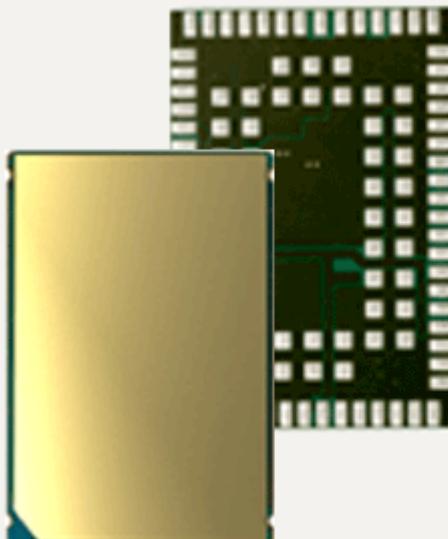![gemalto logo] security to be free

Cinterion® ELS31-US/ELS51-US

Hardware Interface Overview

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DocId: ELS31-US_ELS51-US_HIO_v01.000a

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Contents

Tables

Figures

1 Introduction

This document[1] describes the hardware of the Cinterion® ELS31-US and ELS51-US modules. It helps you quickly retrieve interface specifications, electrical and mechanical details and information on the requirements to be considered for integrating further components.

The ELS31-US and ELS51-US modules include a baseband, a complete dual band RF front-end, memory and required circuitry to meet 3GPP E-UTRA (Long Term Evolution - LTE, Release 10 set of specifications).

The module variants differentiate a follows:
- ELS31-US provides LTE connectivity with IP Services
- ELS51-US adds a Linux execution environment available for customer applications

1.1 Key Features at a Glance

Feature	Implementation
General	
Frequency bands	LTE Triband: B2, B4, B12
Output power	Class 3 (+23dBm +-2dB) for LTE 1900, LTE FDD B2 Class 3 (+23dBm +-2dB) for LTE AWS, LTE B4 Class 3 (+23dBm +-2dB) for LTE 700, LTE FDD B12
Power supply	3.3V to 4.5V
Operating temperature (board temperature)	Normal operation: -30°C to +80°C Extended operation: -40°C to +90°C
Physical	Dimensions: 27.60mm x 18.80mm x 2.05mm Weight: approx. 3g
RoHS	All hardware components fully compliant with EU RoHS Directive
LTE features	
3GPP Release 9	DL 10Mbps, UL 5Mbps LTE Cat. 1 data rates
SMS	Point-to-point MT and MO Text mode Storage in mobile equipment
Software	
AT commands	Hayes, 3GPP TS 27.007, TS 27.005, product specific
SIM Application Toolkit	SAT Release 99
Firmware update	Generic update from host application over ASC0 or USB modem OTA over ASC0 and over USB

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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.

Feature	Implementation
Interfaces	
Module interface	Surface mount device with solderable connection pads (SMT application interface). Land grid array (LGA) technology ensures high solder joint reliability and allows the use of an optional module mounting socket. For more information on how to integrate SMT modules see also [4]. This application note comprises chapters on module mounting and application layout issues as well as on SMT application development equipment.
USB	USB 2.0 High Speed (480Mbit/s) device interface, Full Speed (12Mbit/s) compliant
2 serial interfaces	ASC0: • 8-wire modem interface with status and control lines, unbalanced, asynchronous • Default baud rate: 115,200 baud • Adjustable baud rates: 4,800 to 921,600, no autobauding support • Supports RTS0/CTS0 hardware flow control. • Indication of incoming data/SMS on RING0 (can be used to wake up host from power down modes) ASC1 (shared with GPIO lines): • 4-wire, unbalanced asynchronous interface • Default baud rate: 115,200 baud • Adjustable baud rates: 4,800bps to 921,600bps • Supports RTS1/CTS1 hardware flow control
UICC interface	Supported SIM/USIM cards: 3V, 1.8V
Embedded UICC	Module is prepared for an embedded UICC
GPIO interface	20 pads of the application interface programmable as GPIO pads (17) or GPO pads (3): GP(I)Os can be configured as COUNTER, FST_SHDN, ASC0, ASC1, and SPI signal lines Programming is done via AT commands
I^{2}C interface	Supports I^{2}C serial interface
SPI interface	Supports SPI interface
SDIO	**ELS51-US only:** 4 wire interface.
HSIC	**ELS51-US only:** High Speed Interchip Communication interface.
ADC	Analog-to-Digital Converter with one unbalanced analog input.
Digitial audio interface	Hardware prepared for future use.
Antenna interface pads	50Ω LTE main antenna, 50Ω LTE diversity antenna

Feature	Implementation
Power on/off, Reset	
Power on/off	Switch-on by hardware signal ON Switch-off by AT command Switch off by hardware signal GPIO4/FST_SHDN instead of AT command Automatic switch-off in case of critical temperature and voltage conditions
Reset	Orderly shutdown and reset by AT command Emergency reset by hardware signal EMERG_RST
Evaluation kit	
Evaluation module	ELS31-US/ELS51-US module soldered onto a dedicated PCB that can be connected to an adapter in order to be mounted onto the DSB75.
DSB75	DSB75 Development Support Board designed to test and type approve Gemalto M2M modules and provide a sample configuration for application engineering. A special adapter is required to connect the ELS31-US/ELS51-US evaluation module to the DSB75.

1.2 ELS31-US/ELS51-US System Overview
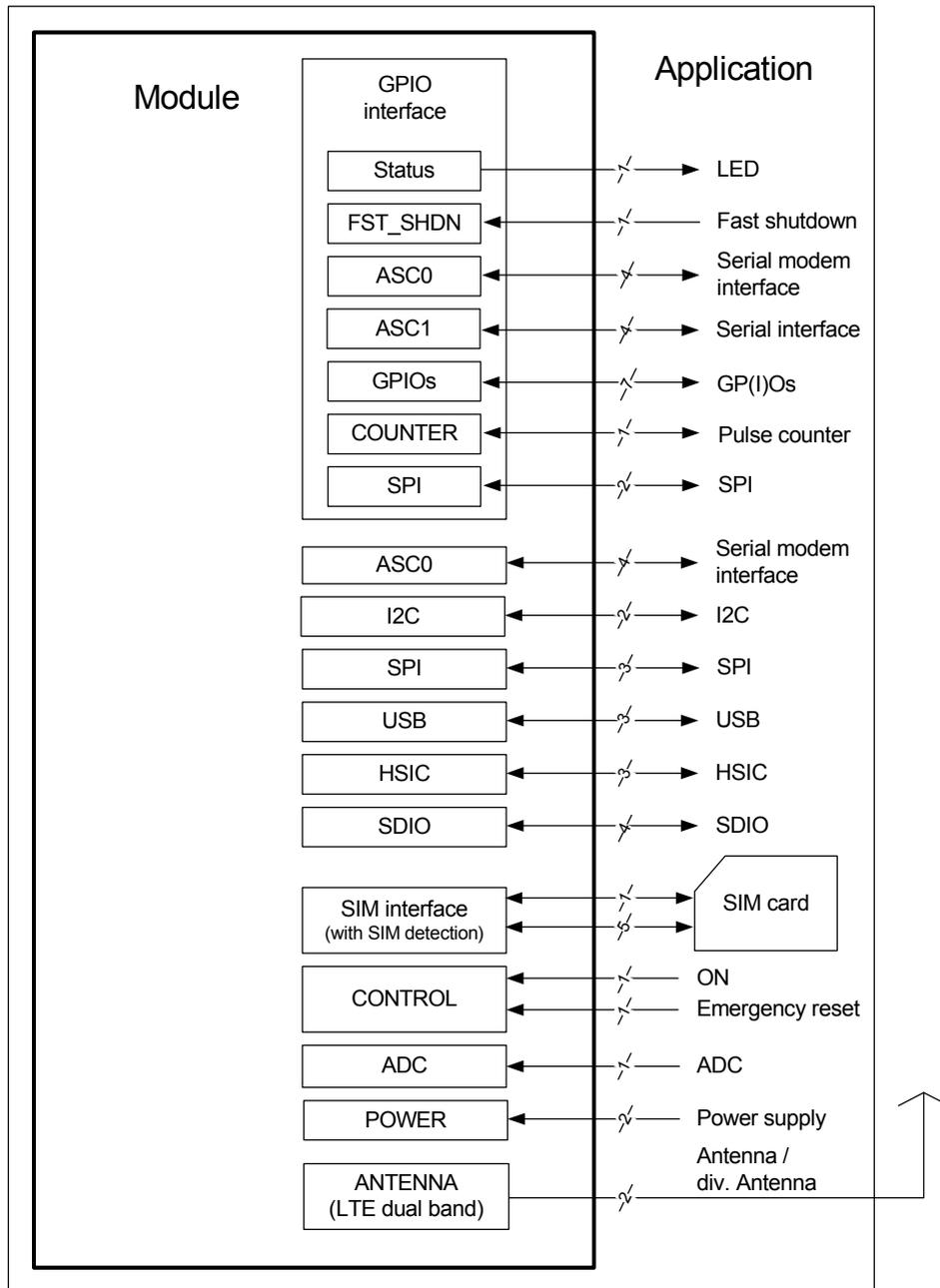
Figure 1: ELS31-US/ELS51-US system overview

2   Interface Characteristics

ELS31-US/ELS51-US is equipped with an SMT application interface that connects to the external application. The SMT application interface incorporates the various application interfaces as well as the RF antenna interfaces.

2.1   Application Interface

2.1.1   USB Interface

ELS31-US/ELS51-US supports a USB 2.0 High Speed (480Mbit/s) device interface that is Full Speed (12Mbit/s) compliant. The USB interface is primarily intended for use as command and data interface and for downloading firmware.

The V_{USB} line is used for cable detection only, this is to be supplied by the external device. The USB circuitry in the ELS31-US/ELS51-US is designed to meet the USB 2.0 specification for self-power.2.0"[1].
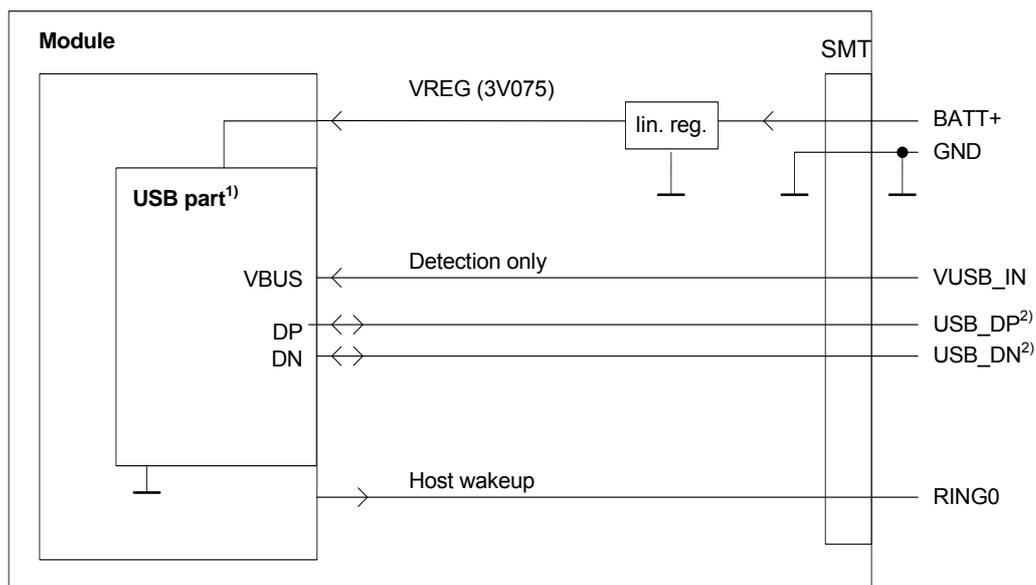
[1] It is recommended to add EMI suppression filter (see section 2.1.3.1)
[2] If the USB interface is operated in High Speed mode (480MHz), it is recommended to take special care routing the data lines USB_DP and USB_DN. Application layout should in this case implement a differential impedance of 90Ohm for proper signal integrity.

Figure 2: USB circuit

To properly connect the module's USB interface to the external application, a USB 2.0 compatible connector and cable or hardware design is required. Furthermore, the USB modem driver distributed with ELS31-US/ELS51-US needs to be installed.

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1. The specification is ready for download on http://www.usb.org/developers/docs/

2.1.2   Serial Interface ASC0

ELS31-US/ELS51-US offers an 8-wire unbalanced, asynchronous modem interface ASC0 conforming to ITU-T V.24 protocol DCE signalling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0V (for low data bit or active state) and 1.8V (for high data bit or inactive state).

ELS31-US/ELS51-US is 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 the module's TXD0 signal line
- Port RXD @ application receives data from the module's RXD0 signal line
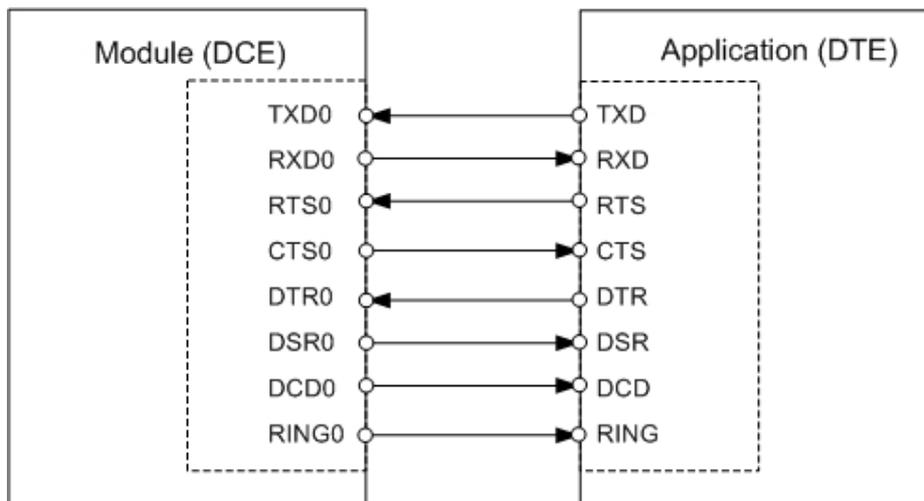
Figure 3: Serial interface ASC0

Features:
- Includes the data lines TXD0 and RXD0, the status lines RTS0 and CTS0 and, in addition, the modem control lines DTR0, DSR0, DCD0 and RING0.
- Configured for 8 data bits, no parity and 1 stop bit.
- ASC0 can be operated at fixed bit rates from 4800bps up to 921600bps.
- Supports RTS0/CTS0 hardware flow control. Communication is possible by using only RXD and TXD lines, if RTS0 is pulled low.
- Wake up from SLEEP mode by RTS0 activation.

The ASC0 interface is dedicated to signaling via AT commands (3GPP standard 27.007 + module specific AT commands).

2.1.3   Serial Interface ASC1

ELS31-US/ELS51-US provides a 4-wire unbalanced, asynchronous modem interface ASC1 conforming to ITU-T V.24 protocol DCE signaling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0V (for low data bit or active state) and 1.8V (for high data bit or inactive state).

The ASC1 interface lines are originally available as GPIO lines. If configured as ASC1 lines, the GPIO lines are assigned as follows: GPIO16 --> RXD1, GPIO17 --> TXD1, GPIO18 --> RTS1 and GPIO19 --> CTS1. Configuration is done by AT command (see [1]: AT^SCFG). The configuration is non-volatile and becomes active after a module restart.

ELS51-US is 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 module's TXD1 signal line
*   Port RXD @ application receives data from the module's RXD1 signal line
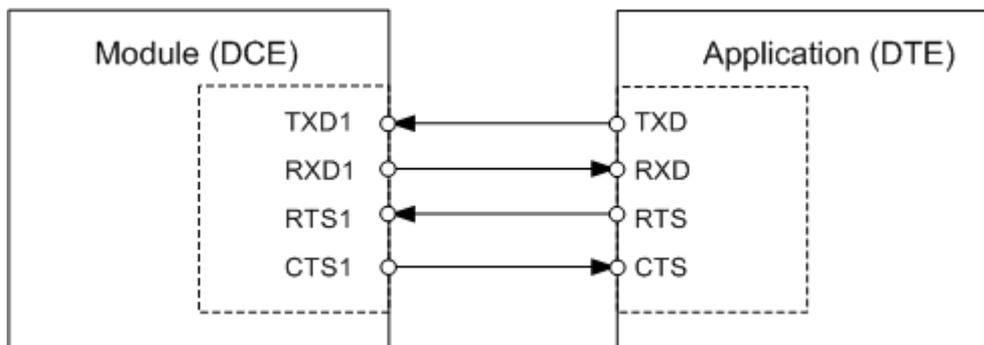
Figure 4: Serial interface ASC1

Features
*   Includes only the data lines TXD1 and RXD1 plus RTS1 and CTS1 for hardware hand-shake.
*   On ASC1 no RING line is available.
*   Configured for 8 data bits, no parity and 1 or 2 stop bits.
*   ASC1 can be operated at fixed bit rates from 4800 bps to 921600 bps.
*   Supports RTS1/CTS1 hardware flow control. Communication is possible by using only RXD and TXD lines, if RTS1 is pulled low.
*   Wake up from SLEEP mode by RTS0 activation.

AT commands for signaling are not supported on ASC1 interface. ASC1 is intended only for data transfer in a Linux environment.

2.1.4   UICC/SIM/USIM Interface

ELS31-US/ELS51-US has an integrated UICC/SIM/USIM interface compatible with the 3GPP 31.102 and ETSI 102 221. This is wired to the host interface in order to be connected to an external SIM card holder. Five pads on the SMT application interface are reserved for the SIM interface.

The UICC/SIM/USIM interface supports 3V and 1.8V SIM cards.

The CCIN signal serves to detect whether a tray (with SIM card) is present in the card holder. The CCIN signal must be connected to V180 for the detection to work on the module. Otherwise the SIM card can never be detected by the module.

Using the CCIN signal is mandatory for compliance with the GSM 11.11 recommendation if the mechanical design of the host application allows the user to remove the SIM card during operation. To take advantage of this feature, an appropriate SIM card detect switch is required on the card holder. For example, this is true for the model supplied by Molex, which has been tested to operate with ELS31-US/ELS51-US and is part of the Gemalto M2M reference equipment submitted for type approval. See Section 7.1 for Molex ordering numbers.

Table 1: Signals of the SIM interface (SMT application interface)

Signal	Description
GND	Separate ground connection for SIM card to improve EMC.
CCCLK	Chipcard clock
CCVCC	SIM supply voltage.
CCIO	Serial data line, input and output.
CCRST	Chipcard reset
CCIN	Input on the baseband processor for detecting a SIM card tray in the holder. If the SIM is removed during operation the SIM interface is shut down immediately to prevent destruction of the SIM. The CCIN signal is by default low and will change to high level if a SIM card is inserted. The CCIN signal is mandatory for applications that allow the user to remove the SIM card during operation. The CCIN signal is solely intended for use with a SIM card. It must not be used for any other purposes. Failure to comply with this requirement may invalidate the type approval of ELS31-US/ELS51-US.

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 the SIM card during operation. In this case, the application must restart ELS31-US/ELS51-US.

The figure below shows a circuit to connect an external SIM card holder.
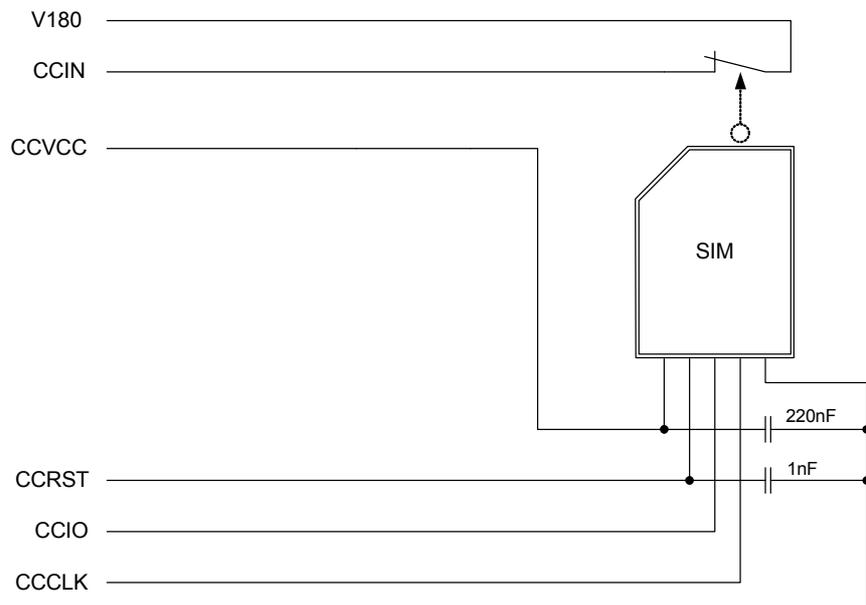
Figure 5: External UICC/SIM/USIM card holder circuit

The total cable length between the SMT application interface pads on ELS31-US/ELS51-US and the pads of the external SIM card holder must not exceed 100mm in order to meet the specifications of 3GPP TS 51.010-1 and to satisfy the requirements of EMC compliance.

To avoid possible cross-talk from the CCCLK signal to the CCIO signal be careful that both lines are not placed closely next to each other. A useful approach is using a GND line to shield the CCIO line from the CCCLK line.

The ELS31-US/ELS51-US includes embedded ESD protection for the SIM interface that complies to ETSI EN 301 489-1/7: Contact discharge: ± 4kV, air discharge: ± 8kV.

2.1.5   GPIO Interface

ELS31-US/ELS51-US offers a GPIO interface with 17 GPIO and 3 GPO lines. The lines are shared with other interfaces or functions: Fast shutdown (see Section 2.1.11.2), status LED (see Section 2.1.11.1), a pulse counter (see Section 2.1.8), ASC0 (see Section 2.1.2), ASC1 (see Section 2.1.3), SPI (see Section 2.1.7), and HSIC (see Section 2.1.9).

The following table shows the configuration variants for the GPIO pads. All variants are mutually exclusive, i.e. a pad configured for instance as Status LED is locked for alternative usage.

Table 2: GPIO lines and possible alternative assignment

GPIO	Fast Shutdown	Status LED	Pulse Counter	ASC0	ASC1	SPI	HSIC
GPIO1				DTR0			
GPIO2				DCD0			
GPIO3				DSR0			
GPIO4	FST_SHDN						
GPO5		LED					
GPIO6							
GPIO7							
GPIO8			COUNTER				
GPIO16					RXD1		AP_WAKEUP
GPIO17					TXD1		HOST_ACTIVE
GPIO18					RTS1		CP_WAKEUP
GPIO19					CTS1		SUSPEND
GPIO20							
GPIO21							
GPIO22							
GPO23							
GPIO24				RING0			
GPIO25							
GPO26						SPI_CS1	
GPIO27						SPI_CS2	

After startup, the above mentioned alternative GPIO line assignments can be configured using AT commands (see [1]). The configuration is non-volatile and available after module restart.

Notes:
• GPO5, GPO23 and GPO26 are GPOs only.

2.1.6   I²C Interface

I²C is a serial, 8-bit oriented data transfer bus for bit rates up to 100kbps. It consists of two lines, the serial data line I2CDAT and the serial clock line I2CCLK. The module acts as a single master device, e.g. the clock I2CCLK is driven by the 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 module operates as master-transmitter or as master-receiver. The customer application transmits or receives data only on request of the module.

The I²C interface can be powered via the V180 line of ELS31-US/ELS51-US. If connected to the V180 line, the I²C interface will properly shut down when the module enters the Power Down mode.

Note: Good care should be taken when creating the PCB layout of the host application: The traces of I2CCLK and I2CDAT should be equal in length and as short as possible.

2.1.7   SPI Interface

The ELS31-US/ELS51-US GPIO interface lines can be configured as Serial Peripheral Interface (SPI). The SPI is a synchronous serial interface for control and data transfer between ELS31-US/ELS51-US 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 SPI_MOSI and SPI_MISO, the clock line SPI_CLK a well as the chip select lines SPI_CS1 and SPI_CS2.

2.1.8   Pulse Counter

The GPIO8 line can be configured as pulse counter line COUNTER (for GPIOs see Section 2.1.5). The pulse counter interface can be used, for example, as a clock - it is designed to measure signals from 0 to 1000 pulses per second. Note that the pulse counter works in batches of 8 pulses, i.e., the URC indicates the number of pulses counted in batches of 8 pulses. For more information on how to use this feature see [1].

2.1.9   HSIC Interface (ELS51-US Only)

The (USB) High Speed Inter Chip (HSIC) interface can be used between the module and an external application processor, and is compliant to the High Speed USB 2.0 interface with 480Mbit/s. The maximum distance between module processor and external application processor should not exceed 100mm.

The HSIC interface comprises two signal lines (strobe - HSIC_STRB - and data - HSIC_DATA) used in a source synchronous serial interface with a 240MHz clock to provide a 480Mbps USB interface. The HSIC_STRB and HSIC_DATA lines are high-speed signals and should be routed as 50Ohm impedance traces. The trace length of these signals should be balanced to minimize timing skew and be no longer than 100mm.

The HSIC interface implementation complies with the USB HSIC standard "High-Speed Inter-Chip USB Electrical Specification", Version 1, September 23, 2007[1].

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1. The USB specifications are ready for download on http://www.usb.org/developers/docs/usb20_docs/

2.1.10   SDIO Interface (ELS51-US Only)

The Secure Digital Input Output (SDIO) interface can be used to for instance connect an SD card. The SDIO interface has the following features:

Table 3: SDIO interface features

Feature	Description/Value
Interface Type	SDIO/SD1 (1 data line), SDIO/SD4 (4 data lines), MMC4 (4 data lines)
Voltage	1.8 V
DMA Mode	SDMA / ADMA1 / ADMA2
Number of SLOTs	1
Implement DDR mode	Yes
Card inserted status	Yes
SDIOCLK frequency	Default Mode: 23 MHz maximum High Speed Mode: 46 MHz maximum UHS-I Mode: 92 MHz
Max block length	2048 bytes
SDIO interrupt support	Yes, support SDIO/SD1, SDIO/SD4 mode interrupts

Table 4 lists the six SDIO interface lines:

Table 4: SDIO interface lines

Signal	Direction	Description
SDIOCLK	Out	SD master clock output to SD/MMC/SDIO device.
SDIOCMD	I/O	Command line.
SDIO0	I/O	Data lines. Only SDIO0 carries data in 1-bit SD mode, SDIO0..3 carry data in 4-bits mode. SDIO interrupt is multiplexed with SDIO1.
SDIO1	I/O	
SDIO2	I/O	
SDIO3	I/O	

2.1.11 Control Signals

2.1.11.1 Status LED

The LED line can also be configured as GPO5 line, and can be used to drive a status LED that indicates different operating modes of the module (for GPOs see Section 2.1.5). LED and GPO functionality are mutually exclusive.

2.1.11.2 Fast Shutdown

The GPIO4 interface line can be configured as fast shutdown signal line FST_SHDN. The configured FST_SHDN line is an active low control signal. If enabled, a low impulse of 10 milliseconds on the FST_SHDN line starts the fast shutdown procedure.The fast shutdown procedure still finishes any data activities on the module's flash file system, thus ensuring data integrity, but the module will no longer deregister gracefully from the network.

2.2   RF Antenna Interface

The RF interface has an impedance of 50Ω. ELS31-US/ELS51-US is capable of sustaining a total mismatch at the antenna line without any damage, even when transmitting at maximum RF power.

The external antenna must be matched properly to achieve best performance regarding radiated power, modulation accuracy and harmonic suppression. Antenna matching networks are not included on the ELS31-US/ELS51-US module and should be placed in the host application if the antenna does not have an impedance of 50Ω.

Regarding the return loss ELS31-US/ELS51-US provides the following values in the active band:

Table 5: Return loss in the active band

State of module	Return loss of module	Recommended return loss of application
Receive	≥ 8dB	≥ 12dB
Transmit	not applicable	≥ 12dB

2.2.1   Antenna Installation

The antenna is connected by soldering the antenna pads (RF_OUT, pad #59 and DIV_ANT, pad 56) its neighboring ground pads (GND, i.e., pads #55, #57, #58 and #60) directly to the application's PCB. The antenna pad is the antenna reference point (ARP) for ELS31-US/ELS51-US. All RF data specified throughout this document is related to the ARP.

The distance between the antenna RF pads and its neighboring GND pads has been optimized for best possible impedance. On the application PCB, special attention should be paid to these 3 pads, in order to prevent mismatch.

The wiring of the antenna connection line, starting from the antenna pad to the application antenna should result in a 50Ω line impedance. Line width and distance to the GND plane needs to be optimized with regard to the PCB's layer stack. Some examples are given in Section 2.2.2.

To prevent receiver desensitization due to interferences generated by fast transients like high speed clocks on the application PCB, it is recommended to realize the antenna connection line using embedded Stripline rather than Micro-Stripline technology. Please see Section 2.2.2.2 for an example.

For type approval purposes, the use of a 50Ω coaxial antenna connector (U.FL-R-SMT) might be necessary. In this case the U.FL-R-SMT connector should be placed as close as possible to ELS31-US/ELS51-US's antenna pad.

2.2.2 RF Line Routing Design

2.2.2.1 RF Interface Signals Circuit Diagram Example

Figure 6 is a topology reference, and it is recommended not to deviate from this circuit for your external application.

The RF inter-connects called RF Port 1 and RF Port 2 are examples only. Depending on the RF antenna, the interfacing system will dictate the RF inter-connects.
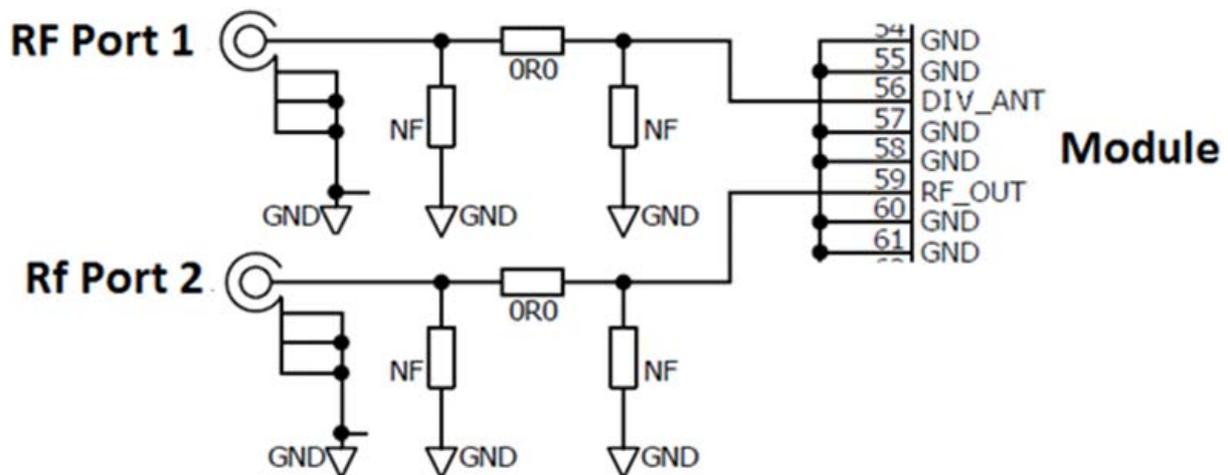
Figure 6: RF interface signals example

Please be also aware of ESD protection required on the RF interface lines. ESD protection might be utilized through the above pi-network (primarily intended for managing any additional RF optimization needs), or by additional components in series with the pi-network illustrated above.

2.2.2.2 Line Arrangement Examples

Several dedicated tools are available to calculate line arrangements for specific applications and PCB materials - for example from http://www.polarinstruments.com/ (commercial software) or from http://web.awrcorp.com/Usa/Products/Optional-Products/TX-Line/ (free software).

Embedded Stripline

This figure below shows a line arrangement example for embedded stripline with 65µm FR4 prepreg (type: 1080) and 710µm FR4 core (4-layer PCB).
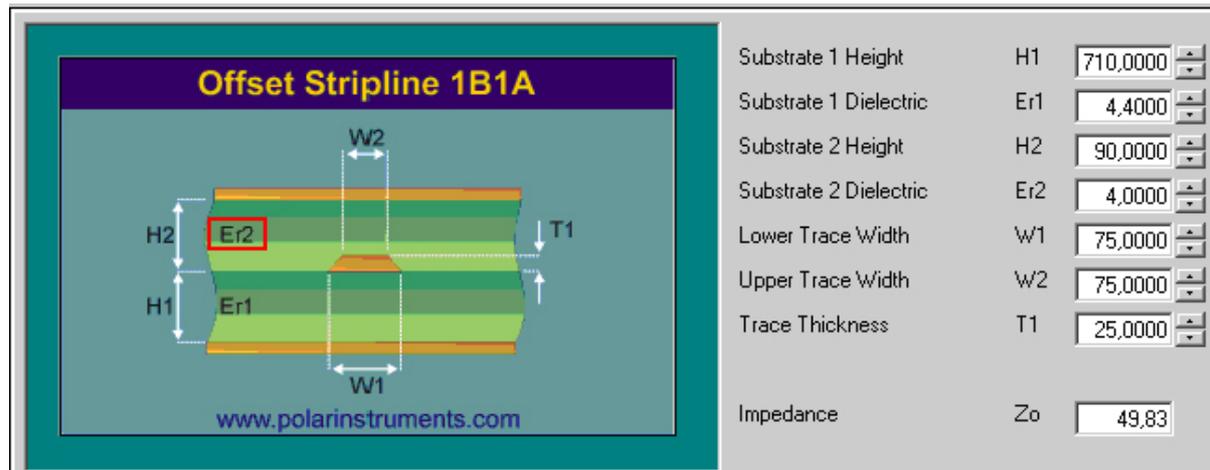
Figure 7: Embedded Stripline with 65µm prepreg (1080) and 710µm core

Micro-Stripline

This section gives two line arrangement examples for micro-stripline.

- Micro-Stripline on 1.0mm Standard FR4 2-Layer PCB
  The following two figures show examples with different values for D1 (ground strip separation).
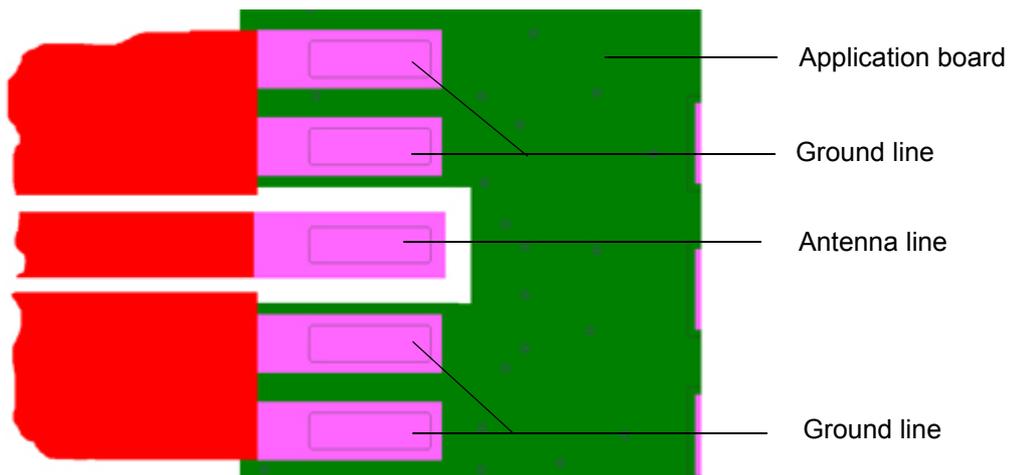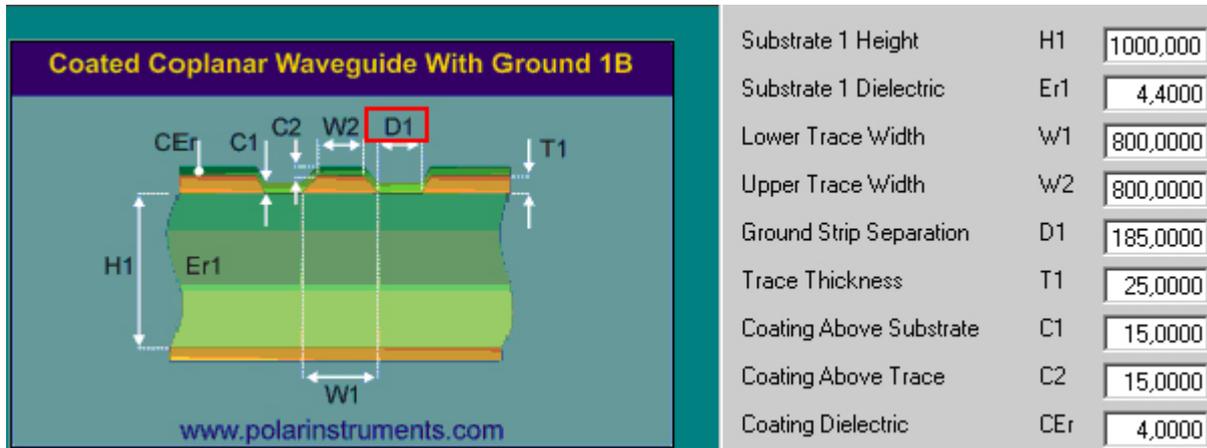
Figure 8: Micro-Stripline on 1.0mm standard FR4 2-layer PCB - example 1

Coated Coplanar Waveguide With Ground 1B

www.polarinstruments.com

Substrate 1 Height	H1	1000,000
Substrate 1 Dielectric	Er1	4,4000
Lower Trace Width	W1	1050,000
Upper Trace Width	W2	1050,000
Ground Strip Separation	D1	275,0000
Trace Thickness	T1	25,0000
Coating Above Substrate	C1	15,0000
Coating Above Trace	C2	15,0000
Coating Dielectric	CEr	4,0000

- Application board
- Ground line
- Antenna line
- Ground line

Figure 9: Micro-Stripline on 1.0mm Standard FR4 PCB - example 2

- Micro-Stripline on 1.5mm Standard FR4 2-Layer PCB
  The following two figures show examples with different values for D1 (ground strip separation).

Coated Coplanar Waveguide With Ground 1B		
Substrate 1 Height	H1	1500,000
Substrate 1 Dielectric	Er1	4,4000
Lower Trace Width	W1	800,0000
Upper Trace Width	W2	800,0000
Ground Strip Separation	D1	165,0000
Trace Thickness	T1	25,0000
Coating Above Substrate	C1	15,0000
Coating Above Trace	C2	15,0000
Coating Dielectric	CEr	4,0000

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Application board

Ground line

Antenna line

Ground line
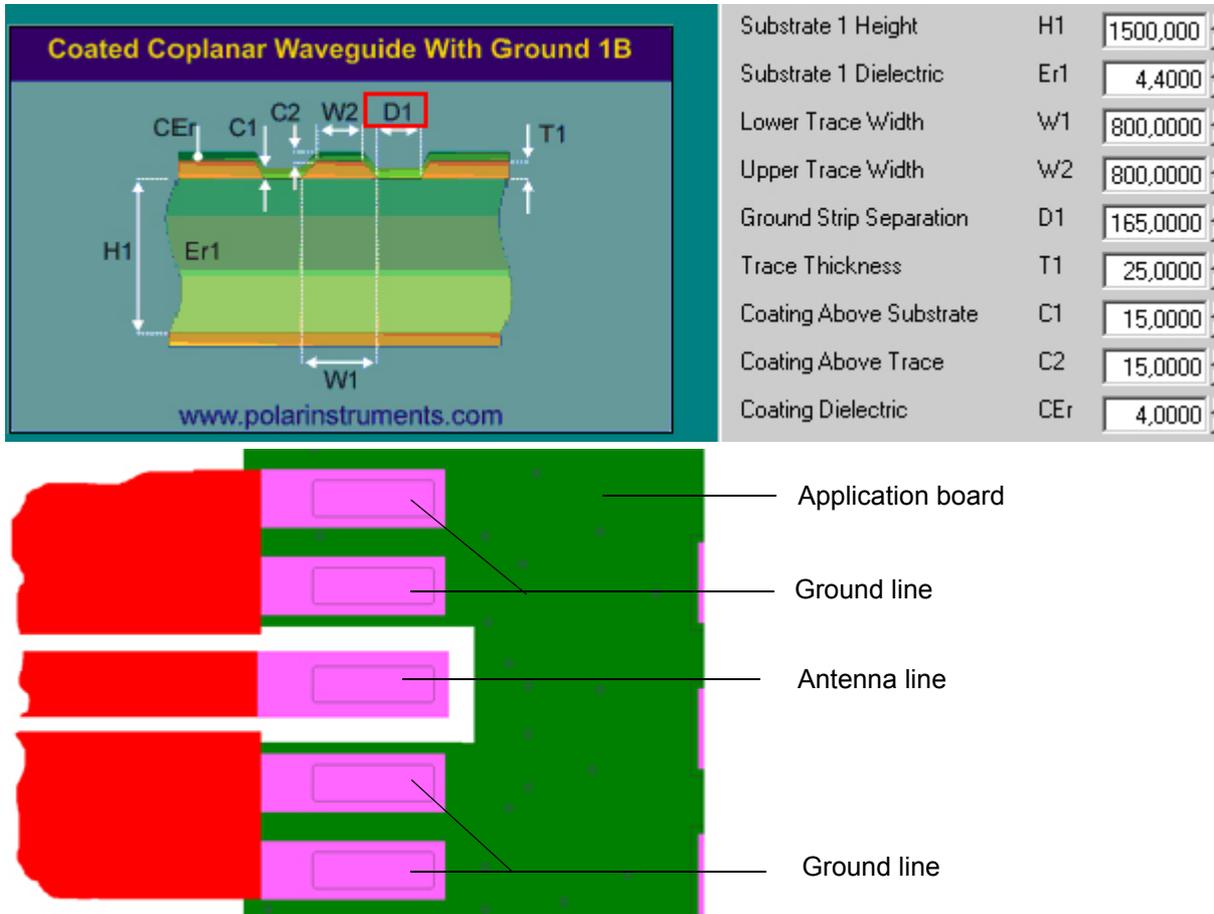
Figure 10: Micro-Stripline on 1.5mm Standard FR4 PCB - example 1

Substrate 1 Height	H1	1500,000
Substrate 1 Dielectric	Er1	4,4000
Lower Trace Width	W1	1150,000
Upper Trace Width	W2	1150,000
Ground Strip Separation	D1	225,0000
Trace Thickness	T1	25,0000
Coating Above Substrate	C1	15,0000
Coating Above Trace	C2	15,0000
Coating Dielectric	CEr	4,0000

- Application board
- Ground line
- Antenna line
- Ground line

Figure 11: Micro-Stripline on 1.5mm Standard FR4 PCB - example 2

2.3   Sample Application

Figure 12 shows a typical example of how to integrate a ELS31-US/ELS51-US module with an application. Usage of the various host interfaces depends on the desired features of the application.

Because of the high RF field density inside the module, it cannot be guaranteed that no self interference might occur, depending on frequency and the applications grounding concept. The potential interferers may be minimized by placing small capacitors (47pF) at suspected lines (e.g. RXD0, or ON).

While developing SMT applications it is strongly recommended to provide test points for certain signals, i.e., lines to and from the module - for debug and/or test purposes. The SMT application should allow for an easy access to these signals. For details on how to implement test points see [4].

The EMC measures are best practice recommendations. In fact, an adequate EMC strategy for an individual application is very much determined by the overall layout and, especially, the position of components. For example, mounting the internal acoustic transducers directly on the PCB eliminates the need to use the ferrite beads shown in the sample schematic.

Note: ELS31-US/ELS51-US is not intended for use with cables longer than 3m.

Disclaimer
No warranty, either stated or implied, is provided on the sample schematic diagram shown in Figure 12 and the information detailed in this section. As functionality and compliance with national regulations depend to a great amount on the used electronic components and the individual application layout manufacturers are required to ensure adequate design and operating safeguards for their products using ELS31-US/ELS51-US modules.

Figure 12: Schematic diagram of ELS31-US/ELS51-US sample application

3 Operating Characteristics
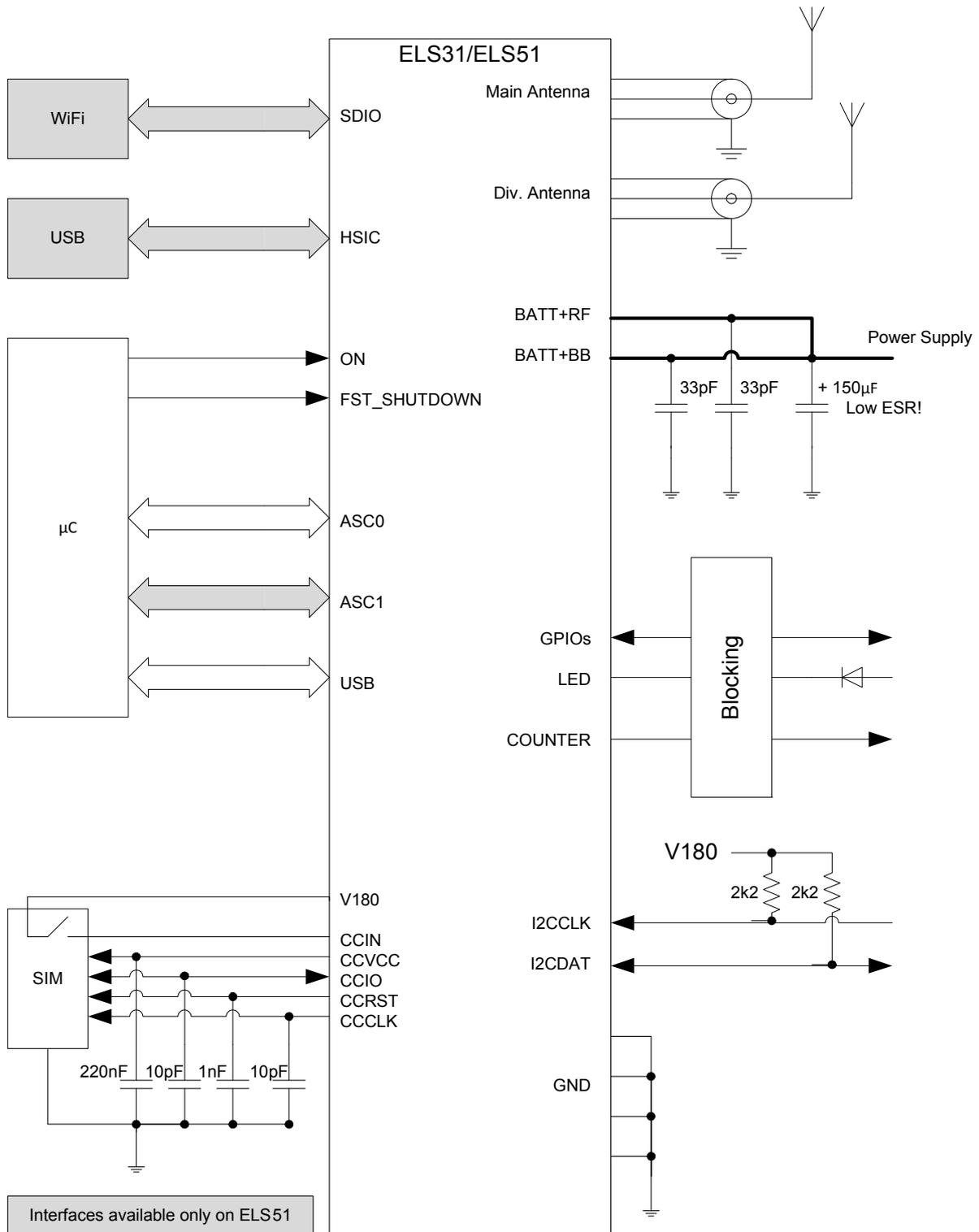
3.1 Operating Modes

The table below briefly summarizes the various operating modes referred to throughout the document.

Table 6: Overview of operating modes

Mode	Function	
Normal opera-tion	LTE IDLE	No data transfer is in progress and the USB connection is suspended by host (or is not present) and no active communication via ASC0/ASC1. In IDLE mode, the software can be active or in SLEEP state.
	LTE DATA	LTE data transfer in progress. Power consumption depends on network settings and data transfer rate.
Power Down	Normal shutdown after sending the power down command. 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 LTE network and disables all AT commands whose execution requires a radio connection. Airplane mode can be controlled by AT command (see [1]). In Airplane mode, the software can be active or in SLEEP state.	

3.2 Power Supply

ELS31-US/ELS51-US needs to be connected to a power supply at the SMT application interface - 2 BATT lines and GND. There are two separate voltage domains for BATT:
• BATT_BB with a line mainly for the baseband power supply.
• BATT_RF with a line for the RF power amplifier supply.

Please note that throughout the document BATT refers to both voltage domains and power supply lines - BATT_BB and BATT_RF.

The power supply of ELS31-US/ELS51-US has to be a single voltage source at BATT_BB and BATT_RF. It must be able to provide the current for all operation modes of the module.

All the key functions for supplying power to the device are handled by the power management section of the analog controller. This IC provides the following features:

• Stabilizes the supply voltages for the baseband using low drop linear voltage regulators and a DC-DC step down switching regulator.
• Switches the module's power voltages for the power-up and -down procedures.
• SIM switch to provide SIM power supply.

4 Mechanical Dimensions, Mounting and Packaging

The following sections describe the mechanical dimensions of ELS31-US/ELS51-US and give recommendations for integrating ELS31-US/ELS51-US into the host application.

4.1 Mechanical Dimensions of ELS31-US/ELS51-US

Figure 13 shows the top and bottom view of ELS31-US/ELS51-US and provides an overview of the board's mechanical dimensions. For further details see Figure 14.
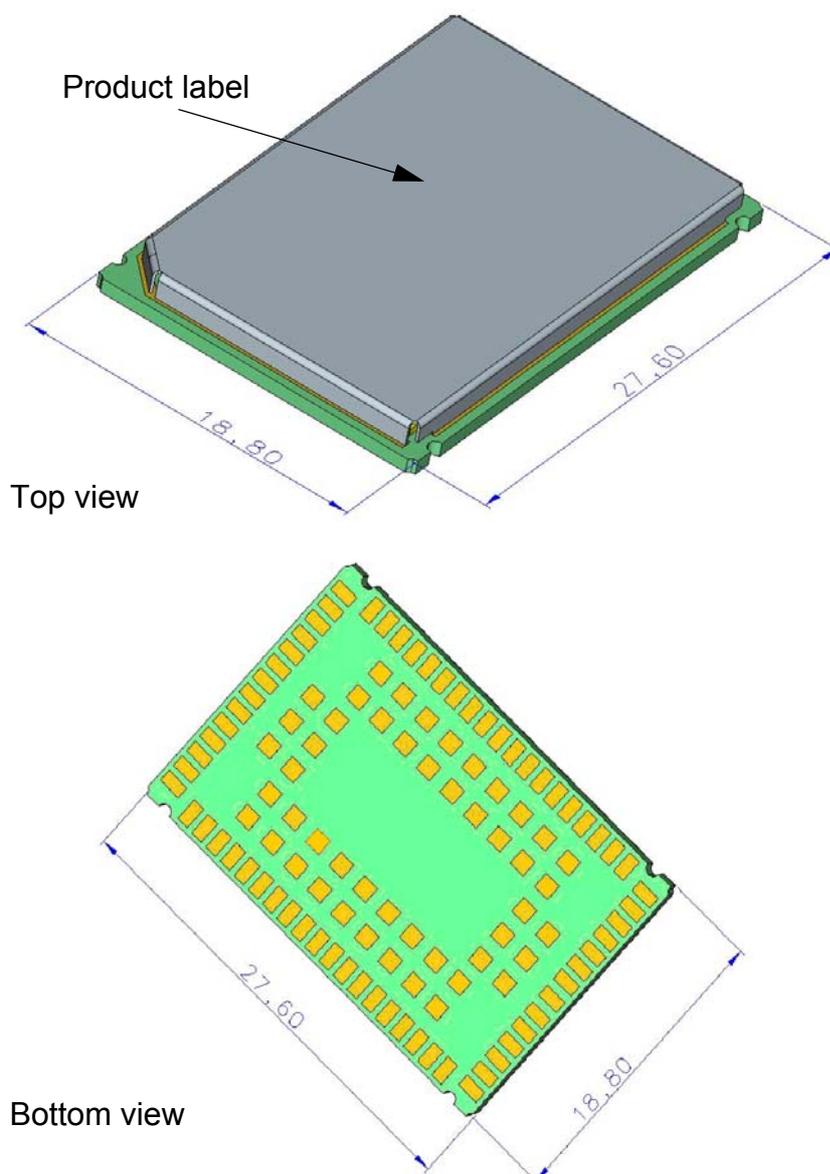
Figure 13: ELS31-US/ELS51-US– top and bottom view
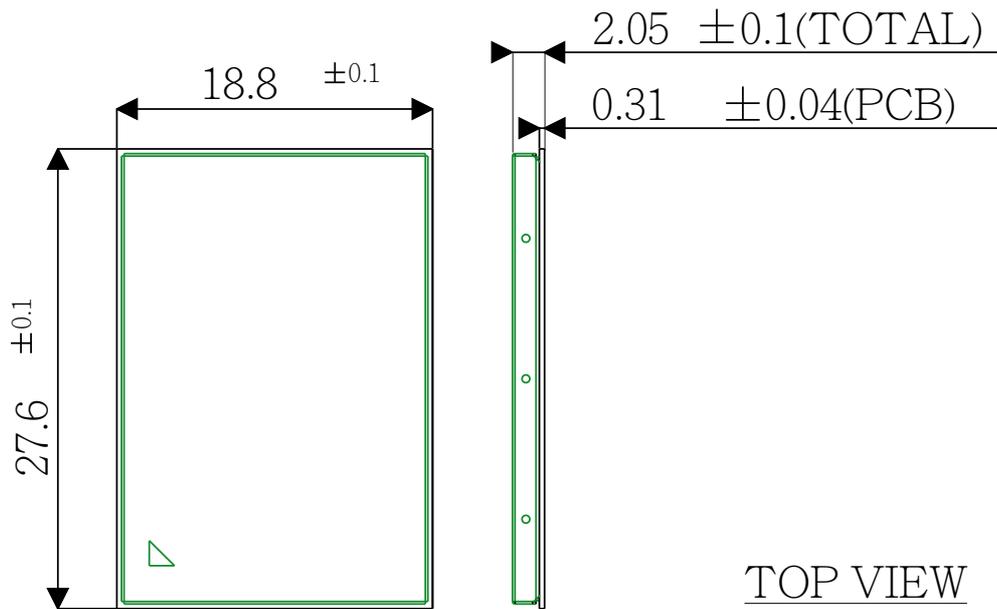
Figure 14: Dimensions of ELS31-US/ELS51-US (all dimensions in mm)
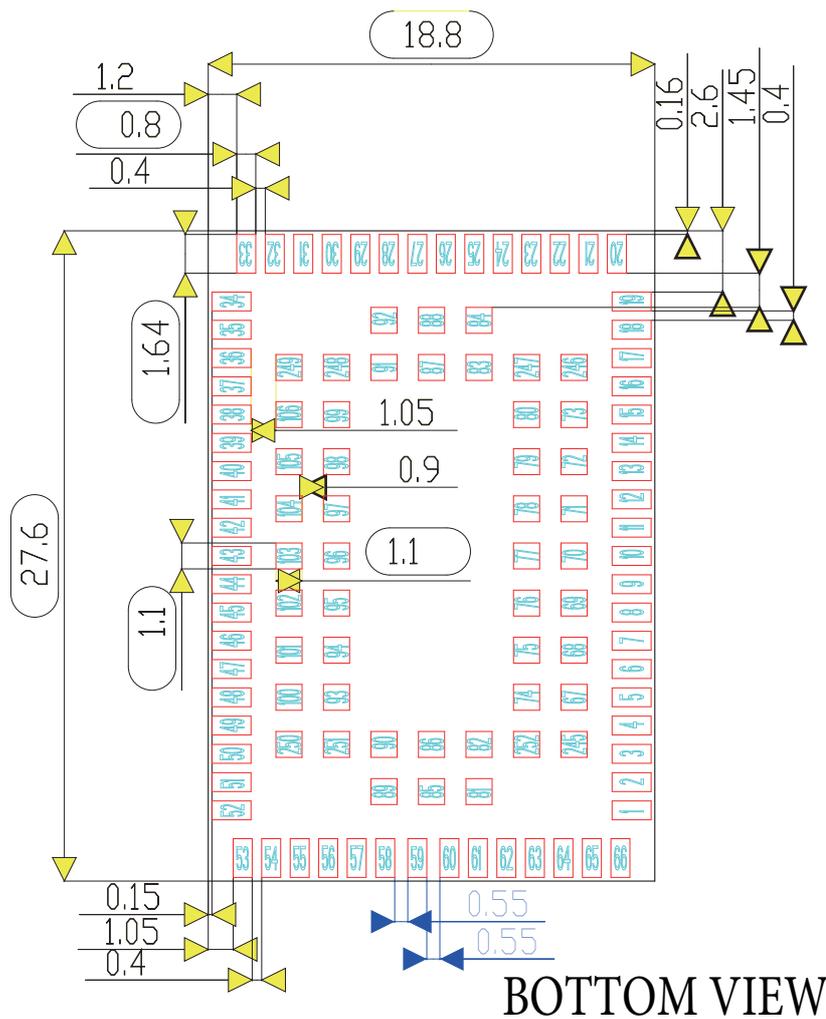
Figure 15: Dimensions of ELS31-US/ELS51-US (all dimensions in mm) - bottom view

5 Regulatory and Type Approval Information

5.1 Directives and Standards

ELS31-US/ELS51-US is designed to comply with the directives and standards listed below.

It is the responsibility of the application manufacturer to ensure compliance of the final product with all provisions of the applicable directives and standards as well as with the technical specifications provided in the "ELS31-US/ELS51-US Hardware Interface Description".

Table 7: Directives

| 2002/95/EC (RoHS 1) 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) | |

Table 8: Standards of North American type approval

CFR Title 47	Code of Federal Regulations, Part 22 and Part 24 (Telecommunications, PCS); US Equipment Authorization FCC	
OET Bulletin 65 (Edition 97-01)	Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields	
UL 60 950-1	Product Safety Certification (Safety requirements)	
California Leadfree Mandate	Covered by European RoHS requirements	
RSS132 (Issue2) RSS133 (Issue5)	Canadian Standard	

Table 9: Standards of GCF type approval

3GPP TS 51.010-1	Digital cellular telecommunications system (Release 10); Mobile Station (MS) conformance specification;
GCF-CC V3.58	Global Certification Forum - Certification Criteria

Table 10: Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes

Table 11: 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	"Marking for Control of Pollution Caused by Electronic Information Products" (2006-06). 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 Gemalto M2M Hardware Interface Description. Please see Table 12 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.

Table 12: Toxic or hazardous substances or elements with defined concentration limits

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

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.

5.2   SAR requirements specific to portable mobiles

Mobile phones, PDAs or other portable transmitters and receivers incorporating a GSM module must be in accordance with the guidelines for human exposure to radio frequency energy. This requires the Specific Absorption Rate (SAR) of portable ELS31-US/ELS51-US based applications to be evaluated and approved for compliance with national and/or international regulations.

Since the SAR value varies significantly with the individual product design manufacturers are advised to submit their product for approval if designed for portable use. For US markets the relevant directives are mentioned below. It is the responsibility of the manufacturer of the final product to verify whether or not further standards, recommendations or directives are in force outside these areas.

Products intended for sale on US markets

ES 59005/ANSI C95.1 Considerations for evaluation of human exposure to Electromagnetic Fields (EMFs) from Mobile Telecommunication Equipment (MTE) in the frequency range 30MHz - 6GHz

Please note that SAR requirements are specific only for portable devices and not for mobile devices as defined below:

- Portable device:
  A portable device is defined as a transmitting device designed to be used so that the radiating structure(s) of the device is/are within 20 centimeters of the body of the user.
- Mobile device:
  A mobile device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons. In this context, the term "fixed location" means that the device is physically secured at one location and is not able to be easily moved to another location.

5.3 Reference Equipment for Type Approval

The Gemalto M2M reference setup submitted to type approve ELS31-US/ELS51-US (including a special approval adapter for the DSB75) is shown in the following figure[1]:
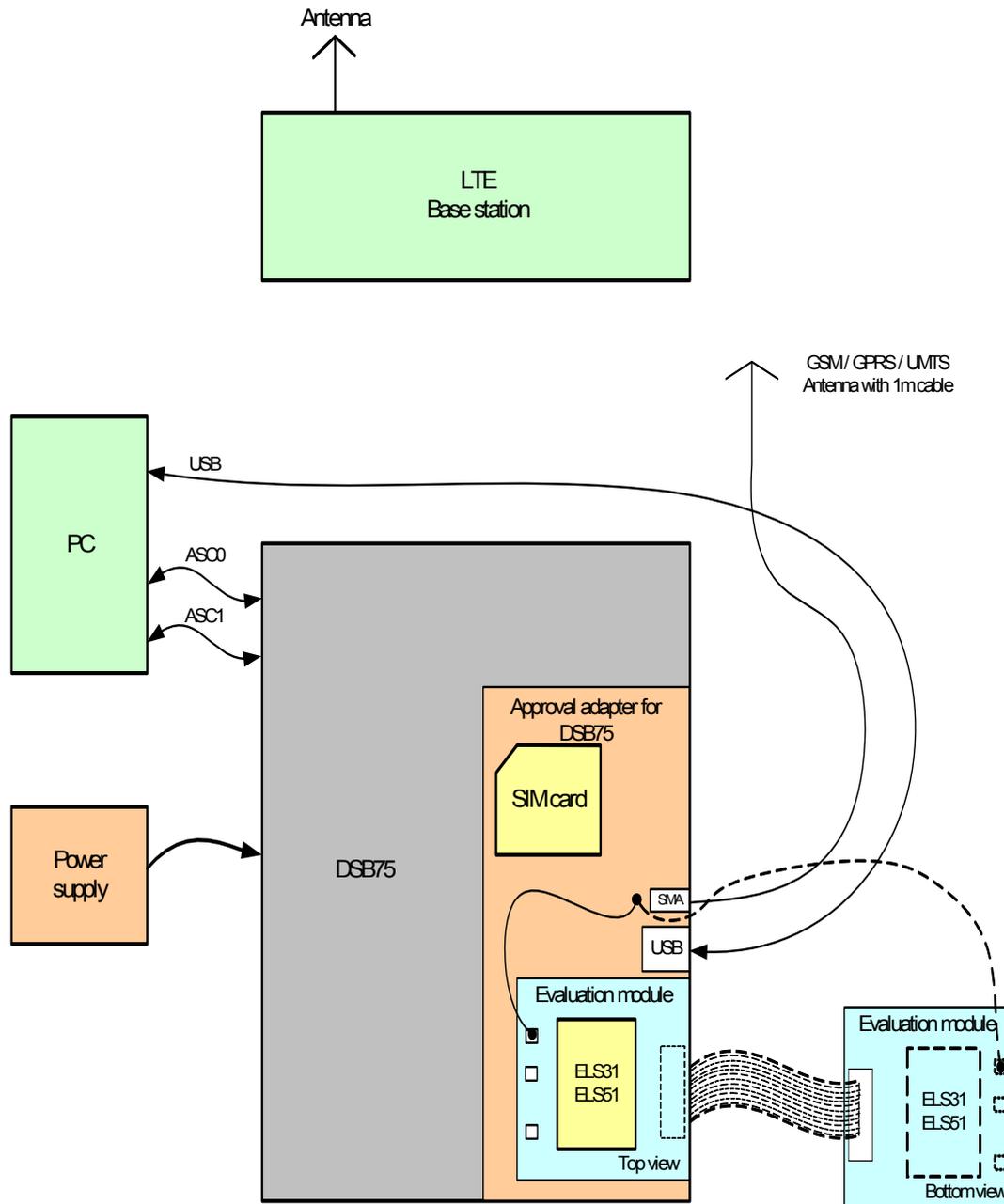
Figure 16: Reference equipment for Type Approval

1. For RF performance tests a mini-SMT/U.FL to SMA adapter with attached 6dB coaxial attenuator is chosen to connect the evaluation module directly to the GSM/UMTS test equipment instead of employing the SMA antenna connectors on the ELS31-US/ELS51-US-DSB75 adapter as shown in Figure 16. The following products are recommended:
Hirose® SMA-Jack/U.FL-Plug conversion adapter HRMJ-U.FLP(40)
(for details see see http://www.hirose-connectors.com/ or http://www.farnell.com/
Aeroflex Weinschel Fixed Coaxial Attenuator Model 3T/4T
(for details see http://www.aeroflex.com/ams/weinschel/pdfiles/wmod3&4T.pdf)

5.4   Compliance with FCC and IC Rules and Regulations

The Equipment Authorization Certification for the Gemalto M2M reference application described in Section 5.3 will be registered under the following identifiers:

- ELS31-US:
    FCC Identifier: QIPELS31-US
    Industry Canada Certification Number: 7830A-ELS31US
    Granted to Gemalto M2M GmbH

- ELS51-US:
    FCC Identifier: QIPELS51-US (not yet granted)
    Industry Canada Certification Number: 7830A-ELS51US (not yet granted)
    Granted to Gemalto M2M GmbH

Manufacturers of mobile or fixed devices incorporating ELS31-US/ELS51-US modules are authorized to use the FCC Grants and Industry Canada Certificates of the ELS31-US/ELS51-US modules for their own final products according to the conditions referenced in these documents. In this case, an FCC/ IC label of the module shall be visible from the outside, or the host device shall bear a second label stating "Contains FCC ID: QIPELS31-US" / "Contains FCC ID: QIPELS51-US", and accordingly "Contains IC: 7830A-ELS31US" / "Contains IC: 7830A-ELS51US". The integration is limited to fixed or mobile categorized host devices, where a separation distance between the antenna and any person of min. 20cm can be assured during normal operating conditions.

For mobile and fixed operation configurations the antenna gain, including cable loss, must not exceed the limits in the following Table 9 for FCC and IC.

Table 13: Antenna gain limits for FCC and IC (TBD)

Operating band	FCC limit	IC limit	Unit
Maximum gain in lower operating bands with f< 1GHz (LTE Bd12)	8.72	6.10	dBi
Maximum gain in higher operating bands with f=1700MHz (LTE Bd4)	5.00	5.00	dBi
Maximum gain in higher operating bands with f=1900MHz (LTE Bd2)	8.01	8.01	dBi

IMPORTANT:
Manufacturers of portable applications incorporating ELS31-US/ELS51-US modules are required to have their final product certified and apply for their own FCC Grant and Industry Canada Certificate related to the specific portable mobile. This is mandatory to meet the SAR requirements for portable mobiles (see Section 5.2 for detail).

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Note: This 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 and with Industry Canada license-exempt RSS standard(s). These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio fre-

quency 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.

This Class B digital apparatus complies with Canadian ICES-003.

If Canadian approval is requested for devices incorporating ELS31US / ELS51-US modules the above note will have to be provided in the English and French language in the final user documentation. Manufacturers/OEM Integrators must ensure that the final user documentation does not contain any information on how to install or remove the module from the final product.

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 at least 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 Document Information

6.1 Revision History

New document: "Cinterion® ELS31-/ELS51-US Hardware Interface Overview" v01.000a

Chapter	What is new
--	Initial document setup.

6.2 Related Documents

[1] ELS31-US/ELS51-US AT Command Set
[2] ELS31-US/ELS51-US Release Note
[3] Application Note 40: Thermal Solutions
[4] Application Note 48: SMT Module Integration
[5] Universal Serial Bus Specification Revision 2.0, April 27, 2000

6.3 Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-digital converter
AGC	Automatic Gain Control
ANSI	American National Standards Institute
ARFCN	Absolute Radio Frequency Channel Number
ARP	Antenna Reference Point
ASC0/ASC1	Asynchronous Controller. Abbreviations used for first and second serial interface of the module
B	Thermistor Constant
BER	Bit Error Rate
BTS	Base Transceiver Station
CB or CBM	Cell Broadcast Message
CE	Conformité Européene (European Conformity)
CHAP	Challenge Handshake Authentication Protocol
CPU	Central Processing Unit
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear to Send
DAC	Digital-to-Analog Converter
DAI	Digital Audio Interface

Abbreviation	Description
dBm0	Digital level, 3.14dBm0 corresponds to full scale, see ITU G.711, A-law
DCE	Data Communication Equipment (typically modems, e.g. Gemalto M2M module)
DCS 1800	Digital Cellular System, also referred to as PCN
DRX	Discontinuous Reception
DSB	Development Support Box
DSP	Digital Signal Processor
DSR	Data Set Ready
DTE	Data Terminal Equipment (typically computer, terminal, printer or, for example, GSM application)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
EIRP	Equivalent Isotropic Radiated Power
EMC	Electromagnetic Compatibility
ERP	Effective Radiated Power
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FCC	Federal Communications Commission (U.S.)
FDMA	Frequency Division Multiple Access
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
GPIO	General Purpose Input/Output
GPRS	General Packet Radio Service
GSM	Global Standard for Mobile Communications
HiZ	High Impedance
HR	Half Rate
HSIC	High-Speed Inter-Chip
I/O	Input/Output
IC	Integrated Circuit
IMEI	International Mobile Equipment Identity
ISO	International Standards Organization
ITU	International Telecommunications Union
kbps	kbits per second
LED	Light Emitting Diode
Li-Ion/Li+	Lithium-Ion
Li battery	Rechargeable Lithium Ion or Lithium Polymer battery
LTE	Long Term Evolution

Abbreviation	Description
Mbps	Mbits per second
MMI	Man Machine Interface
MO	Mobile Originated
MS	Mobile Station (GSM module), also referred to as TE
MSISDN	Mobile Station International ISDN number
MT	Mobile Terminated
NTC	Negative Temperature Coefficient
OEM	Original Equipment Manufacturer
PA	Power Amplifier
PAP	Password Authentication Protocol
PBCCH	Packet Switched Broadcast Control Channel
PCB	Printed Circuit Board
PCL	Power Control Level
PCM	Pulse Code Modulation
PCN	Personal Communications Network, also referred to as DCS 1800
PCS	Personal Communication System, also referred to as GSM 1900
PLL	Phase Locked Loop
PPP	Point-to-point protocol
PSK	Phase Shift Keying
PSU	Power Supply Unit
R&TTE	Radio and Telecommunication Terminal Equipment
RAM	Random Access Memory
RF	Radio Frequency
RLS	Radio Link Stability
RoHS	Restriction of the use of certain hazardous substances in electrical and electronic equipment.
RTS	Request to Send
Rx	Receive Direction
SAR	Specific Absorption Rate
SAW	Surface Acoustic Wave
SDIO	Secure Digital Input Output
SELV	Safety Extra Low Voltage
SIM	Subscriber Identification Module
SMD	Surface Mount Device
SMS	Short Message Service
SMT	Surface Mount Technology
SRAM	Static Random Access Memory
TA	Terminal adapter (e.g. GSM module)

Abbreviation	Description
TDMA	Time Division Multiple Access
TE	Terminal Equipment, also referred to as DTE
TLS	Transport Layer Security
Tx	Transmit Direction
UART	Universal asynchronous receiver-transmitter
URC	Unsolicited Result Code
USSD	Unstructured Supplementary Service Data
VSWR	Voltage Standing Wave Ratio

6.4   Safety Precaution Notes

The following safety precautions must be observed during all phases of the operation, usage, service or repair of any cellular terminal or mobile incorporating ELS31-US/ELS51-US. Manufacturers of the cellular terminal are advised to convey the following safety information to users and operating personnel and to 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 assumes no liability for customer's failure to comply with these precautions.

♥	When in a hospital or other health care facility, observe the restrictions on the use of mobiles. Switch the cellular terminal or mobile off, if instructed to do so by the guidelines posted in sensitive areas. Medical equipment may be sensitive to RF energy. 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.
✈	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.
♨	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.
▤	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.
🚗	Road safety comes first! Do not use a hand-held cellular terminal or mobile when 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.
SOS	IMPORTANT! Cellular terminals or mobiles operate using radio signals and cellular networks. Because of this, connection 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. Remember, in order to make or receive calls, the cellular terminal or mobile must be switched on and in a service area with adequate cellular signal strength. 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. Some networks require that a valid SIM card be properly inserted in the cellular terminal or mobile.

7   Appendix

7.1   List of Parts and Accessories

Table 14: List of parts and accessories

Description	Supplier	Ordering information
ELS31-US	Gemalto M2M	Standard module Gemalto M2M IMEI: Packaging unit (ordering) number: L30960-N4520-A200 Module label number: S30960-S4520-A200-1[1] Customer IMEI module Packaging unit (ordering) number: L30960-N4525-A200 Module label number: S30960-S4520-A200-1[1]
ELS51-US	Gemalto M2M	Standard module Gemalto M2M IMEI: Packaging unit (ordering) number: L30960-N4550-A200 Module label number: S30960-S4550-A200-1[1] Customer IMEI module Packaging unit (ordering) number: L30960-N4555-A200 Module label number: S30960-S4555-A200-1[1]
ELS31-US Evaluation Module	Gemalto M2M	Ordering number: L30960-N4521-A200
ELS51-US Evaluation Module	Gemalto M2M	Ordering number: L30960-N4551-A200
DSB75 Evaluation Kit	Gemalto M2M	Ordering number: L36880-N8811-A100
DSB Mini Compact Evaluation Board	Gemalto M2M	Ordering number: L30960-N0030-A100
Starter Kit B80	Gemalto M2M	Ordering Number L30960-N0040-A100
Multi-Adapter R1 for mounting ELS31-US/ELS51-US evaluation modules onto DSB75	Gemalto M2M	Ordering number: L30960-N0010-A100
Approval adapter for mounting ELS31-US/ELS51-US evaluation modules onto DSB75	Gemalto M2M	Ordering number: L30960-N2301-A100
SIM card holder incl. push button ejector and slide-in tray	Molex	Ordering numbers: 91228 91236 Sales contacts are listed in Table 15.

1. Note: At the discretion of Gemalto M2M, module label information can either be laser engraved on the module's shielding or be printed on a label adhered to the module's shielding.

Table 15: Molex sales contacts (subject to change)

Molex For further information please click: http://www.molex.com	Molex Deutschland GmbH Otto-Hahn-Str. 1b 69190 Walldorf Germany Phone: +49-6227-3091-0 Fax: +49-6227-3091-8100 Email: mxgermany@molex.com	American Headquarters Lisle, Illinois 60532 U.S.A. Phone: +1-800-78MOLEX Fax: +1-630-969-1352
Molex China Distributors Beijing, Room 1311, Tower B, COFCO Plaza No. 8, Jian Guo Men Nei Street, 100005 Beijing P.R. China Phone: +86-10-6526-9628 Fax: +86-10-6526-9730	Molex Singapore Pte. Ltd. 110, International Road Jurong Town, Singapore 629174 Phone: +65-6-268-6868 Fax: +65-6-265-6044	Molex Japan Co. Ltd. 1-5-4 Fukami-Higashi, Yamato-City, Kanagawa, 242-8585 Japan Phone: +81-46-265-2325 Fax: +81-46-265-2365

About Gemalto

Gemalto (Euronext NL0000400653 GTO) is the world leader in digital security with 2015 annual revenues of €3.1 billion and blue-chip customers in over 180 countries. Our 14,000+ employees operate out of 118 offices, 45 personalization and data centers, and 27 research and software development centers located in 49 countries.

We are at the heart of the rapidly evolving digital society. Billions of people worldwide increasingly want the freedom to communicate, travel, shop, bank, entertain and work - anytime, everywhere - in ways that are enjoyable and safe. Gemalto delivers on their expanding needs for personal mobile services, payment security, authenticated cloud access, identity and privacy protection, eHealthcare and eGovernment efficiency, convenient ticketing and dependable machine-to-machine (M2M) applications.

Gemalto develops secure embedded software and secure products which we design and personalize. Our platforms and services manage these secure products, the confidential data they contain and the trusted end-user services they enable. Our innovations enable our clients to offer trusted and convenient digital services to billions of individuals.

Gemalto thrives with the growing number of people using its solutions to interact with the digital and wireless world.

For more information please visit
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