup>2</sup>C lines, and either via the LTE module's AT command interface, or for ELS61T-x Terminals only through a Java MIDlet during runtime (see [Figure 26](#)). **Note:** When using a Java MIDlet to set GPIO directions using the I<sup>2</sup>C interface, please allow for a guard time of at least 500ms between two I<sup>2</sup>C commands.

The I<sup>2</sup>C interface implements the write and the read protocol as described in [Section 8.4.1](#). The 7-bit device address is 0x6A (binary: 1101010). The default address can be changed by configuration command (see [Section 8.3.1.10](#)).

### 8.4.1 I<sup>2</sup>C Interface Command Specification

#### 8.4.1.1 WRITE Command Syntax

|   |  |   |                  |   |           |   |   |
|---|--|---|------------------|---|-----------|---|---|
| S | Slave address<br>(including write bit "W") | A | Register address | A | Data byte | A | P |
|---|--|---|------------------|---|-----------|---|---|

Example setting the GPIO12 signal direction to "output" (see also section [Examples](#)):

|   |                                   |   |      |   |      |   |   |
|---|-----------------------------------|---|------|---|------|---|---|
| S | 0xD4<br>(including write bit "0") | A | 0x14 | A | 0x01 | A | P |
|---|-----------------------------------|---|------|---|------|---|---|

Legend:

S: Start Condition, W: Write bit (=0), A: Acknowledge, P: Stop Condition.

#### 8.4.1.2 READ Command Syntax

|   |   |   |                  |   |                                |   |   |
|---|---|---|------------------|---|--------------------------------|---|---|
| S | Slave address<br>(including read bit "R") | A | Register address | A | Data length<br>(only one byte) | N | P |
|---|---|---|------------------|---|--------------------------------|---|---|

Example reading the last status = OK (see also section [Examples](#)):

|   |                                  |   |      |   |                         |   |   |
|---|----------------------------------|---|------|---|-------------------------|---|---|
| S | 0xD5<br>(including read bit "1") | A | 0x00 | A | 0x01<br>(only one byte) | N | P |
|---|----------------------------------|---|------|---|-------------------------|---|---|

Legend:

S: Start Condition, R: Read bit (=1), A: Acknowledge, N: Not Acknowledge, P: Stop Condition.

### 8.4.1.3 I<sup>2</sup>C Protocol Overview

In write mode (i.e., slave address “0xD4”), one address byte and one data byte is sent to the LTE Terminal/Watchdog. The address byte specifies a register to write the data byte to. The data byte value is only written, if it is valid, i.e., in the specified range. After a write attempt, the status code of the operation is saved and the read address register (RAR) is automatically set to the status register address (SR). A subsequent read command from the status register (SR) will then return the latest status code (see [Table 30](#)). Only when the address byte is the RAR, i.e. another register is selected to be read, the RAR is not automatically set to the SR register. See [Section 8.4.1.4](#) for sample watchdog configurations via I<sup>2</sup>C.

In read mode, one data byte can be read from the LTE Terminal/Watchdog. Attempts to read more bytes will result in undefined values being returned by the device. The device will always return the value that is addressed by the RAR. To read a specific register, a write command with RAR as the address byte and the register to be read as the data byte has to be issued first. The next read will then return the value at this address. Note that there are only a few registers that can be read (see register table - [Table 29](#)). When the RAR is written with a non-read address, the RAR is set to the SR, and the status code `ILLEGAL_ARGUMENT` is saved. Note also that a consecutive read is not valid, as the return value will be `ILLEGAL_ARGUMENT`, but the caller cannot determine whether the result is the value at the faulty address or an error status code. See [Section 8.4.1.4](#) for sample watchdog configurations via I<sup>2</sup>C.

### 8.4.1.4 I<sup>2</sup>C Commands

The following table lists the address register for configuration commands via I<sup>2</sup>C interface.

**Table 29:** Address register for I<sup>2</sup>C commands

| Register address | Read/Write | Description  | Name     | Non-volatile | Default | Value range  |
|------------------|------------|--|----------|--------------|---------|--|
| 0x00             | R          | Status; only address register to read directly from.                             | SR       | -            | OK      | See result codes <a href="#">Table 30</a>                |
| 0x09             | W          | RST_I2C  |          | Yes          | 0       |  |
| 0x10             | W          | GPIO6  | GPIOxR   | Yes          | 0       | Level shifter's GPIO direction:<br>0: Input<br>1: Output |
| 0x11             | W          | GPIO7  |          | Yes          | 0       |  |
| 0x12             | W          | GPIO8  |          | Yes          | 0       |  |
| 0x13             | W          | GPIO11   |          | Yes          | 0       |  |
| 0x14             | W          | GPIO12   |          | Yes          | 0       |  |
| 0x15             | W          | GPIO13   |          | Yes          | 0       |  |
| 0x16             | W          | GPIO22   |          | Yes          | 0       |  |
| 0x17             | W          | GPIO23   |          | Yes          | 0       |  |
| 0x18             | W          | GPIO21   |          | Yes          | 0       |  |
| 0x19             | W          | GPIO20   |          | Yes          | 0       |  |
| 0x30             | R          | GPIO direction Low Byte:<br>Read out 8 bits for the GPIOs [15,14,13,12,11,8,7,6] | GPIO_LBR | -            |         | [0..0xFF]  |

## 8.4 Qualified Watchdog Configuration

**Table 29:** Address register for I<sup>2</sup>C commands

| Register address | Read/Write | Description  | Name    | Non-volatile | Default | Value range   |
|------------------|------------|--|---------|--------------|---------|---|
| 0x31             | R          | GPIO direction High Byte:<br>Read out 2 bits for the GPIOs 20 and 21 in the representation: [0,0,0,0,0,0,<20>,<21>]  | GPIOHBR | -            |         | [0..0xFF]   |
| 0x50             | R/W        | ADC1_IN/DSR0   | ADCDSRR | Yes          | 0x00    | 0: Analog In<br>1: Digital Out  |
| 0x80             | W          | Trigger delay. Specifies delay time for a reset. If a trigger delay time is specified, the watchdog is prevented from resetting the module for the given time. | TDR     | No           | 0x00    | Set time in minutes.<br>1...255: Minutes<br>0: Disable  |
| 0xFD             | R          | Hardware watchdog's firmware version   | VER     | --           |         | [0x00..0x99]<br>[MAJ MIN]<br>4:MSB: MAJ<br>4:LSB: MIN<br><br>MAJ: Main release number (e.g., 1.x)<br>MIN: Sub release number (e.g., x.0) as in version v1.0 |
| 0xFF             | W          | Read address register (RAR)  | RAR     | No           | 0x00    | 0x00..0xFF<br>Only valid addresses contain valid values   |

Possible result codes for status command (see [Section 8.4.1.3](#) and above [Table 29](#)):

**Table 30:** I<sup>2</sup>C status result codes

| Result           | Code | Comment   |
|------------------|------|---|
| OK               | 0x00 | Last command was executed successfully              |
| PROTOCOL_ERROR   | 0x01 | Protocol error, i.e. wrong number of bytes          |
| ILLEGAL_ADDRESS  | 0x02 | Illegal register address                            |
| ILLEGAL_ARGUMENT | 0x03 | Illegal argument. Argument is out of allowed range. |
| UNDEFINED        | 0xFF |   |

**Note:** When using Java on ELS61T-x Terminals to set GPIO directions over the I<sup>2</sup>C interface, please allow for a guard time of at least 500ms between I<sup>2</sup>C commands.

## Examples

The following two samples show how the watchdog can be configured by means of the watchdog's I<sup>2</sup>C interface and using the AT<sup>SSPI</sup> command over RS-232/ASC0 to transfer the I<sup>2</sup>C user data. Please refer to [1] for more information on the AT command AT<sup>SSPI</sup> and on how to configure and control the data transfer over the LTE module's I<sup>2</sup>C interface.

The above Table 29 specifies the address register that can be used in I<sup>2</sup>C configuration commands.

The **first** example sets the level shifter's GPIO12 direction to "output". It therefore configures a write register marked as "W" in Table 29. For more information on the configuration of GPIO directions see Section 8.5.

|                      |  |
|----------------------|--|
| AT <sup>SSPI</sup> = | Open the LTE Terminals I <sup>2</sup> C data connection.   |
| CONNECT              | Indicates that the connection is open.   |
| <aD41401>            | WRITE command enclosed by <>: "a" is a command ID to better identify and match acknowledgments, "D4" indicates the slave address (write mode), "14" specifies the address register GPIO12, and "01" sets the data byte (i.e., line is "output").<br><b>Note:</b> The data byte value is only written if valid, i.e., if in the specified range. After a WRITE command, the status code of the operation is saved to the status register (SR) and a subsequent READ command from the status register will then return the latest status code as listed in Table 30. |
| {a+}                 | Acknowledgement enclosed in curly brackets of a successful data transmission.  |
| <bD50001>            | READ command enclosed by <>: "b" is a command ID to better identify and match acknowledgments, "D5" indicates the slave address (read mode), "00" specifies the address register SR, and "01" sets the data length to be read. <b>Note:</b> The READ command can only be called in conjunction with the SR address "00" and the data length of one byte "01".  |
| {b+00}               | Acknowledgement enclosed in curly brackets of a successful data transmission, together with the response code "00" indicating that the command was successfully executed.  |
| #                    | Close data connection.   |
| OK                   | Connection closed.   |

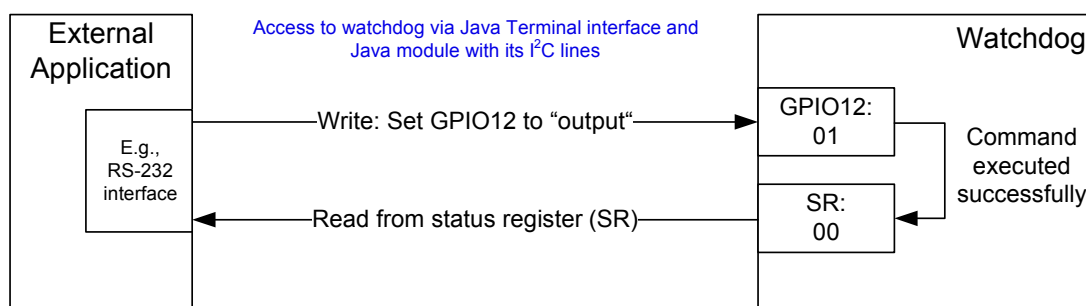


Figure 27: Write data to address register



8.4 Qualified Watchdog Configuration

The **second** example listed below reads out the hardware watchdog’s firmware version, it therefore uses a read register marked as “R” in [Table 29](#).

However, except for the status address register (SR) no information can be directly retrieved from an address register itself, but only indirectly by means of a so-called read-address-register (RAR). An initial WRITE command has to link the register to be read to the RAR first. Now the RAR is linked to the register to be read, and the content of this register can be read from the SR.

|           |   |
|-----------|---|
| AT^SSPI=  | Open the LTE Terminals I <sup>2</sup> C data connection.  |
| CONNECT   | Indicates that the connection is open.  |
| <aD4FFFD> | WRITE command enclosed by <>: “a” is a command ID to better identify and match acknowledgments, “D4” indicates the slave address (write mode), “FF” specifies the read address register RAR, and “FD” sets the data byte to the watchdogs firmware version register VER (i.e., RAR and VER are linked by this command). <b>Note:</b> The data byte value is only written if valid, i.e., if in the specified range. After a WRITE command, the status code of the operation, in this case, i.e., where the register address is the RAR, the content of the register given as data byte is saved to the status register (SR) and a subsequent READ command from the status register will then return the register value, i.e., the hardware watchdog’s firmware version. |
| {a+}      | Acknowledgement enclosed in curly brackets of a successful data transmission.   |
| <bD50001> | READ command enclosed by <>: “b” is a command ID to better identify and match acknowledgments, “D5” indicates the slave address (read mode), “00” specifies the address register SR, and “01” sets the data length to be read. <b>Note:</b> The READ command can only be called in conjunction with the SR address “00” and the data length of one byte “01”.   |
| {b+10}    | Acknowledgement enclosed in curly brackets of a successful data transmission, together with the response code “10” indicating that the command was successfully executed. The response code gives the watchdog’s firmware version as v1.0.  |
| #         | Close data connection.  |
| OK        | Connection closed.  |

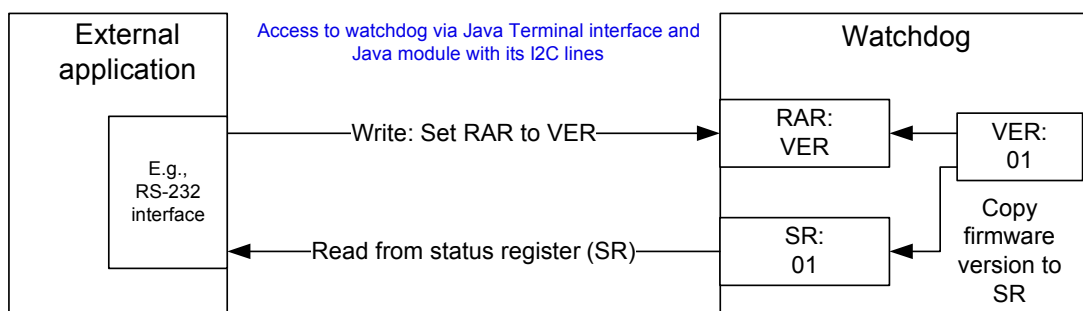


Figure 28: Read data from address register

## 8.5 Configuring GPIO Directions

As already shown in [Figure 6](#) and mentioned in [Section 8.3.1.11](#) the GPIO pins at the LTE Terminals' GPIO connector are not electrically identical to the GPIO lines at the integrated LTE module. A built-in level shifter needs to ensure that the voltage level is correctly converted.

Because of that it is necessary to not only configure the LTE modules' GPIO settings by AT command, but to also configure the the built-in level shifter's GPIO directions by means of the watchdog.

As described in [Section 8.3](#), [Section 8.4](#) and shown in [Figure 26](#) there are various ways to configure the watchdog and therefore the level shifter's GPIO directions:

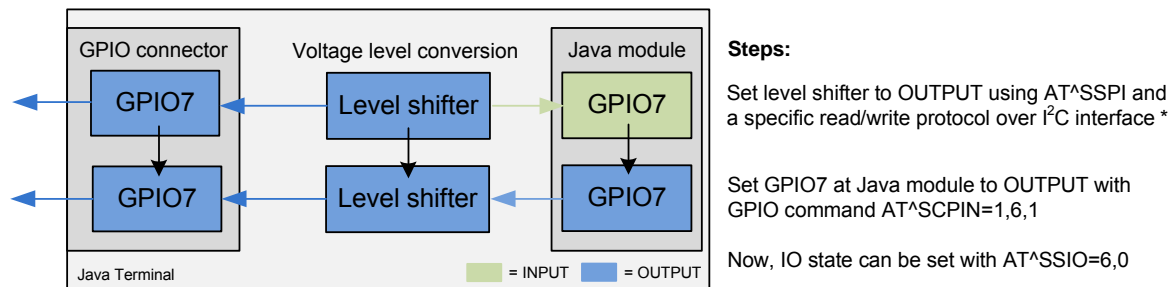
- A qualified configuration including GPIO directions can be done using the watchdog's I<sup>2</sup>C interface. For details see [Section 8.5.1](#). This is the recommended method to set the level shifter's GPIO direction.
- A complete configuration can be done using the TXD0 line of the ASC0 interface. For details see [Section 8.5.2](#).

Notes: The VCCref signal at the LTE Terminal's GPIO connector needs to be connected - for instance to the +5Vout signal - for the level shifters to be active. Also note that in order to have a defined level for GPIOs configured as inputs, external pull-ups or pull-downs will have to be implemented at the GPIO lines.

### 8.5.1 Configuration using I<sup>2</sup>C Interface

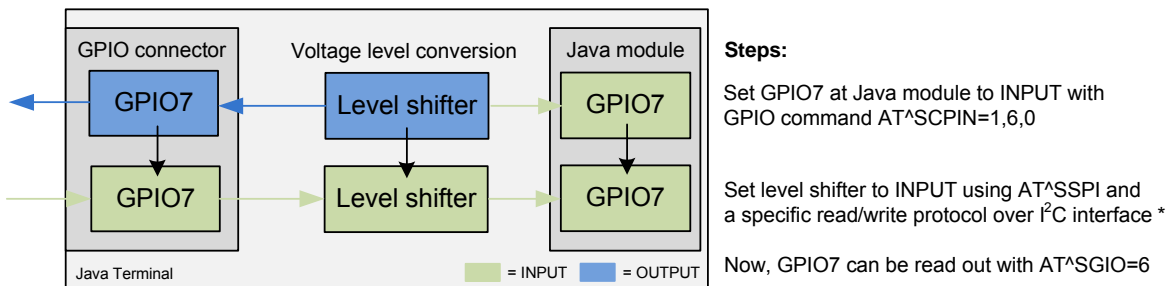
Please refer to [Section 8.4](#) for more information on how to configure the watchdog via I<sup>2</sup>C interface.

[Figure 29](#) explains the configuration steps required to set the LTE Terminals's GPIO7 signal direction to OUTPUT (default direction is INPUT):



**Figure 29:** Setting GPIO direction to OUTPUT via I<sup>2</sup>C interface

[Figure 30](#) shows the configuration steps required to re-set the LTE Terminals's GPIO7 signal direction to INPUT:



**Figure 30:** Setting GPIO direction to INPUT via I<sup>2</sup>C interface

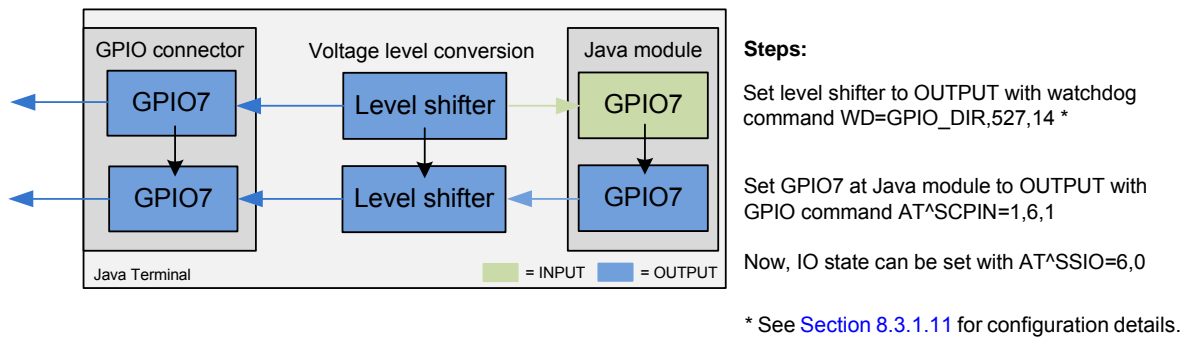
For more information on the AT commands mentioned in the above figures see also [\[1\]](#).

**Note:** When using a Java MIDlet on ELS61T-x Terminals to set GPIO directions using the I<sup>2</sup>C interface, please allow for a guard time of at least 500ms between two I<sup>2</sup>C commands.

### 8.5.2 Configuration using TXD0 Line of ASC0 Interface

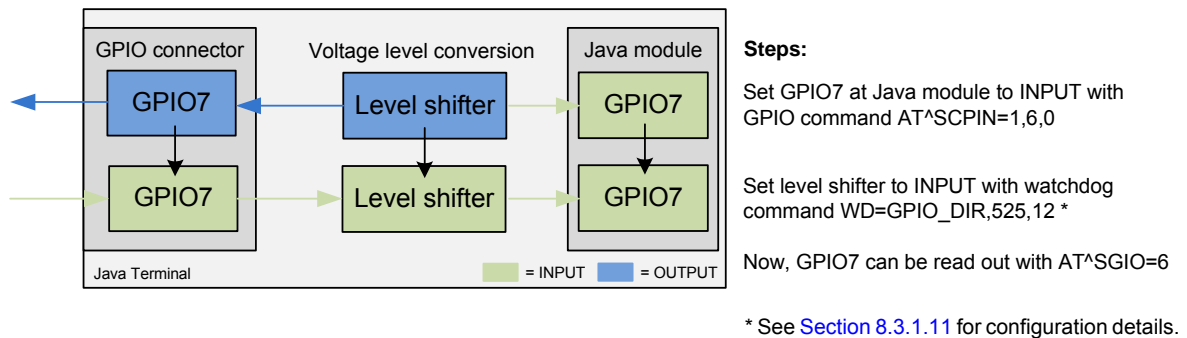
Please refer to [Section 8.3](#) for more information on how to configure the watchdog via TXD0 line of ASC0 interface.

[Figure 29](#) explains the configuration steps required to set the LTE Terminals’s GPIO7 signal direction to OUTPUT (default direction is INPUT):



**Figure 31:** Setting GPIO direction to OUTPUT via TXD0 line (at 1200bps)

[Figure 29](#) shows the configuration steps required to re-set the LTE Terminal’s GPIO7 signal direction to INPUT:



**Figure 32:** Setting GPIO direction to INPUT via TXD0 line (at 1200bps)

For more information on the AT commands mentioned in the above figures see also [\[1\]](#).






## 9.2 Connection Usage

Once the Ethernet connection has been set up successfully, it is possible to transparently exchange data with a remote application, or to administer the LTE terminal. Possible usages are described in more detail in the following sections.

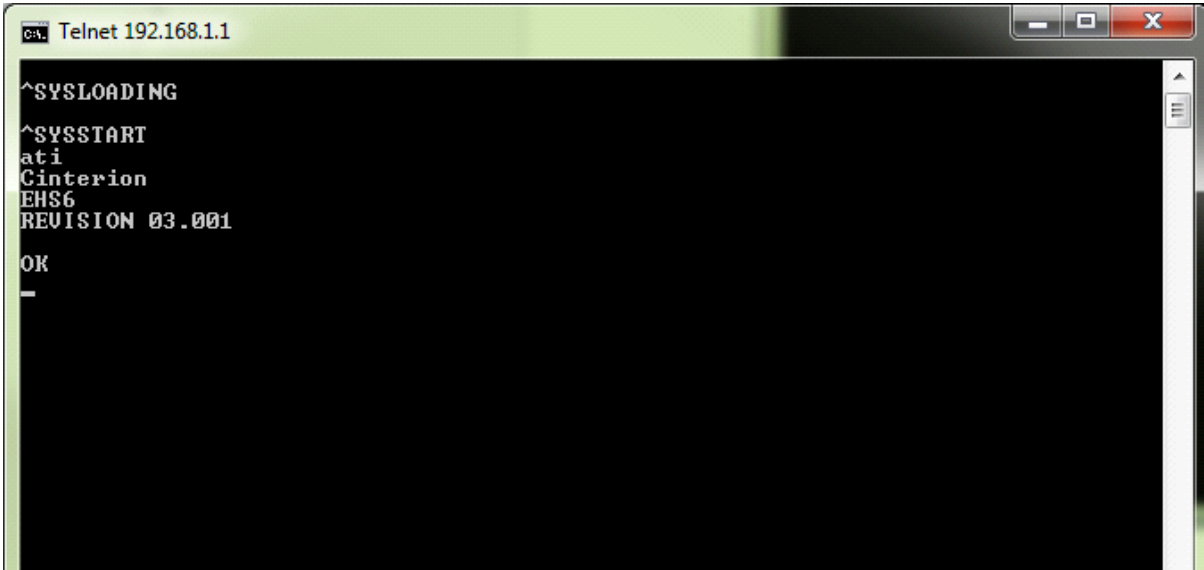
### 9.2.1 Access LTE Terminal via Telnet (or SSH)

LTE Terminal can be accessed from a PC via Telnet (or SSH) for administrative purposes, and there are two types of connection:

- Calling Telnet (or SSH) as described above in [Section 9.1](#) connects to the LTE Terminal's embedded Linux system. The Linux shell provides access to files containing the network configuration (see [Section 9.2.4](#)) as well as the wireless APN configuration (see [Section 9.2.5](#)).
- Calling Telnet with a dedicated port - "1234" - opens a direct link to the LTE module's COM port and with that to the LTE module platform. Over this interface it is possible to control the LTE module, to for instance receive URCs, or query the current firmware version.



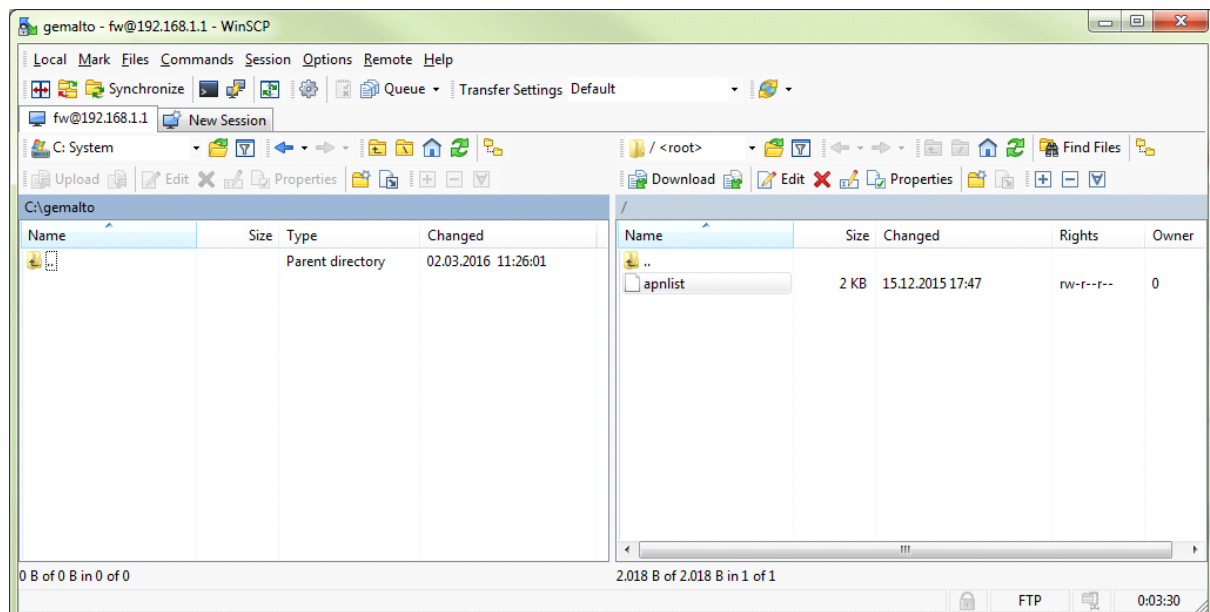
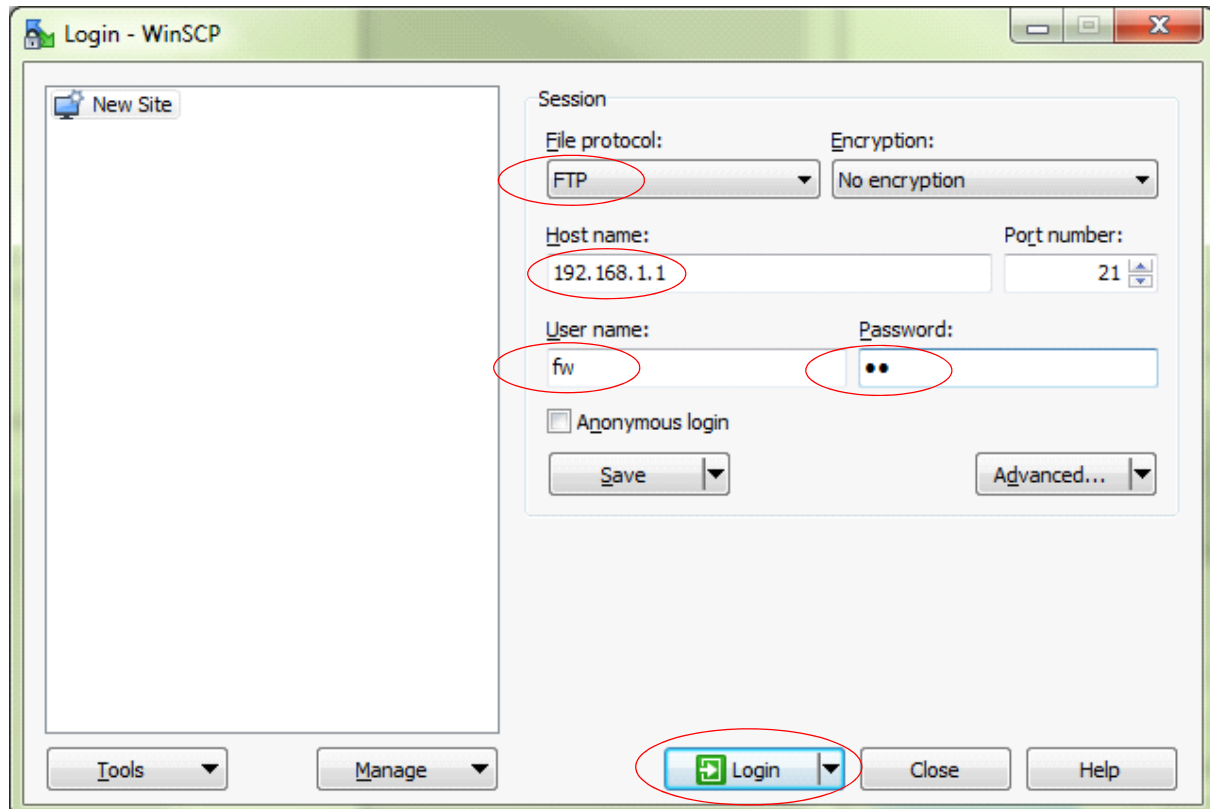
```
C:\Windows\system32\cmd.exe
C:\>telnet 192.168.1.1 1234
```



```
Telnet 192.168.1.1
^SYSLOADING
^SYSSTART
ati
Cinterion
EHS6
REVISION 03.001
OK
-
```

### 9.2.2 Access LTE Terminal via FTP

In addition to Telnet, it is also possible to access the LTE Terminal via FTP, i.e., build a connection to an FTP server on the LTE Terminal that gives access to a defined directory for FTP services. The FTP server's root directory in the embedded Linux file system is "/tmp/fw", the default user name to access FTP services is "fw", and default password is also "fw". If accessing the LTE Terminal's FTP server from a Windows PC, the FTP client should support passive FTP (PASV). The default Windows FTP client does not support passive FTP. However, the FTP client from WinSCP for instance supports this feature. The following figure shows how to use WinSCP to link to the LTE Terminal's FTP server - allowing access to the file "apnlist".





### 9.2.3 Security Notes

Please note that by delivery default it is possible to open a Telnet connection to LTE Terminal's embedded Linux system without being asked for a password. A root login password should therefore be defined to restrict this type of access. If a root login password exists, access to the embedded Linux system is only possible via SSH root login (using e.g., PuTTY for Windows).

### 9.2.4 Configure IP Address

To change the default IP address for LTE Terminal, it is necessary to access LTE Terminal's embedded Linux system as root user. This connection can be accomplished by Telnet (or SSH) as described in [Section 9.1](#).

Once connected, the IP address may be configured as follows:

- Open the file `/etc/config/network`. This file can be opened either on the embedded Linux system by using the vi editor, or on an external PC by copying the file to the FTP directory, transferring the file from the FTP directory to the PC, changing it using a text editor, transferring it back to the FTP directory and finally from there to its original directory. For more information on FTP access see [Section 9.2.2](#).
- Edit the file and adapt the line `option ipaddr 192.168.1.1` to for instance `option ipaddr 192.168.2.1`.
- Commit the new IP address by entering `/etc/init.d/network restart`. After the restart, the system can be reached via the new IP address.

### 9.2.5 Edit APN List

Using the APN list, LTE Terminal determines the applicable APN for the inserted SIM card. The APN list matches the unique mobile country and mobile network codes read from the SIM card to the available APNs. By default, the APN list already comprises a comprehensive number of the most commonly used APNs.

However, it may become necessary to add a particular APN, or to remove unnecessary APNs. To do so, please complete the following steps:

- Open the file `/etc/apnlist`. This file can be opened either on the embedded Linux system by using the vi editor, or on an external PC by copying the file to an FTP directory, transferring the file from the FTP directory to the PC, changing it using a text editor, transferring it back to the FTP directory and finally from there to its original directory. For more information on FTP access see [Section 9.2.2](#).  
The file `apnlist` contains one APN per line using the syntax:  
`<3-digit MCC><2-digit MNC> <access point name>`
- Edit the file by adding, changing or removing APNs.
- Save the file. The adapted APN list is available as soon as it is saved.

## 9.2.6 Enter SIM Pin

Normally, LTE Terminal requires a SIM pin before being able to automatically connect to the APN (Internet). **Note:** The SIM pin should be made available permanently to LTE Terminal before the SIM is actually required, i.e., usually before the SIM is inserted, and a wireless connection is built up. Also, remember to renew the SIM pin before inserting another SIM card.

Please complete the following steps to set the pin for the SIM card to be inserted:

- Connect to LTE Terminal using Telnet (or SSH). For more information see [Section 9.2.1](#).
- Change to directory “/etc” and call the command to enter the <pin code>:  
root@OpenWrt:/etc# uci set network.3gwan.pincode='<pin code>'
- Save the SIM pin to the flash file system, and activate the pin it through a reboot:  
root@OpenWrt:/etc# uci commit  
root@OpenWrt:/etc# reboot

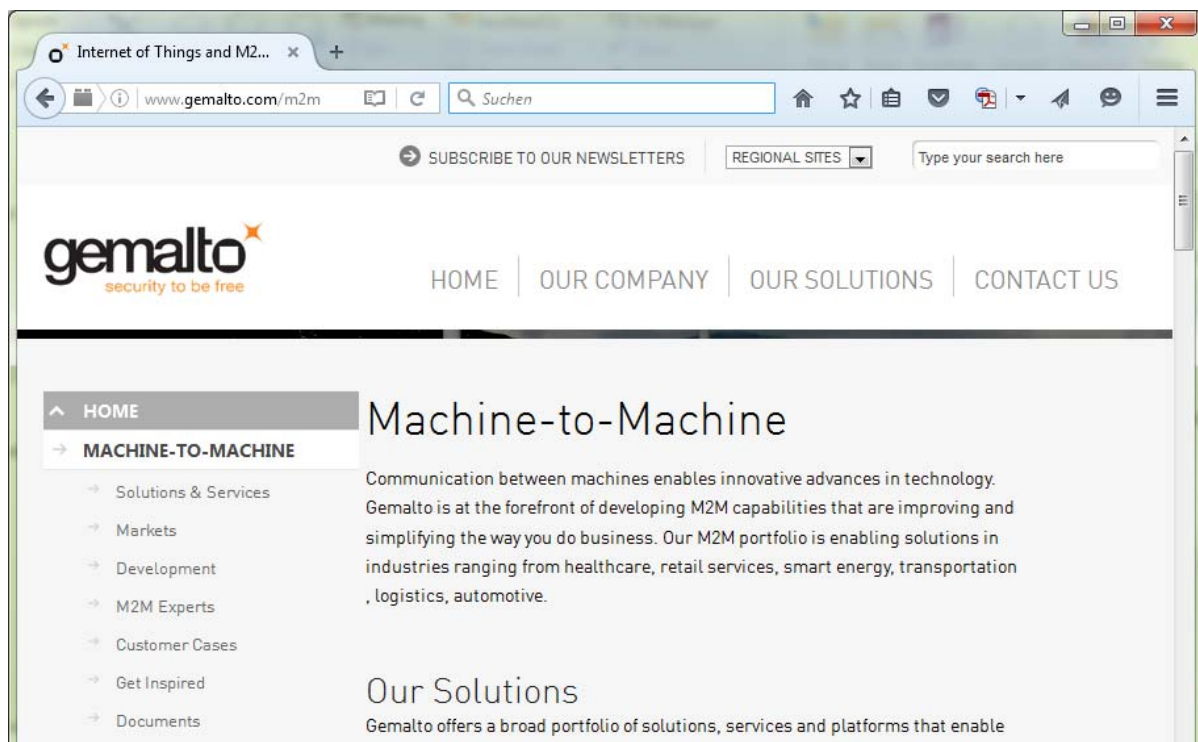
To read the currently used SIM pin please enter the command:

```
root@OpenWrt:/etc# uci show network.3gwan.pincode
```

## 9.2.7 Transparent Data Exchange

To transparently exchange data please complete the following steps:

1. Set up an Ethernet connection as described in [Section 9.1](#), and enter a SIM pin as described in [Section 9.2.6](#).
2. Start an Internet browser on the connected device (e.g., a PC) and call a URL. The PC must be connected to LTE Terminal via Ethernet, and needs to be set up in the same IP sub-network, or has to be able to receive a valid IP address from LTE Terminal’s DHCP server. By means of LTE Terminal, it is now possible to open up an IP connection to a remote host using a wireless network provider’s data gateway.
3. If the Website does not open, the correct APN may not be available in the APN list. The appropriate APN should then be added to the list as described in [Section 9.2.5](#).



## 9.2.8 Update LTE Module Firmware

To update the firmware of the Terminal's LTE module, please complete the following steps:

- Connect to the LTE Terminal using FTP as described in [Section 9.2.2](#).
- Transfer the firmware download files from the PC to the LTE Terminal's FTP directory. The firmware update files have the extensions `*.usf`, `*.jad`, and `*.jar`.
- Connect to the LTE Terminal using Telnet (or SSH) as described in [Section 9.2.1](#).
- Call the firmware update shell script: `./etc/gmup.sh`. After a successful update the LTE terminal restarts automatically.

## 9.2.9 Update Ethernet Sub-System Software

To update the software of the LTE Terminal's Ethernet sub-system, please complete the following steps:

- Connect to the LTE Terminal using FTP as described in [Section 9.2.2](#).
- Transfer the software download file from the PC to the LTE Terminal's FTP directory. The software update file has the extension `*.bin`, e.g., `xxx_yyy_zzz.bin`.
- Connect to the LTE Terminal using Telnet (or SSH) as described in [Section 9.2.1](#).
- Call the software update shell script: `./etc/ewup.sh`. After a successful update the LTE Terminal restarts automatically.

## About Gemalto

Since 1996, Gemalto has been pioneering groundbreaking M2M and IoT products that keep our customers on the leading edge of innovation.

We work closely with global mobile network operators to ensure that Cinterion® modules evolve in sync with wireless networks, providing a seamless migration path to protect your IoT technology investment.

Cinterion products integrate seamlessly with Gemalto identity modules, security solutions and licensing and monetization solutions, to streamline development timelines and provide cost efficiencies that improve the bottom line. As an experienced software provider, we help customers manage connectivity, security and quality of service for the long lifecycle of IoT solutions.

For more information please visit  
[www.gemalto.com/m2m](http://www.gemalto.com/m2m), [www.facebook.com/gemalto](https://www.facebook.com/gemalto), or [Follow@gemaltoIoT](https://twitter.com/gemaltoIoT) on twitter.

**Gemalto M2M GmbH**  
Werinherstrasse 81  
81541 Munich  
Germany

➔ [GEMALTO.COM/M2M](http://GEMALTO.COM/M2M)

**gemalto**  
security to be free