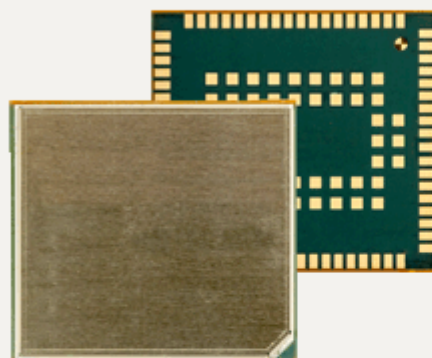


Cinterion[®] ELS61-E

Hardware Interface Description

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1 Introduction

This document¹ describes the hardware of the Cinterion® ELS61-E module. It helps you quickly retrieve interface specifications, electrical and mechanical details and information on the requirements to be considered for integrating further components.

1.1 Key Features at a Glance

Feature	Implementation
<i>General</i>	
Frequency bands	GSM/GPRS/EDGE: Dual band 900/1800MHz LTE: Quad band 800 (Bd 20) / 900 (Bd 8) / 1800 (Bd 3) / 2100 MHz (Bd 1)
GSM class	Small MS
Output power (according to Release 99)	Class 4 (+32.5dBm ±2dB) for EGSM900 Class 1 (+30dBm ±2dB) for GSM1800 Class E2 (+26.5dBm ± 3dB) for GSM 900 8-PSK Class E2 (+26dBm +3 /-4dB) for GSM 1800 8-PSK
Output power (according to Release 8)	Class 3 (+23dBm ±2dB) for LTE 800, LTE FDD Bd20 Class 3 (+23dBm ±2dB) for LTE 900, LTE FDD Bd8 Class 3 (+23dBm ±2dB) for LTE 1800, LTE FDD Bd3 Class 3 (+23dBm ±2dB) for LTE 2100, LTE FDD Bd1
Power supply	3.0V to 4.5V
Operating temperature (board temperature)	Normal operation: -30°C to +85°C Extended operation: -40°C to +90°C
Physical	Dimensions: 27.6mm x 25.4mm x 2.2mm Weight: approx. 3.5g
RoHS	All hardware components fully compliant with EU RoHS Directive
<i>LTE features</i>	
3GPP Release 9	UE CAT 1 supported DL 10.2Mbps, UL 5.2Mbps

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 Key Features at a Glance

Feature	Implementation
<i>GSM/GPRS/EGPRS features</i>	
Data transfer	<p>GPRS:</p> <ul style="list-style-type: none"> • Multislot Class 12 • Full PBCCH support • Mobile Station Class B • Coding Scheme 1 – 4 <p>EGPRS:</p> <ul style="list-style-type: none"> • Multislot Class 12 • EDGE E2 power class for 8 PSK • Downlink coding schemes – CS 1-4, MCS 1-9 • Uplink coding schemes – CS 1-4, MCS 1-9 • SRB loopback and test mode B • 8-bit, 11-bit RACH • PBCCH support • 1 phase/2 phase access procedures • Link adaptation and IR • NACC, extended UL TBF • Mobile Station Class B
SMS	<p>Point-to-point MT and MO</p> <p>Cell broadcast</p> <p>Text and PDU mode</p> <p>Storage: SIM card plus SMS locations in mobile equipment</p>
<i>Software</i>	
AT commands	<p>Hayes 3GPP TS 27.007, TS 27.005, Gemalto M2M</p> <p>AT commands for RIL compatibility</p>
Java™ Open Platform	<p>Java™ Open Platform with</p> <ul style="list-style-type: none"> • Java™ profile IMP-NG & CLDC 1.1 HI • Secure data transmission via HTTPS/SSL • Multi-threading programming and multi-application execution <p>Major benefits: seamless integration into Java applications, ease of programming, no need for application microcontroller, extremely cost-efficient hardware and software design – ideal platform for industrial 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>
Microsoft™ compatibility	RIL for Pocket PC and Smartphone
SIM Application Toolkit	SAT letter classes b, c, e; with BIP
Firmware update	Generic update from host application over ASC0 or USB modem.

1.1 Key Features at a Glance

Feature	Implementation
<i>Interfaces</i>	
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 [3]. This application note comprises chapters on module mounting and application layout issues as well as on additional SMT application development equipment.
USB	USB 2.0 High Speed (480Mbit/s) device interface, Full Speed (12Mbit/s) compliant
2 serial interfaces	ASC0 (shared with GPIO lines): <ul style="list-style-type: none"> 8-wire modem interface with status and control lines, unbalanced, asynchronous Adjustable baud rates: 1,200bps to 921,600bps Autobauding: 1,200bps to 230,400bps Supports RTS0/CTS0 hardware flow control. ASC1 (shared with GPIO lines): <ul style="list-style-type: none"> 4-wire, unbalanced asynchronous interface Adjustable baud rates: 1,200bps to 921,600bps Autobauding: 1,200bps to 230,400bps Supports RTS1/CTS1 hardware flow control
UICC interface	Supported SIM/USIM cards: 3V, 1.8V
GPIO interface	22 GPIO lines comprising: 13 lines shared with ASC0, ASC1 and SPI lines, with network status indication, PWM functionality, fast shutdown and pulse counter 9 GPIO lines not shared
I ² C interface	Supports I ² C serial interface
SPI interface	Serial peripheral interface, shared with GPIO lines
Antenna interface pads	50Ω. GSM/LTE main antenna, LTE Rx Diversity antenna
<i>Power on/off, Reset</i>	
Power on/off	Switch-on by hardware signal ON Switch-off by AT command Switch off by hardware signal FST_SHDN instead of AT command Automatic switch-off in case of critical temperature or voltage conditions
Reset	Orderly shutdown and reset by AT command Emergency reset by hardware signal EMERG_RST
<i>Special features</i>	
Real time clock	Timer functions via AT commands
Phonebook	SIM and phone
<i>Evaluation kit</i>	
Evaluation module	ELS61-E 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 ELS61-E evaluation module to the DSB75.

1.2 ELS61-E System Overview

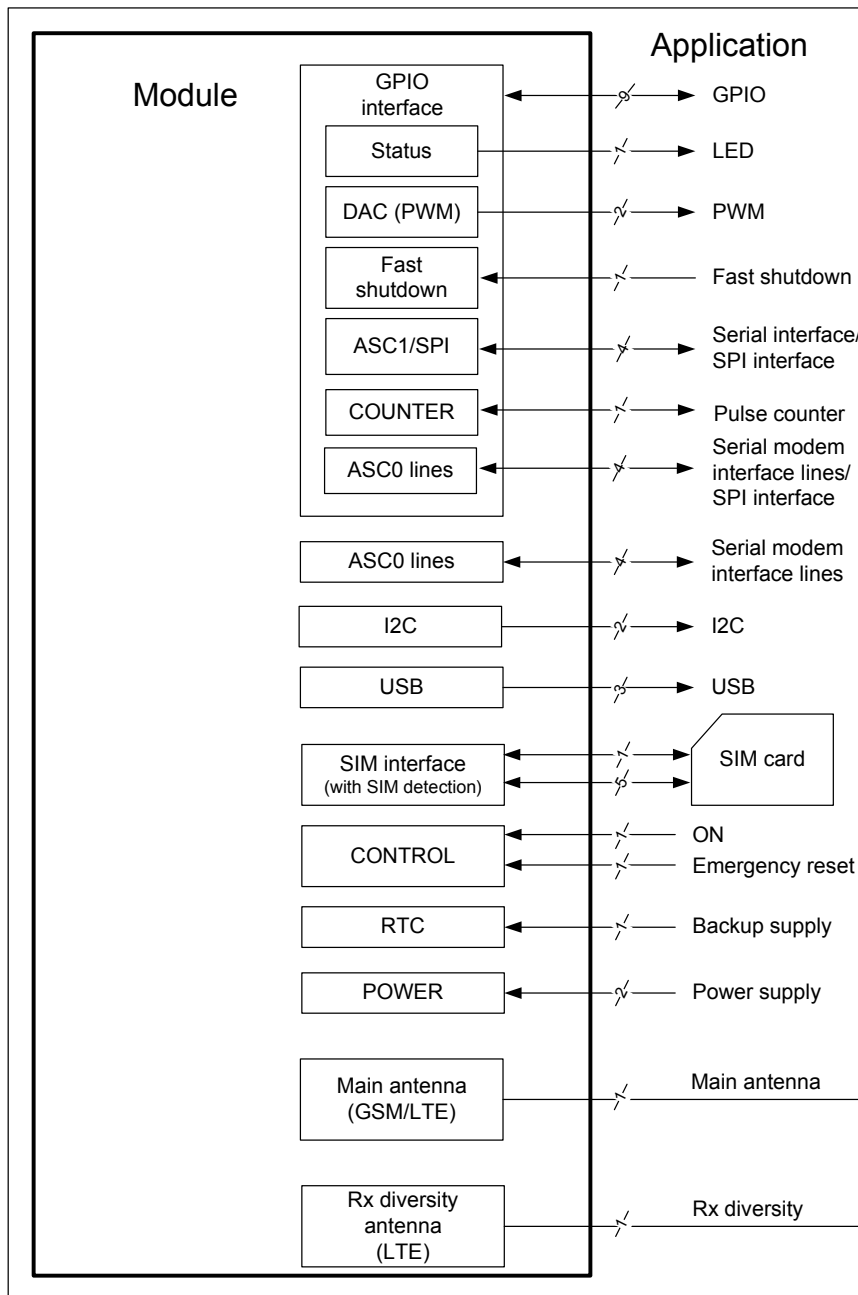


Figure 1: ELS61-E system overview

1.3 Circuit Concept

1.3 Circuit Concept

Figure 2 and Figure 3 show block diagrams of the ELS61-E module and illustrate the major functional components:

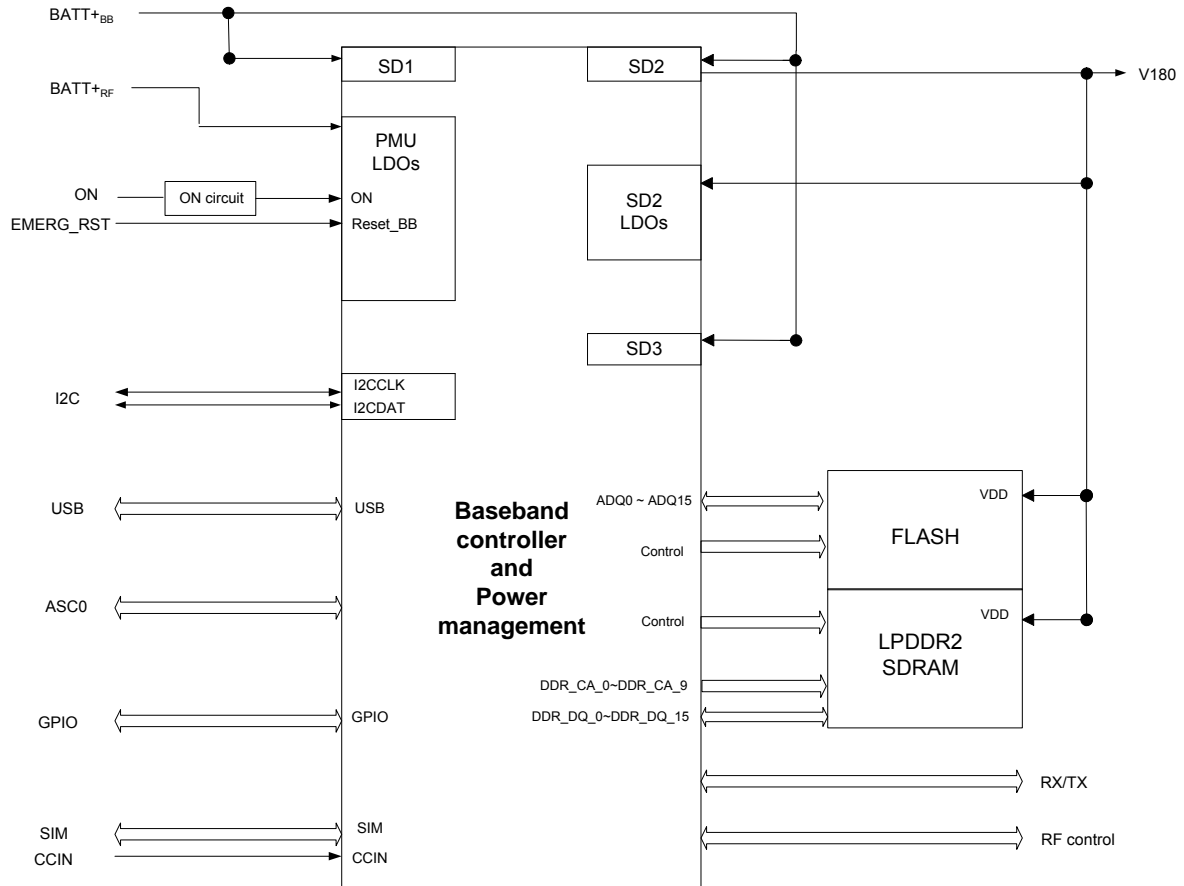


Figure 2: ELS61-E block diagram

1.3 Circuit Concept

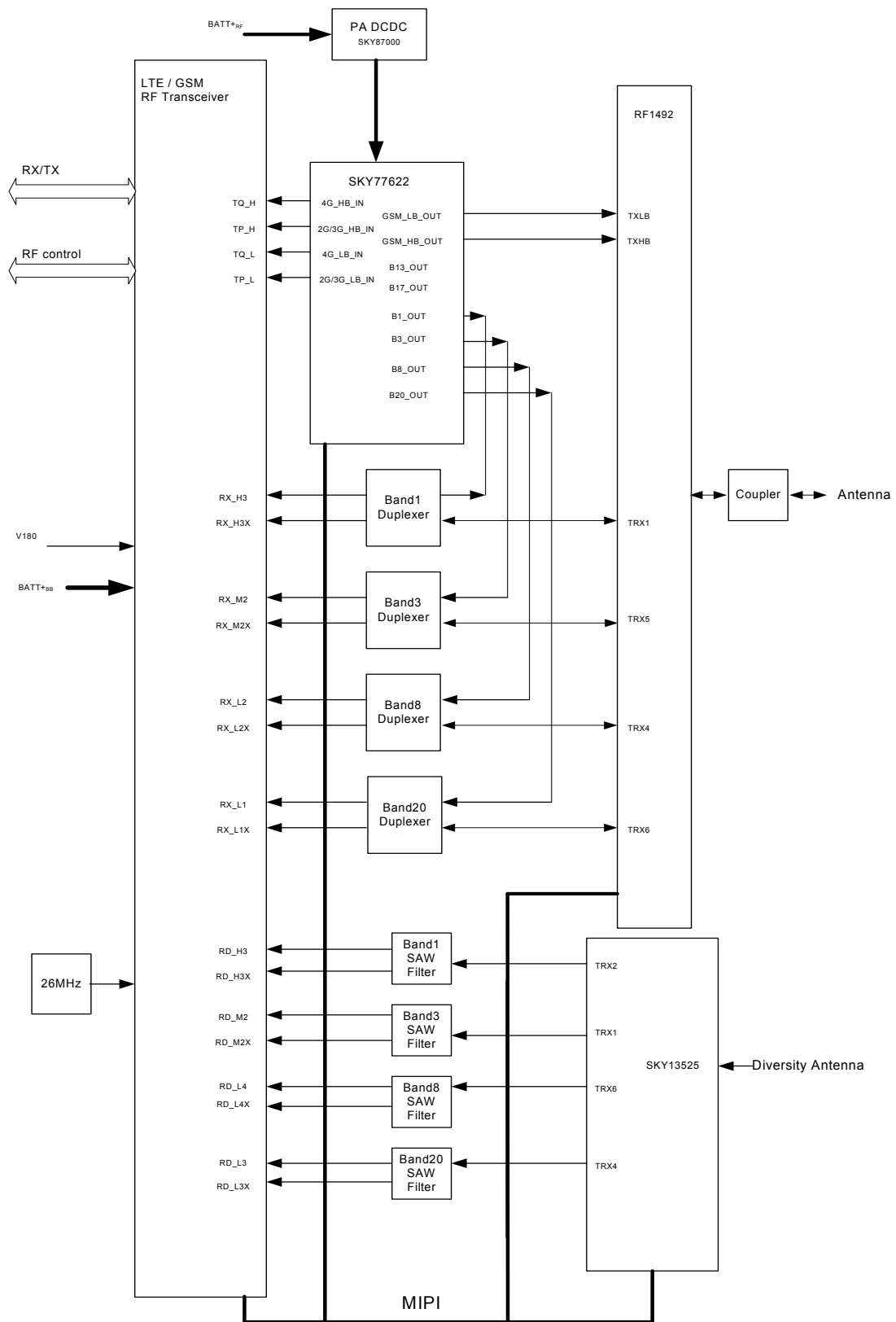


Figure 3: ELS61-E RF section block diagram

2 Interface Characteristics

ELS61-E 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 interface.

2.1 Application Interface

2.1.1 Pad Assignment

The SMT application interface on the ELS61-E provides connecting pads to integrate the module into external applications. Figure 4 shows the connecting pads' numbering plan, the following Table 1 lists the pads' assignments.

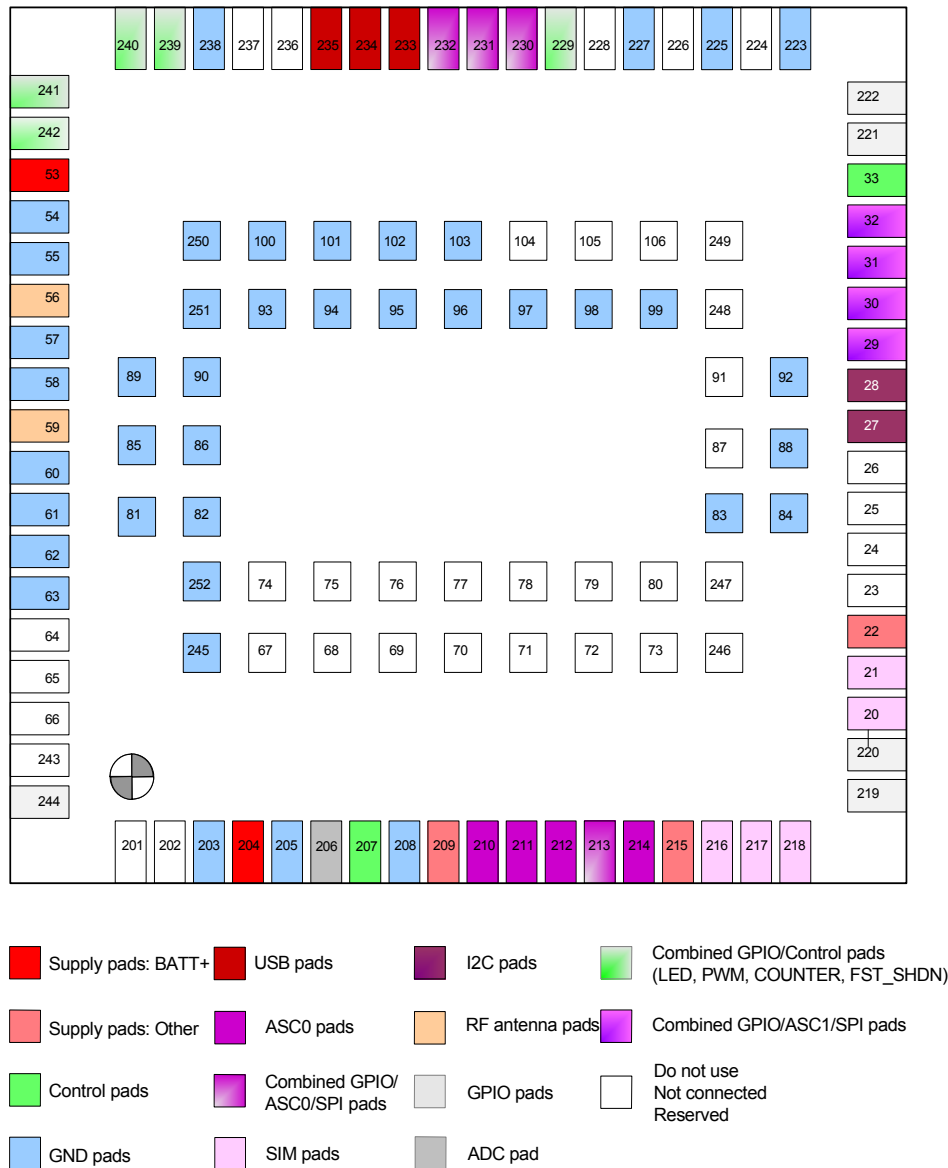


Figure 4: Numbering plan for connecting pads (bottom view)

2.1 Application Interface

Table 1: Pad assignments

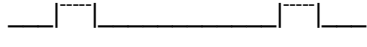
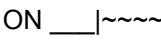
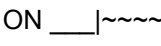
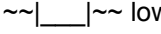
Pad no.	Signal name	Pad no.	Signal name	Pad no.	Signal name
201	Not connected	24	GPIO22	235	USB_DN
202	Not connected	25	GPIO21	236	Not connected
203	GND	26	GPIO23	237	Not connected
204	BATT ⁺ _{BB}	27	I2CDAT	238	GND
205	GND	28	I2CCLK	239	GPIO5/LED
206	ADC1	29	GPIO17/TXD1/MISO	240	GPIO6/PWM2
207	ON	30	GPIO16/RXD1/MOSI	241	GPIO7/PWM1
208	GND	31	GPIO18/RTS1	242	GPIO8/COUNTER
209	V180	32	GPIO19/CTS1/SPI_CS	53	BATT ⁺ _{RF}
210	RXD0	33	EMERG_RST	54	GND
211	CTS0	221	GPIO12	55	GND
212	TXD0	222	GPIO11	56	ANT_DRX
213	GPIO24/RING0	223	GND	57	GND
214	RTS0	224	Not connected	58	GND
215	VDDL	225	GND	59	ANT_MAIN
216	CCRST	226	Not connected	60	GND
217	CCIN	227	GND	61	GND
218	CCIO	228	Not connected	62	GND
219	GPIO14	229	GPIO4/FST_SHDN	63	GND
220	GPIO13	230	GPIO3/DSR0/SPI_CLK	64	Not connected
20	CCVCC	231	GPIO2/DCD0	65	Not connected
21	CCCLK	232	GPIO1/DTR0	66	Not connected
22	VCORE	233	VUSB	243	Not connected
23	GPIO20	234	USB_DP	244	GPIO15
Centrally located pads					
67	Not connected	83	GND	99	GND
68	Not connected	84	GND	100	GND
69	Not connected	85	GND	101	GND
70	Not connected	86	GND	102	GND
71	Not connected	87	Not connected	103	GND
72	Not connected	88	GND	104	Not connected
73	Not connected	89	GND	105	Not connected
74	Do not use	90	GND	106	Not connected
75	Do not use	91	Not connected	245	GND
76	Not connected	92	GND	246	Not connected
77	Not connected	93	GND	247	Not connected
78	Not connected	94	GND	248	Not connected
79	Not connected	95	GND	249	Not connected
80	Not connected	96	GND	250	GND
81	GND	97	GND	251	GND
82	GND	98	GND	252	GND

Signal pads that are not used should not be connected to an external application.

Please note that the reference voltages listed in [Table 2](#) are the values measured directly on the ELS61-E module. They do not apply to the accessories connected.

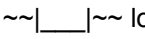
2.1.2 Signal Properties

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
Power supply	BATT+ _{BB} BATT+ _{RF}	I	<p><u>GSM activated:</u> $V_{I\max} = 4.5V$ $V_{I\text{norm}} = 3.8V$ $V_{I\min} = 3.3V$ during Tx burst on board</p> <p>$I \approx 2.3A$, during Tx burst (GSM)</p>  <p>$n \text{ Tx} = n \times 577\mu\text{s}$ peak current every 4.616ms</p> <p><u>LTE activated:</u> $V_{I\max} = 4.5V$ $V_{I\text{norm}} = 4.0V$ $V_{I\min} = 3.0V$ during Transmit active.</p>	<p>Lines of BATT+ and GND must be connected in parallel for supply purposes because higher peak currents may occur.</p> <p>Minimum voltage must not fall below 3.0V including drop, ripple, spikes and not rise above 4.5V.</p> <p>BATT+_{BB} and BATT+_{RF} require an ultra low ESR capacitor: BATT+_{BB} --> 150µF BATT+_{RF} --> 50µF If using Multilayer Ceramic Chip Capacitors (MLCC) please take DC-bias into account.</p>
Power supply	GND		Ground	Application Ground
External supply voltage	V180	O	<p>Normal operation: $V_{O\text{norm}} = 1.80V \pm 3\%$ $I_{O\max} = -10mA$</p> <p>SLEEP mode Operation: $V_{O\text{Sleep}} = 1.80V \pm 5\%$ $I_{O\max} = -10mA$</p> <p>$CL_{\max} = 2\mu F$</p>	<p>V180 should be used to supply level shifters at the interfaces or to supply external application circuits.</p> <p>VCORE and V180 may be used for the power indication circuit.</p>
	VCORE	O	<p>$V_{O\text{norm}} = 1.2V$ $I_{O\max} = -10mA$ $CL_{\max} = 100nF$</p> <p>SLEEP mode Operation: $V_{O\text{Sleep}} = 0.90V \dots 1.2V \pm 4\%$ $I_{O\max} = -10mA$</p>	<p>V180 is sensitive to back powering. While not used $V_{I\max}$ must be <0.2V.</p> <p>If unused keep lines open.</p>
Ignition	ON	I	<p>$V_{IH\max} = 5V$ tolerant $V_{IH\min} = 1.3V$ $V_{IL\max} = 0.5V$ Slew rate $\leq 1ms$</p>  <p>ON </p>	This signal switches the module on, and is rising edge sensitive triggered.
Emergency restart	EMERG_RST	I	<p>$R_I \approx 1k\Omega$, $C_I \approx 1nF$ $V_{OH\max} = VDDLP \text{ max}$ $V_{IH\min} = 1.35V$ $V_{IL\max} = 0.3V$ at $\sim 200\mu A$</p>  <p>$\sim \sim \underline{\quad} \sim \sim$ low impulse width > 10ms</p>	<p>This line must be driven low by an open drain or open collector driver connected to GND.</p> <p>If unused keep line open.</p>

2.1 Application Interface

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
Fast shutdown	FST_SHDN	I	$V_{ILmax} = 0.35V$ $V_{IHmin} = 1.30V$ $V_{IHmax} = 1.85V$  low impulse width > 10ms	<p>This line must be driven low. If unused keep line open.</p> <p>Note that the fast shutdown line is originally available as GPIO line. If configured as fast shutdown, the GPIO line is assigned as follows: GPIO4 --> FST_SHDN</p>
RTC backup	VDDL	I/O	$V_{Onorm} = 1.8V$ $I_{Omax} = -25mA$ $V_{Imax} = 1.9V$ $V_{Imin} = 1.0V$ $I_{ityp} < 1\mu A$	<p>It is recommended to use a serial resistor between VDDL and a possible capacitor.</p> <p>If unused keep line open.</p>
USB	VUSB_IN	I	$V_{Imin} = 3V$ $V_{Imax} = 5.25V$ Active and suspend current: $I_{max} < 100\mu A$	<p>All electrical characteristics according to USB Implementers' Forum, USB 2.0 Specification.</p> <p>If unused keep lines open.</p>
	USB_DN	I/O	Full and high speed signal characteristics according USB 2.0 Specification.	
	USB_DP			
Serial Interface ASC0	RXD0	O	$V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.55V$ at $I = -1mA$ $V_{OHmax} = 1.85V$	<p>If unused keep lines open.</p> <p>Note that some ASC0 lines are originally available as GPIO lines. If configured as ASC0 lines, the GPIO lines are assigned as follows: GPIO1 --> DTR0 GPIO2 --> DCD0 GPIO3 --> DSR0 GPIO24 --> RING0</p> <p>The DSR0 line is also shared with the SPI interface's SPI_CLK signal.</p>
	CTS0	O		
	DSR0	O		
	DCD0	O		
	RING0	O		
	TXD0	I	$V_{ILmax} = 0.35V$ $V_{IHmin} = 1.30V$ $V_{IHmax} = 1.85V$	
	RTS0	I	Pull down resistor active $V_{ILmax} = 0.35V$ at $> 50\mu A$ $V_{IHmin} = 1.30V$ at $< 240\mu A$ $V_{IHmax} = 1.85V$ at $< 240\mu A$	
DTR0	I	Pull up resistor active $V_{ILmax} = 0.35V$ at $< -200\mu A$ $V_{IHmin} = 1.30V$ at $> -50\mu A$ $V_{IHmax} = 1.85V$		

2.1 Application Interface

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
Serial Interface ASC1	RXD1	O	$V_{OL\max} = 0.25V$ at $I = 1mA$ $V_{OH\min} = 1.55V$ at $I = -1mA$	If unused keep line open. Note that 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 GPIO19 --> CTS1
	TXD1	I	$V_{OH\max} = 1.85V$	
	RTS1	I	$V_{IL\max} = 0.35V$	
	CTS1	O	$V_{IH\min} = 1.30V$ $V_{IH\max} = 1.85V$	
SIM card detection	CCIN	I	$R_I \approx 110k\Omega$ $V_{IH\min} = 1.45V$ at $I = 15\mu A$, $V_{IH\max} = 1.9V$ $V_{IL\max} = 0.3V$	CCIN = High, SIM card inserted. For details please refer to Section 2.1.6 . If unused keep line open.
3V SIM Card Interface	CCRST	O	$V_{OL\max} = 0.30V$ at $I = 1mA$ $V_{OH\min} = 2.45V$ at $I = -1mA$ $V_{OH\max} = 2.90V$	Maximum cable length or copper track to SIM card holder should not exceed 100mm.
	CCIO	I/O	$V_{IL\max} = 0.50V$ $V_{IH\min} = 2.05V$ $V_{IH\max} = 2.90V$ $V_{OL\max} = 0.25V$ at $I = 1mA$ $V_{OH\min} = 2.50V$ at $I = -1mA$ $V_{OH\max} = 2.90V$	
	CCCLK	O	$V_{OL\max} = 0.25V$ at $I = 1mA$ $V_{OH\min} = 2.40V$ at $I = -1mA$ $V_{OH\max} = 2.90V$	
	CCVCC	O	$V_{O\min} = 2.80V$ $V_{O\text{typ}} = 2.85V$ $V_{O\max} = 2.90V$ $I_{O\max} = -30mA$	

2.1 Application Interface

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
1.8V SIM Card Interface	CCRST	O	$V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.45V$ at $I = -1mA$ $V_{OHmax} = 1.90V$	Maximum cable length or copper track to SIM card holder should not exceed 100mm.
	CCIO	I/O	$V_{ILmax} = 0.35V$ $V_{IHmin} = 1.25V$ $V_{IHmax} = 1.85V$ $V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.50V$ at $I = -1mA$ $V_{OHmax} = 1.85V$	
	CCCLK	O	$V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.50V$ at $I = -1mA$ $V_{OHmax} = 1.85V$	
	CCVCC	O	$V_{Omin} = 1.75V$ $V_{Otyp} = 1.80V$ $V_{Omax} = 1.85V$ $I_{Omax} = -30mA$	
I ² C	I2CCLK	IO	Open drain IO $V_{OLmin} = 0.35V$ at $I = -3mA$ $V_{OHmax} = 1.85V$ $R_{external\ pull\ up\ min} = 560\Omega$ $V_{ILmax} = 0.35V$ $V_{IHmin} = 1.3V$ $V_{IHmax} = 1.85V$	According to the I ² 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. The value of the pull-up depends on the capacitive load of the whole system (I ² C Slave + lines). The maximum sink current of I2CDAT and I2CCLK is 4mA. If lines are unused keep lines open.
	I2CDAT	IO		
SPI	SPI_CLK	O	$V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.55V$ at $I = -1mA$ $V_{OHmax} = 1.85V$	If lines are unused keep lines open. Note that the SPI interface lines are originally available as GPIO lines. If configured as SPI lines, the GPIO lines are assigned as follows: GPIO3 --> SPI_CLK GPIO16 --> MOSI GPIO17 --> MISO GPIO19 --> SPI_CS
	MOSI	O		
	MISO	I		
	SPI_CS	O	$V_{ILmax} = 0.35V$ $V_{IHmin} = 1.30V$ $V_{IHmax} = 1.85V$	

2.1 Application Interface

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
GPIO interface	GPIO1-GPIO3	IO	$V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.55V$ at $I = -1mA$ $V_{OHmax} = 1.85V$ $V_{ILmax} = 0.35V$ $V_{IHmin} = 1.30V$ $V_{IHmax} = 1.85V$	If unused keep line open. Please note that most GPIO lines can be configured by AT command for alternative functions: GPIO1-GPIO3: ASC0 control lines DTR0, DCD0 and DSR0 GPIO4: Fast shutdown GPIO5: Status LED line GPIO6/GPIO7: PWM GPIO8: Pulse Counter GPIO16-GPIO19: ASC1 or SPI GPIO24: ASC0 control line RING0
	GPIO4	IO		
	GPIO5	IO		
	GPIO6	IO		
	GPIO7	IO		
	GPIO8	IO		
	GPIO11-GPIO15	IO		
	GPIO16-GPIO19	IO		
	GPIO20-GPIO23	IO		
GPIO24	IO			
Status LED	LED	O	$V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.55V$ at $I = -1mA$ $V_{OHmax} = 1.85V$	If unused keep line open. Note that the LED line is originally available as GPIO line. If configured as LED line, the GPIO line is assigned as follows: GPIO5 --> LED
PWM	PWM1	O	$V_{OLmax} = 0.25V$ at $I = 1mA$ $V_{OHmin} = 1.55V$ at $I = -1mA$ $V_{OHmax} = 1.85V$	If unused keep lines open. Note that the PWM lines are originally available as GPIO lines. If configured as PWM lines, the GPIO lines are assigned as follows: GPIO7 --> PWM1 GPIO6 --> PWM2
	PWM2	O		
Pulse counter	COUNTER	I	Internal up resistor active $V_{ILmax} = 0.35V$ at $< -200\mu A$ $V_{IHmin} = 1.30V$ at $> -50\mu A$ $V_{IHmax} = 1.85V$	If unused keep line open. Note that the COUNTER line is originally available as GPIO line. If configured as COUNTER line, the GPIO line is assigned as follows: GPIO8 --> COUNTER
ADC (Analog-to-Digital Converter)	ADC1	I	$R_I = 1M\Omega$ $V_I = 0V \dots 1.2V$ (valid range) $V_{IHmax} = 1.2V$ Resolution 1024 steps Tolerance 0.3%	ADC can be used as input for external measurements. If unused keep line open.

2.1.2.1 Absolute Maximum Ratings

The absolute maximum ratings stated in [Table 3](#) are stress ratings under any conditions. Stresses beyond any of these limits will cause permanent damage to ELS61-E.

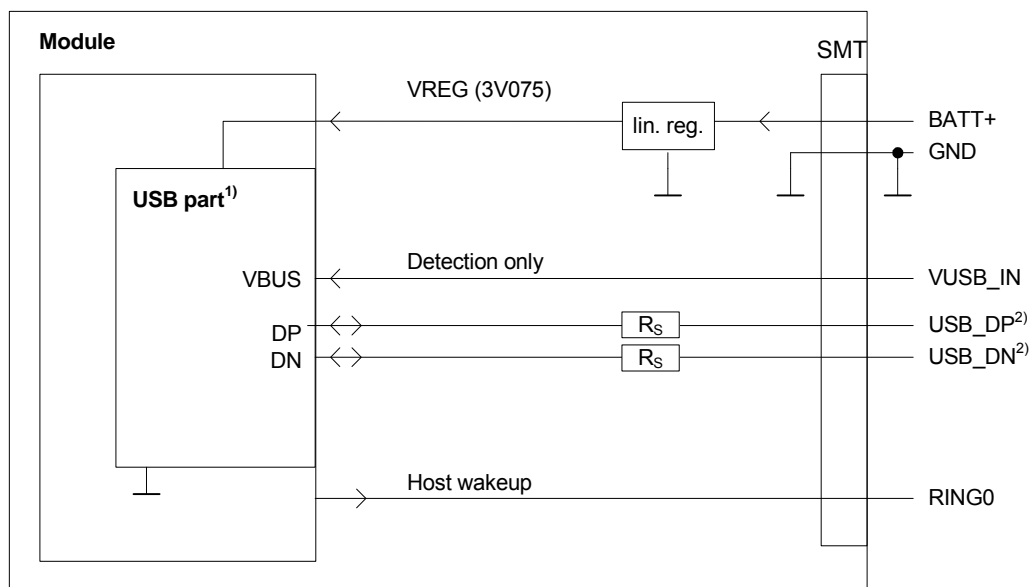
Table 3: Absolute maximum ratings

Parameter	Min	Max	Unit
Supply voltage BATT _{BB} , BATT _{RF}	-0.5	+5.5	V
Voltage at all digital lines in Power Down mode	-0.3	+0.3	V
Voltage at digital lines in normal operation	-0.2	V180 + 0.2	V
Voltage at SIM/USIM interface, CCVCC in normal operation	-0.5	+3.3	V
VDDL input voltage	-0.15	2.0	V
Voltage at ADC line in normal operation	0	1.2	V
Voltage at analog lines in Power Down mode	-0.3	+0.3	V
V180 in normal operation	+1.7	+1.9	V
Current at V180 in normal operation		-50	mA
VCORE in normal operation	+0.85	+1.25	V
Current at VCORE in normal operation		-50	mA

2.1.3 USB Interface

ELS61-E 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 external application is responsible for supplying the VUSB_IN line. This line is used for cable detection only. The USB part (driver and transceiver) is supplied by means of BATT+. This is because ELS61-E is designed as a self-powered device compliant with the “Universal Serial Bus Specification Revision 2.0”¹.



¹) All serial (including R_s) and pull-up resistors for data lines are implemented.

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 90 ohms for proper signal integrity.

Figure 5: 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. For more information on the USB related signals see [Table 2](#). Furthermore, the USB modem driver distributed with ELS61-E needs to be installed.

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

2.1.3.1 Reducing Power Consumption

While a USB connection is active, the module will never switch into SLEEP mode. Only if the USB interface is in Suspended state or Detached (i.e., VUSB_IN = 0) is the module able to switch into SLEEP mode thereby saving power. There are two possibilities to enable power reduction mechanisms:

- **Recommended implementation of USB Suspend/Resume/Remote Wakeup:**
The USB host should be able to bring its USB interface into the Suspended state as described in the “Universal Serial Bus Specification Revision 2.0”¹. For this functionality to work, the VUSB_IN line should always be kept enabled. On incoming calls and other events ELS61-E will then generate a Remote Wakeup request to resume the USB host controller.

See also [5] (USB Specification Revision 2.0, Section 10.2.7, p.282):

"If USB System wishes to place the bus in the Suspended state, it commands the Host Controller to stop all bus traffic, including SOFs. This causes all USB devices to enter the Suspended state. In this state, the USB System may enable the Host Controller to respond to bus wakeup events. This allows the Host Controller to respond to bus wakeup signaling to restart the host system."

- **Implementation for legacy USB applications not supporting USB Suspend/Resume:**
As an alternative to the regular USB suspend and resume mechanism it is possible to employ the RING0 line to wake up the host application in case of incoming calls or events signaled by URCs while the USB interface is in Detached state (i.e., VUSB_IN = 0). Every wakeup event will force a new USB enumeration. Therefore, the external application has to carefully consider the enumeration timings to avoid losing any signalled events. For details on this host wakeup functionality see Section 2.1.13.3. To prevent existing data call connections from being disconnected while the USB interface is in detached state (i.e., VUSB_IN=0) it is possible to call AT&D0, thus ignoring the status of the DTR line (see also [1]).

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

2.1.4 Serial Interface ASC0

ELS61-E 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). For electrical characteristics please refer to [Table 2](#). For an illustration of the interface line's startup behavior see [Figure 7](#).

ELS61-E 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

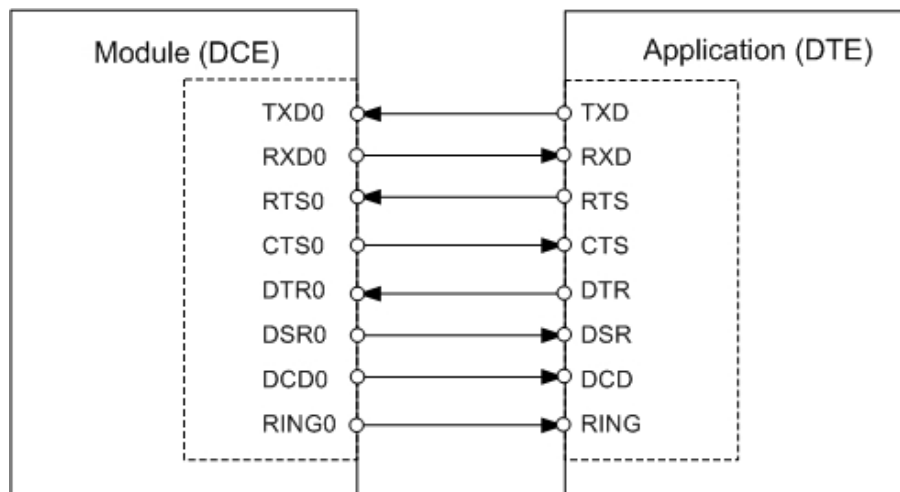


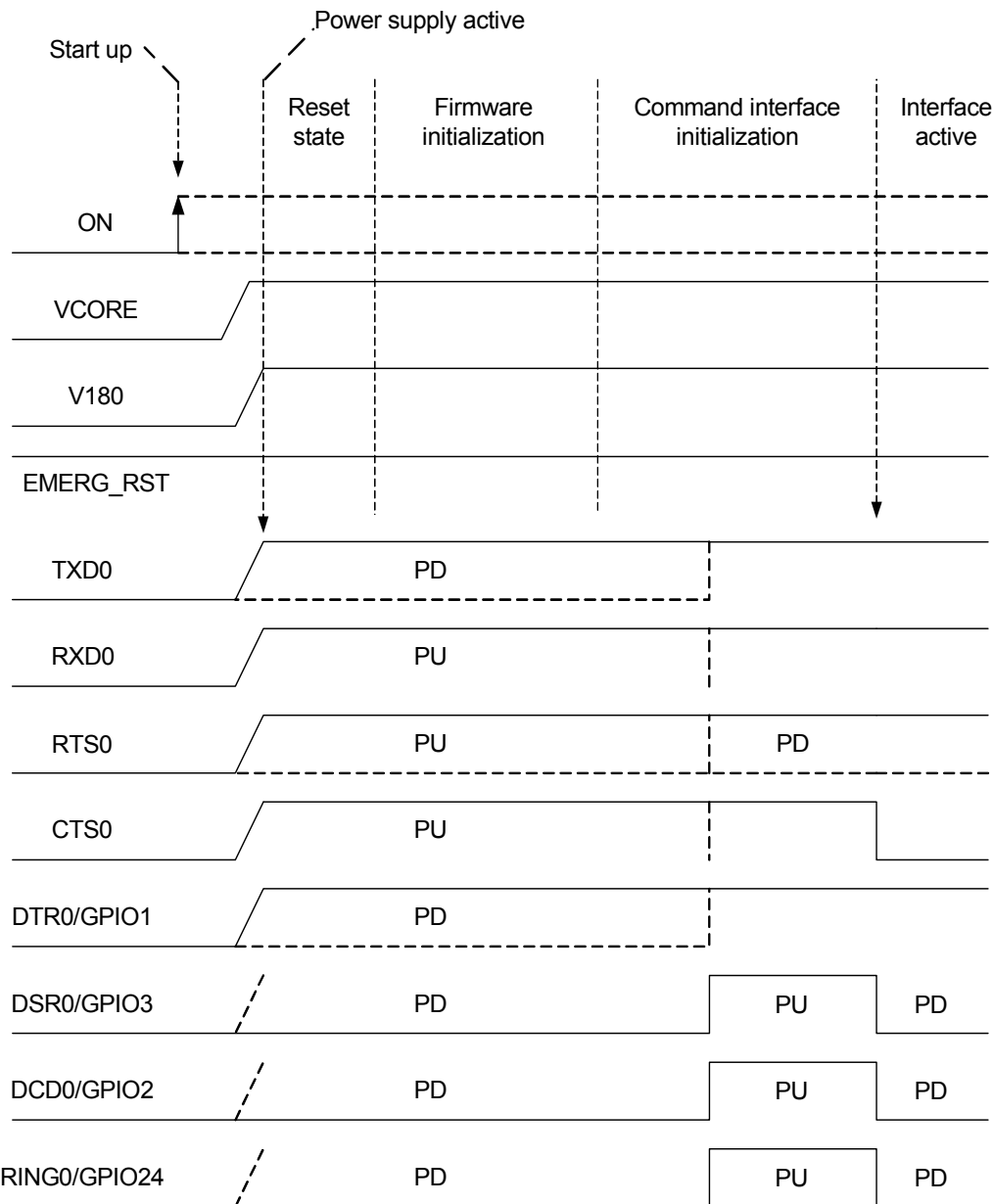
Figure 6: Serial interface ASC0

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.
- The RING0 signal serves to indicate incoming calls and other types of URCs (Unsolicited Result Code). It can also be used to send pulses to the host application, for example to wake up the application from power saving state.
- Configured for 8 data bits, no parity and 1 stop bit.
- ASC0 can be operated at fixed bit rates from 1,200bps up to 921,600bps.
- Autobauding supports bit rates from 1,200bps up to 230,400bps.
- Supports RTS0/CTS0 hardware flow control. The hardware hand shake line RTS0 has an internal pull down resistor causing a low level signal, if the line is not used and open. Although hardware flow control is recommended, this allows communication by using only RXD and TXD lines.
- Wake up from SLEEP mode by RTS0 activation (high to low transition; see [Section 3.4.3](#)).

Note: The ASC0 modem control lines DTR0, DCD0, DSR0 and RING0 are originally available as GPIO lines. If configured as ASC0 lines, these GPIO lines are assigned as follows: GPIO1 --> DTR0, GPIO2 --> DCD0, GPIO3 --> DSR0 and GPIO24 --> RING0. Also, DSR0 is shared with the SPI_CLK line of the SPI interface and may be configured as such. Configuration is done by AT command (see [\[1\]](#)). The configuration is non-volatile and becomes active after a module restart.

The following figure shows the startup behavior of the asynchronous serial interface ASC0.



For pull-up and pull-down values see [Table 10](#).

Figure 7: ASC0 startup behavior

Notes:

During startup the DTR0 signal is driven active low for 500µs. It is recommended to provide a 470Ω serial resistor for the DTR0 line to prevent shorts.

No data must be sent over the ASC0 interface before the interface is active and ready to receive data (see [Section 3.2.1](#)).

An external pull down to ground on the DCD0 line during the startup phase activates a special mode for ELS61-E. In this special mode the AT command interface is not available and the module may therefore no longer behave as expected.

2.1.5 Serial Interface ASC1

Four ELS61-E GPIO lines can be configured as ASC1 interface signals to provide a 4-wire unbalanced, asynchronous modem interface ASC1 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). For electrical characteristics please refer to [Table 2](#). For an illustration of the interface line's startup behavior see [Figure 9](#).

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.

ELS61-E 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

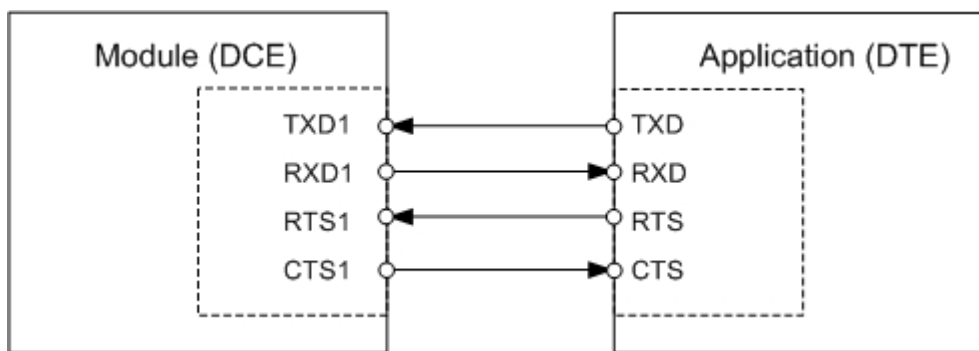
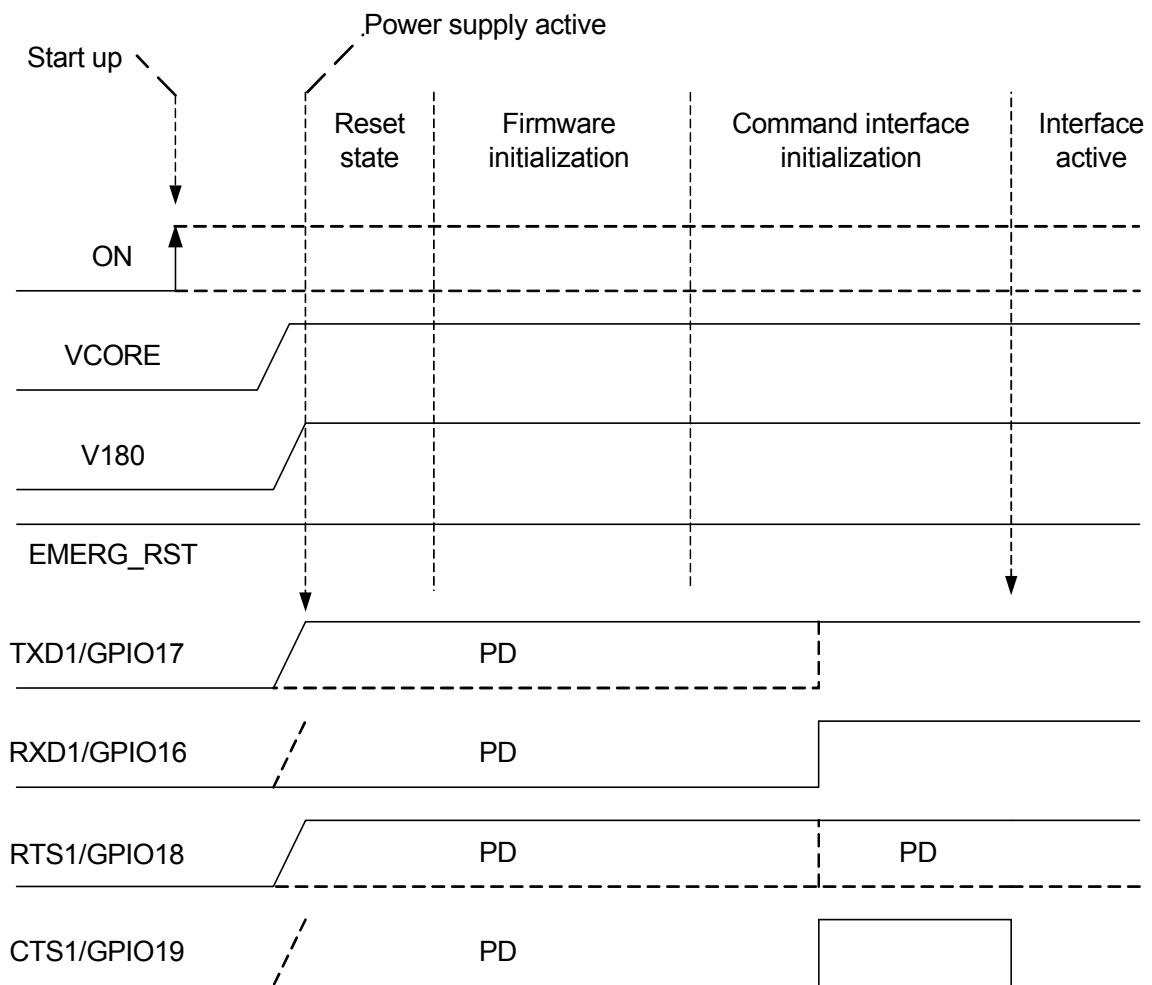


Figure 8: Serial interface ASC1

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 1,200 bps to 921,600 bps.
- Autobauding supports bit rates from 1,200bps up to 230,400bps.
- Supports RTS1/CTS1 hardware flow. The hardware hand shake line RTS0 has an internal pull down resistor causing a low level signal, if the line is not used and open. Although hardware flow control is recommended, this allows communication by using only RXD and TXD lines.

The following figure shows the startup behavior of the asynchronous serial interface ASC1.



*) For pull-down values see [Table 10](#).

Figure 9: ASC1 startup behavior

2.1.6 UICC/SIM/USIM Interface

ELS61-E 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. Please refer to [Table 2](#) for electrical specifications of the UICC/SIM/USIM interface lines depending on whether a 3V or 1.8V SIM card is used.

The CCIN signal serves to detect whether a tray (with SIM card) is present in the card holder. 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 ELS61-E and is part of the Gemalto M2M reference equipment submitted for type approval. See [Section 7.1](#) for Molex ordering numbers.

Table 4: 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 ELS61-E.

Note [1]: 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 ELS61-E.

Note [2]: On the evaluation board, the CCIN signal is inverted, thus the CCIN signal is by default high and will change to a low level if a SIM card is inserted.

The figure below shows a circuit to connect an external SIM card holder.

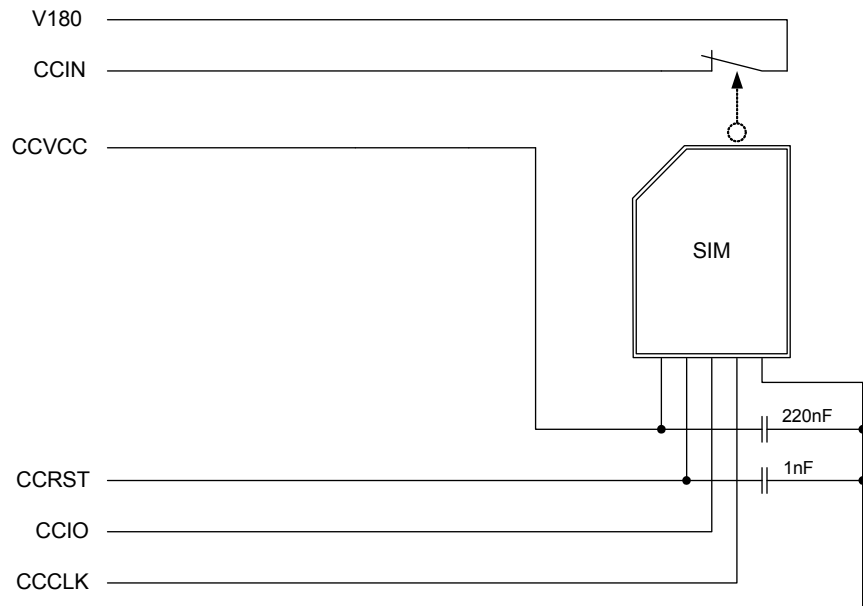


Figure 10: External UICC/SIM/USIM card holder circuit

The total cable length between the SMT application interface pads on ELS61-E 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.

An example for an optimized ESD protection for the SIM interface is shown in [Section 2.1.6.1](#).

2.1.6.1 Enhanced ESD Protection for SIM Interface

To optimize ESD protection for the SIM interface it is possible to add ESD diodes to the SIM interface lines as shown in the example given in [Figure 11](#).

The example was designed to meet ESD protection according ETSI EN 301 489-1/7: Contact discharge: ± 4kV, air discharge: ± 8kV.

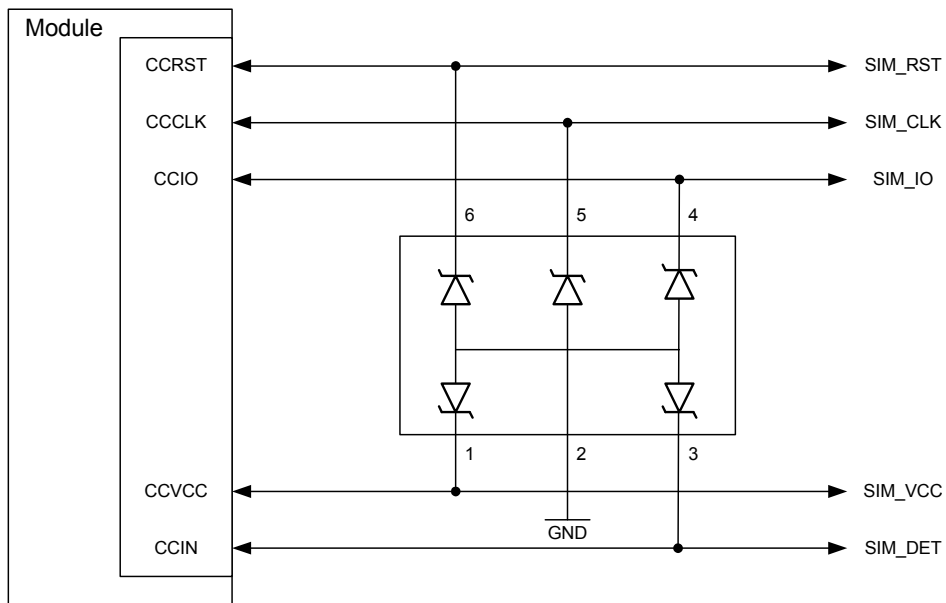


Figure 11: SIM interface - enhanced ESD protection

2.1.7 RTC Backup

The internal Real Time Clock of ELS61-E is supplied from a separate voltage regulator in the power supply component which is also active when ELS61-E is in Power Down mode and BATT+ is available. An alarm function is provided that allows to wake up ELS61-E without logging on to the GSM network.

In addition, you can use the VDDL P pad to backup the RTC from an external capacitor. The capacitor is charged from the internal LDO of ELS61-E. If the voltage supply at BATT+ is disconnected the RTC can be powered by the capacitor. The size of the capacitor determines the duration of buffering when no voltage is applied to ELS61-E, i.e. the greater the capacitor the longer ELS61-E will save the date and time. The RTC can also be supplied from an external battery (rechargeable or non-chargeable). In this case the electrical specification of the VDDL P pad (see [Section 2.1.2](#)) has to be taken in to account.

[Figure 12](#) shows an RTC backup configuration. A serial 1kΩ resistor has to be placed on the application next to VDDL P. It limits the input current of an empty capacitor or battery.

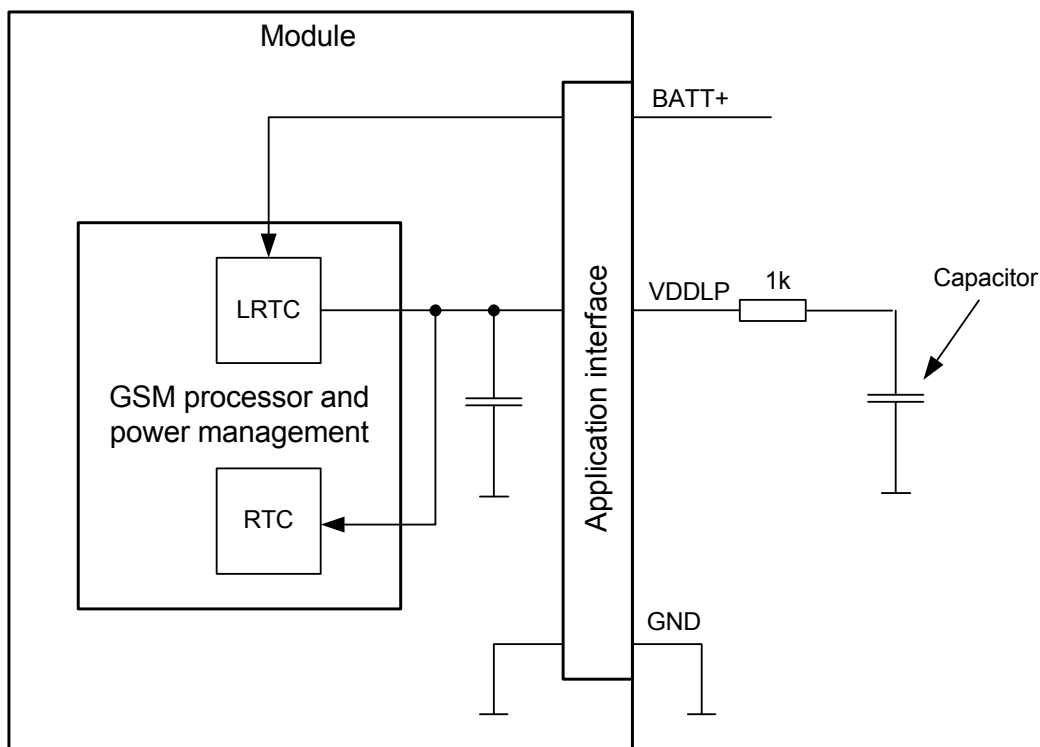


Figure 12: RTC supply variants

2.1.8 GPIO Interface

ELS61-E offers a GPIO interface with 22 GPIO lines. The GPIO lines are shared with other interfaces or functions: Fast shutdown (see [Section 2.1.13.4](#)), status LED (see [Section 2.1.13.1](#)), the PWM functionality (see [Section 2.1.11](#)), an pulse counter (see [Section 2.1.12](#)), ASC0 (see [Section 2.1.4](#)), ASC1 (see [Section 2.1.5](#)), an SPI interface (see [Section 2.1.10](#)).

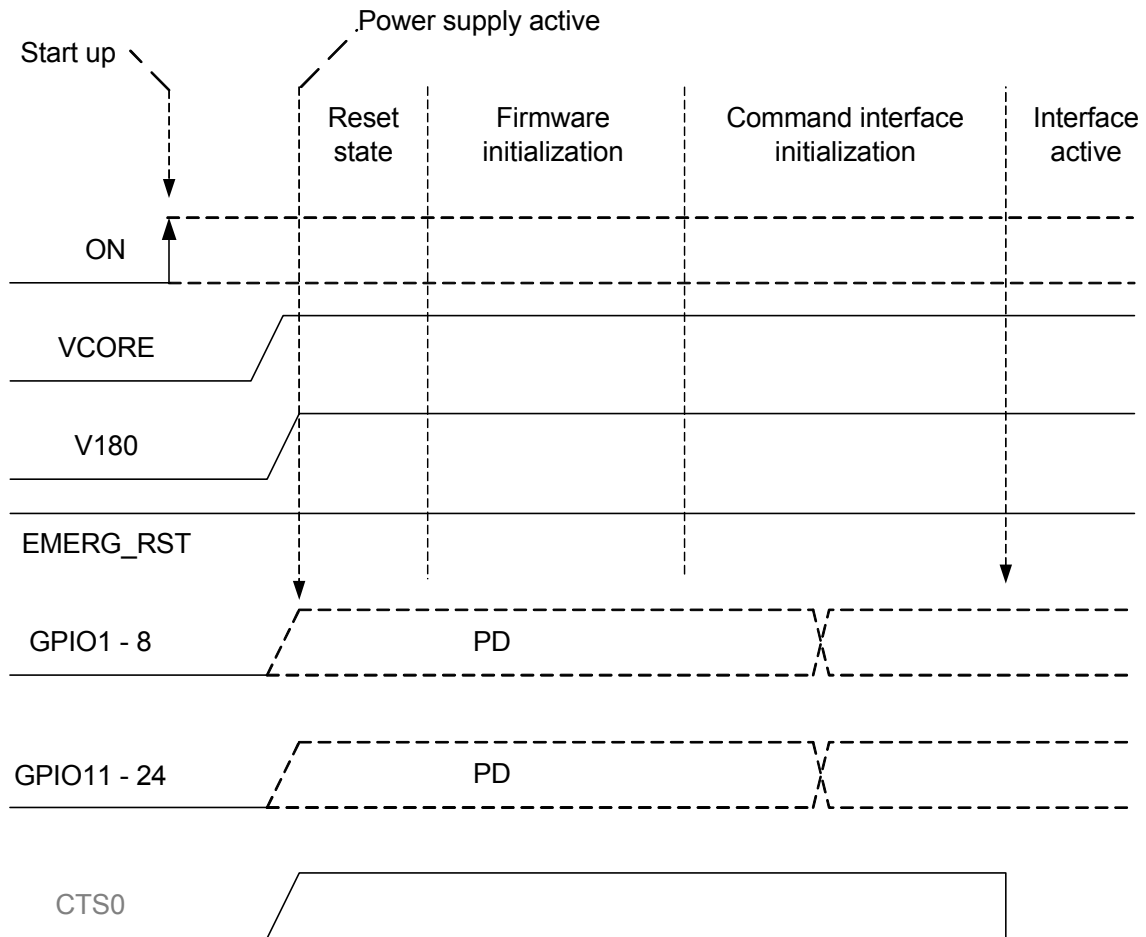
The following table shows the configuration variants for the GPIO pads. All variants are mutually exclusive, i.e. a pad configured for instance as Status LED is locked for alternative usage.

Table 5: GPIO lines and possible alternative assignment

GPIO	Fast Shutdown	Status LED	PWM	Pulse Counter	ASC0	ASC1	SPI
GPIO1					DTR0		
GPIO2					DCD0		
GPIO3					DSR0		SPI_CLK
GPIO4	FST_SHDN						
GPIO5		Status LED					
GPIO6			PWM2				
GPIO7			PWM1				
GPIO8				COUNTER			
GPIO11							
GPIO12							
GPIO13							
GPIO14							
GPIO15							
GPIO16						RXD1	MOSI
GPIO17						TXD1	MISO
GPIO18						RTS1	
GPIO19						CTS1	SPI_CS
GPIO20							
GPIO21							
GPIO22							
GPIO23							
GPIO24					RING0		

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.

The following figure shows the startup behavior of the GPIO interface. With an active state of the ASC0 interface (i.e. CTS0 is at low level) the initialization of the GPIO interface lines is also finished.



*) For pull down values see [Table 10](#).

Figure 13: GPIO startup behavior

2.1.9 I²C Interface

I²C 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 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.

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].

The I²C interface can be powered via the V180 line of ELS61-E. If connected to the V180 line, the I²C interface will properly shut down when the module enters the Power Down mode.

In the 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 2.

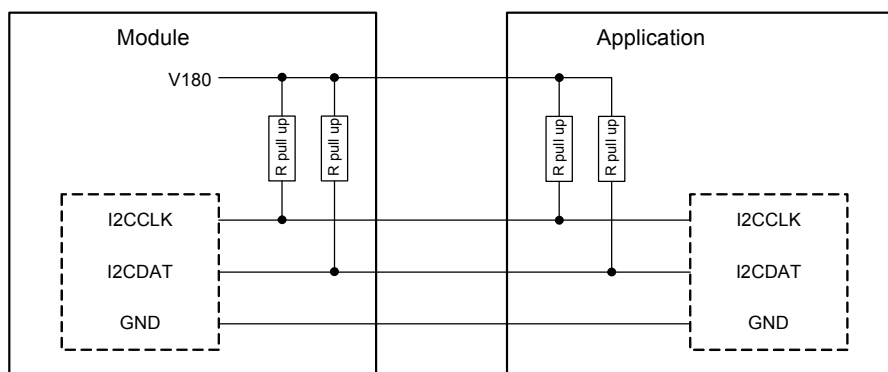


Figure 14: I²C interface connected to V180

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.

The following figure shows the startup behavior of the I²C interface. With an active state of the ASC0 interface (i.e. CTS0 is at low level) the initialization of the I²C interface is also finished.

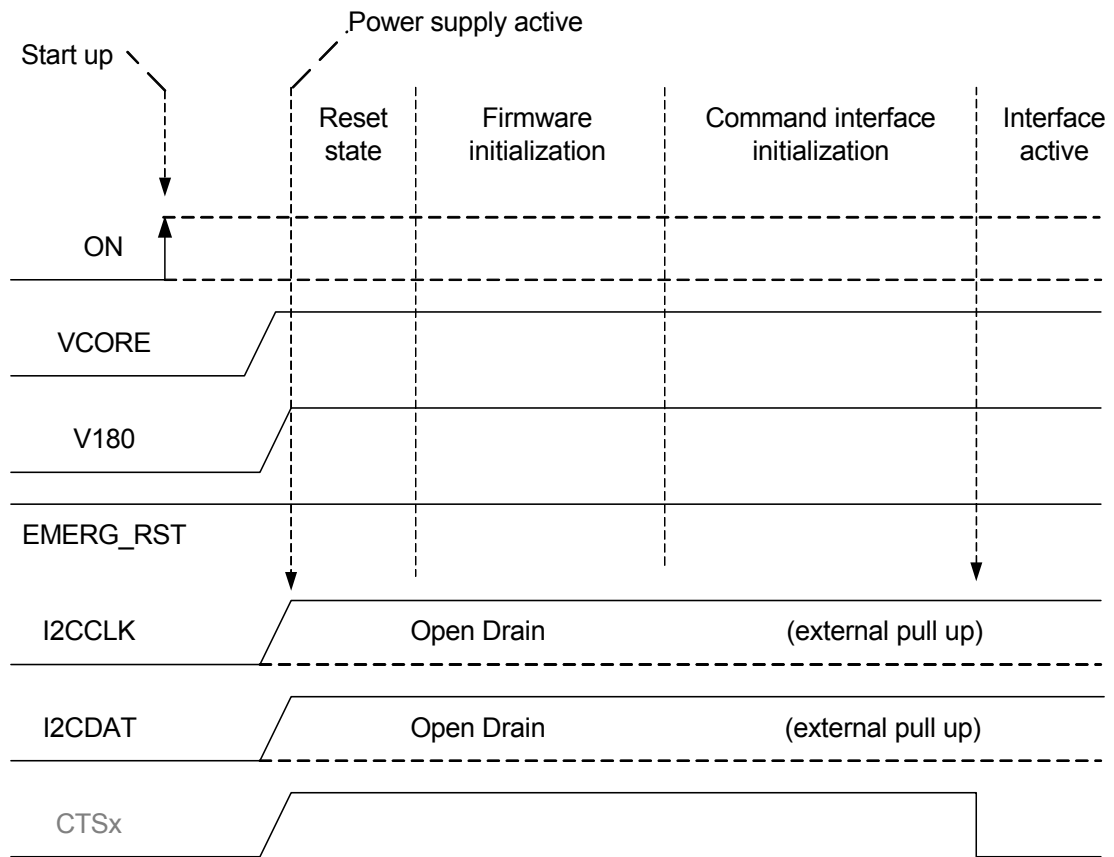


Figure 15: I²C startup behavior

2.1.10 SPI Interface

Four ELS61-E GPIO interface lines can be configured as Serial Peripheral Interface (SPI). The SPI is a synchronous serial interface for control and data transfer between ELS61-E 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 four GPIO lines can be configured as SPI interface signals as follows: GPIO3 --> SPI_CLK, GPIO16 --> MOSI, GPIO17 --> MISO and GPIO19 --> SPI_CS. The configuration is done by AT command (see [1]). It is non-volatile and becomes active after a module restart.

The GPIO lines are also shared with the ASC1 signal lines and the ASC0 modem status signal line DSR0.

To configure and activate the SPI interface use the AT^SSPI command. Detailed information on the AT^SSPI command as well explanations on the SPI modes required for data transmission can be found in [1].

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^SSPI. Make sure the module and the connected slave device works with the same SPI mode.

Figure 16 shows the characteristics of the four SPI modes. The SPI modes 0 and 3 are the most common used modes. For electrical characteristics please refer to Table 2.

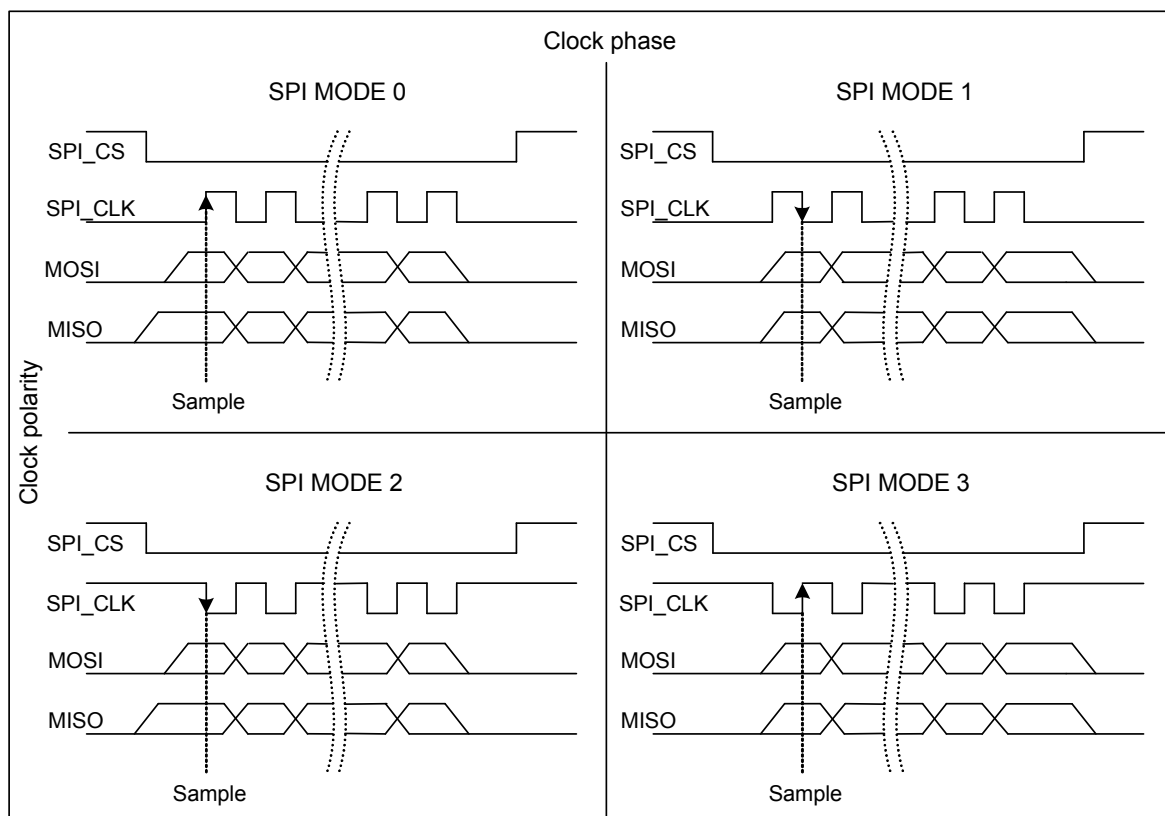


Figure 16: Characteristics of SPI modes

2.1.11 PWM Interfaces

The GPIO6 and GPIO7 interface lines can be configured as Pulse Width Modulation interface lines PWM1 and PWM2. The PWM interface lines can be used, for example, to connect buzzers. The PWM1 line is shared with GPIO7 and the PWM2 line is shared with GPIO6 (for GPIOs see [Section 2.1.8](#)). GPIO and PWM functionality are mutually exclusive.

The startup behavior of the lines is shown in [Figure 13](#).

2.1.12 Pulse Counter

The GPIO8 line can be configured as pulse counter line COUNTER. The pulse counter interface can be used, for example, as a clock (for GPIOs see [Section 2.1.8](#)).

2.1.13 Control Signals

2.1.13.1 Status LED

The GPIO5 interface line can be configured to drive a status LED that indicates different operating modes of the module (for GPIOs see [Section 2.1.8](#)). GPIO and LED functionality are mutually exclusive.

To take advantage of this function connect an LED to the GPIO5/LED line as shown in [Figure 17](#).

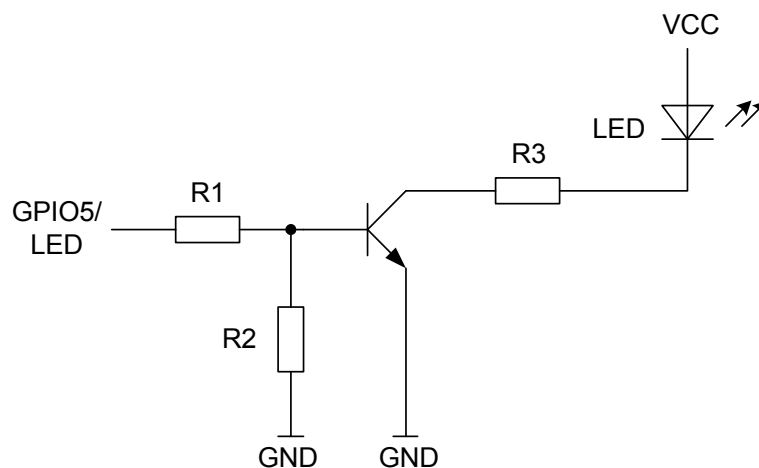


Figure 17: Status signaling with LED driver

2.1.13.2 Power Indication Circuit

In Power Down mode the maximum voltage at any digital or analog interface line must not exceed +0.3V (see also [Section 2.1.2.1](#)). Exceeding this limit for any length of time might cause permanent damage to the module.

It is therefore recommended to implement a power indication signal that reports the module's power state and shows whether it is active or in Power Down mode. While the module is in Power Down mode all signals with a high level from an external application need to be set to low state or high impedance state. The sample power indication circuit illustrated in [Figure 18](#) denotes the module's active state with a low signal and the module's Power Down mode with a high signal or high impedance state.

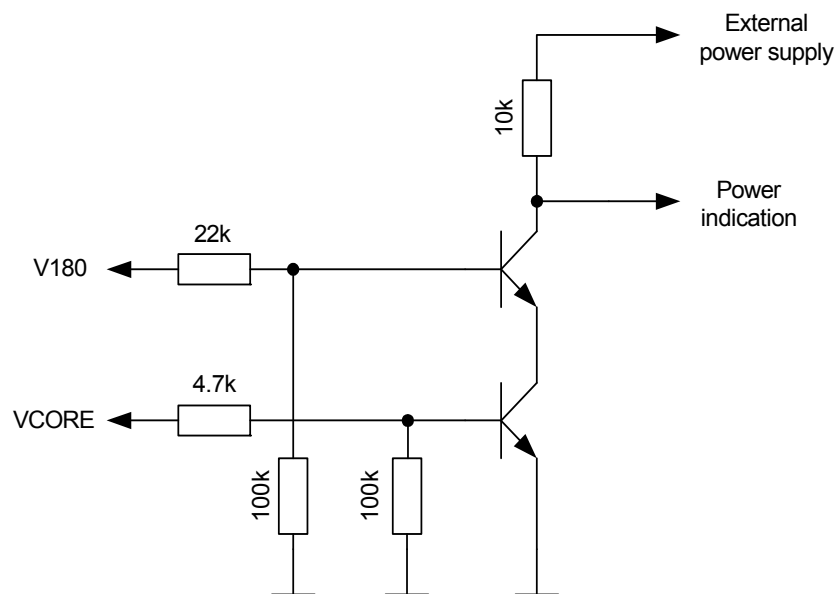


Figure 18: Power indication circuit

2.1.13.3 Host Wakeup

If no call, data or message transfer is in progress, the host may shut down its own USB interface to save power. If a call or other request (URC's, messages) arrives, the host can be notified of these events and be woken up again by a state transition of the ASC0 interface's RING0 line. This functionality should only be used with legacy USB applications not supporting the recommended USB suspend and resume mechanism as described in [\[5\]](#) (see also [Section 2.1.3.1](#)). For more information on how to configure the RING0 line by AT^SCFG command see [\[1\]](#).

Possible RING0 line states are listed in [Table 6](#).

Table 6: Host wakeup lines

Signal	I/O	Description
RING0	O	Inactive to active low transition: 0 = The host shall wake up 1 = No wake up request

2.1.13.4 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 and must be applied for at least 10 milliseconds. If unused this line can be left open because of a configured internal pull-up resistor. Before setting the FST_SHDN line to low, the ON signal should be set to low (see [Figure 19](#)). Otherwise there might be back powering at the ON line in Power Down mode.

By default, the fast shutdown feature is disabled. It has to be enabled using the AT command `AT^SCFG "MEShutdown/Fso"`. For details see [\[1\]](#).

If enabled, a low impulse >10 milliseconds on the FST_SHDN line starts the fast shutdown. The fast shutdown procedure still finishes any data activities on the 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.

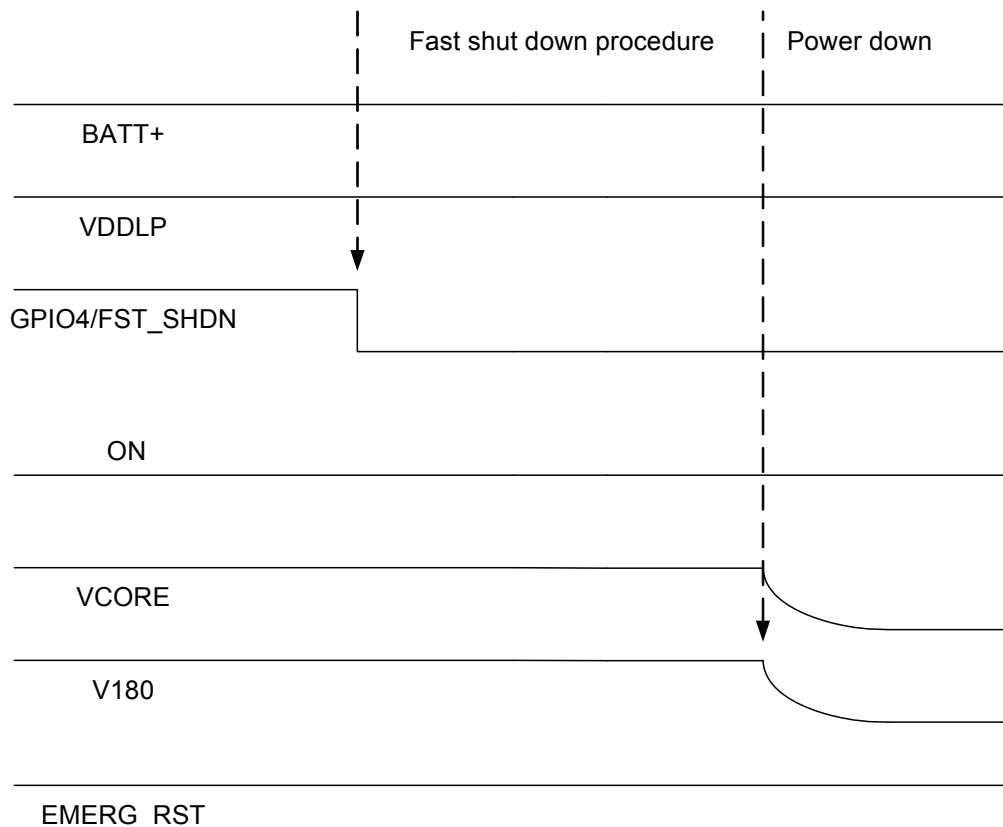


Figure 19: Fast shutdown timing

Please note that if enabled, the normal software controlled shutdown using `AT^SMSO` will also be a fast shutdown, i.e., without network deregistration. However, in this case no URCs including shutdown URCs will be provided by the `AT^SMSO` command.

2.2 RF Antenna Interface

The ELS61-E GSM/LTE antenna interface comprises a GSM/LTE main antenna as well as a LTE Rx diversity antenna to improve signal reliability and quality¹. The RF interface has an impedance of 50Ω. ELS61-E 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 ELS61-E module and should be placed in the host application if the antenna does not have an impedance of 50Ω.

Regarding the return loss ELS61-E provides the following values in the active band:

Table 7: 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 Interface Specifications

Table 8: RF Antenna interface GSM/LTE (at operating temperature range¹)

Parameter	Conditions	Min.	Typical	Max.	Unit
LTE connectivity ²	Band 1, 3, 8, 20				
Receiver Input Sensitivity @ ARP (ch. bandwidth 5MHz)	LTE 800 Band 20		-97		dBm
	LTE 900 Band 8		-97		dBm
	LTE 1800 Band 3		-97		dBm
	LTE 2100 Band 1		-100		dBm
RF Power @ ARP with 50Ω Load	LTE 800 Band 20		+23		dBm
	LTE 900 Band 8		+23		dBm
	LTE 1800 Band 3		+23		dBm
	LTE 2100 Band 1	+21	+23	+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 900	-102	-110		dBm
	GSM 1800	-102	-109		dBm

1. By delivery default the LTE Rx diversity antenna is configured as available for the module since its usage is mandatory for LTE. Please refer to [1] for details on how to configure antenna settings.

2.2 RF Antenna Interface

Table 8: RF Antenna interface GSM/LTE (at operating temperature range¹)

Parameter		Conditions	Min.	Typical	Max.	Unit	
RF Power @ ARP with 50Ω Load	GSM	GSM 900		33		dBm	
		GSM 1800		30		dBm	
RF Power @ ARP with 50Ω Load, (ROPR = 0, i.e. no reduction)	GPRS, 1 TX	GSM 900		32.5		dBm	
		GSM 1800		30		dBm	
	EDGE, 1 TX	GSM 900		27		dBm	
		GSM 1800		26		dBm	
	GPRS, 2 TX	GSM 900		32.5		dBm	
		GSM 1800		29.5		dBm	
	EDGE, 2 TX	GSM 900		27		dBm	
		GSM 1800		26		dBm	
	GPRS, 3 TX	GSM 900		32.5		dBm	
		GSM 1800		29.5		dBm	
	EDGE, 3 TX	GSM 900		27		dBm	
		GSM 1800		26		dBm	
	GPRS, 4 TX	GSM 900		32.5		dBm	
		GSM 1800		29.5		dBm	
	EDGE, 4 TX	GSM 900		27		dBm	
		GSM 1800		26		dBm	
	RF Power @ ARP with 50Ω Load, (ROPR = 1)	GPRS, 1 TX	GSM 900		32.5		dBm
			GSM 1800		29.5		dBm
EDGE, 1 TX		GSM 900		27		dBm	
		GSM 1800		26		dBm	
GPRS, 2 TX		GSM 900		32.5		dBm	
		GSM 1800		29.5		dBm	
EDGE, 2 TX		GSM 900		27		dBm	
		GSM 1800		26		dBm	
GPRS, 3 TX		GSM 900		32		dBm	
		GSM 1800		29		dBm	
EDGE, 3 TX		GSM 900		27		dBm	
		GSM 1800		26		dBm	
GPRS, 4 TX		GSM 900		32.5		dBm	
		GSM 1800		29.5		dBm	
EDGE, 4 TX		GSM 900		27		dBm	
		GSM 1800		26		dBm	

2.2 RF Antenna Interface

Table 8: RF Antenna interface GSM/LTE (at operating temperature range¹)

Parameter		Conditions	Min.	Typical	Max.	Unit
RF Power @ ARP with 50Ω Load, (ROPR = 2)	GPRS, 1 TX	GSM 900		32.5		dBm
		GSM 1800		29.5		dBm
	EDGE, 1 TX	GSM 900		27		dBm
		GSM 1800		26		dBm
	GPRS, 2 TX	GSM 900		30.5		dBm
		GSM 1800		27.5		dBm
	EDGE, 2 TX	GSM 900		27		dBm
		GSM 1800		26		dBm
	GPRS, 3 TX	GSM 900		30		dBm
		GSM 1800		27		dBm
	EDGE, 3 TX	GSM 900		26		dBm
		GSM 1800		25.8		dBm
	GPRS, 4 TX	GSM 900		28.7		dBm
		GSM 1800		25.8		dBm
	EDGE, 4 TX	GSM 900		26.5		dBm
		GSM 1800		25.7		dBm
RF Power @ ARP with 50Ω Load, (ROPR = 3)	GPRS, 1 TX	GSM 900		32.5		dBm
		GSM 1800		29.5		dBm
	EDGE, 1 TX	GSM 900		27		dBm
		GSM 1800		26		dBm
	GPRS, 2 TX	GSM 900		29.5		dBm
		GSM 1800		26.5		dBm
	EDGE, 2 TX	GSM 900		27		dBm
		GSM 1800		26		dBm
	GPRS, 3 TX	GSM 900		28		dBm
		GSM 1800		25		dBm
	EDGE, 3 TX	GSM 900		27		dBm
		GSM 1800		26		dBm
	GPRS, 4 TX	GSM 900		26.5		dBm
		GSM 1800		23.5		dBm
	EDGE, 4 TX	GSM 900		27		dBm
		GSM 1800		26		dBm

2.2 RF Antenna Interface

Table 8: RF Antenna interface GSM/LTE (at operating temperature range¹)

Parameter		Conditions	Min.	Typical	Max.	Unit
RF Power @ ARP with 50Ω Load, (ROPR = 4, i.e. maximum reduction)	GPRS, 1 TX	GSM 900		32.5		dBm
		GSM 1800		29.5		dBm
	EDGE, 1 TX	GSM 900		27		dBm
		GSM 1800		26		dBm
	GPRS, 2 TX	GSM 900		29.5		dBm
		GSM 1800		26.5		dBm
	EDGE, 2 TX	GSM 900		24		dBm
		GSM 1800		23		dBm
	GPRS, 3 TX	GSM 900		28		dBm
		GSM 1800		25		dBm
	EDGE, 3 TX	GSM 900		22		dBm
		GSM 1800		21		dBm
	GPRS, 4 TX	GSM 900		26.5		dBm
		GSM 1800		23.5		dBm
	EDGE, 4 TX	GSM 900		21		dBm
		GSM 1800		20		dBm

1. At temperature range no active power reduction is implemented - any deviations are hardware related.
2. Applies also to LTE Rx diversity antenna.

2.2.2 Antenna Installation

The antenna is connected by soldering the antenna pad (ANT_MAIN or ANT_DRX) and its neighboring ground pads (GND) directly to the application’s PCB. The antenna pads are the antenna reference points (ARP) for ELS61-E. All RF data specified throughout this document is related to the ARP.

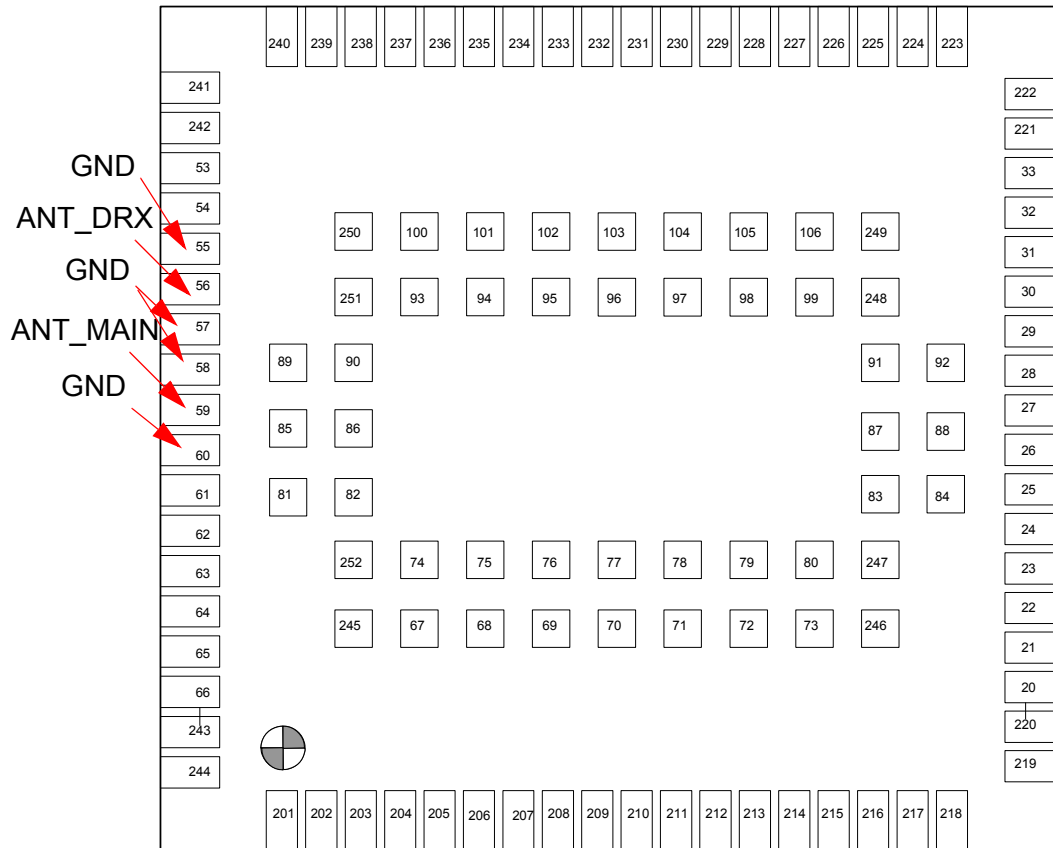


Figure 20: Antenna pads (bottom view)

The distance between the antenna pad and its neighboring GND pads has been optimized for best possible impedance. To prevent mismatch, special attention should be paid to these pads on the application’s PCB.

The wiring of the antenna connection, starting from the antenna pad to the application’s 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 2.2.3](#).

To prevent receiver desensitization due to interferences generated by fast transients like high speed clocks on the external application PCB, it is recommended to realize the antenna connection line using embedded Stripline rather than Micro-Stripline technology. Please see [Section 2.2.3.1](#) for examples of how to design the antenna connection in order to achieve the required 50Ω line impedance.

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 ELS61-E’s antenna pad.

2.2.3 RF Line Routing Design

2.2.3.1 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 65 μ m FR4 prepreg (type: 1080) and 710 μ m FR4 core (4-layer PCB).

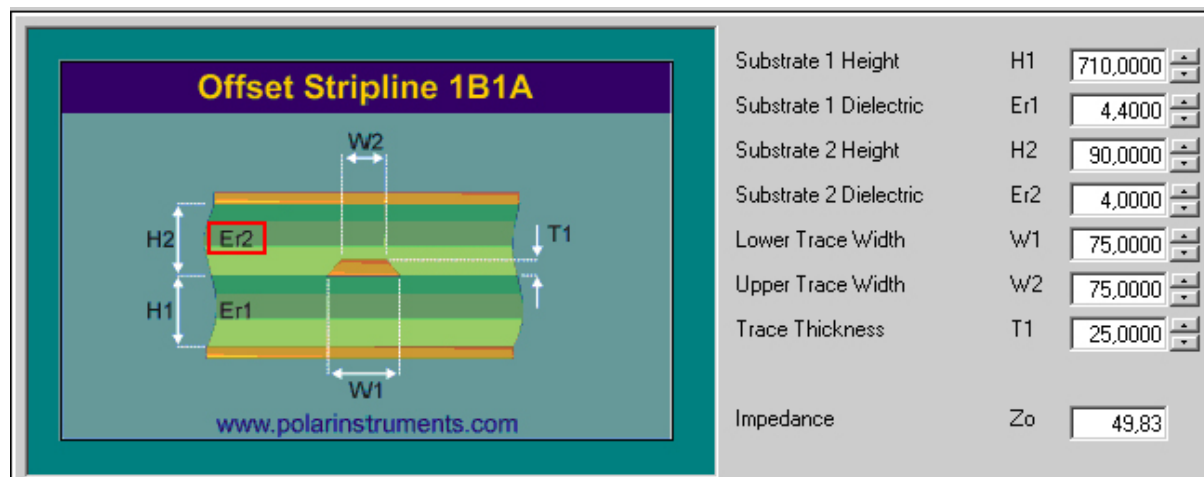


Figure 21: Embedded Stripline with 65 μ m prepreg (1080) and 710 μ m core

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).

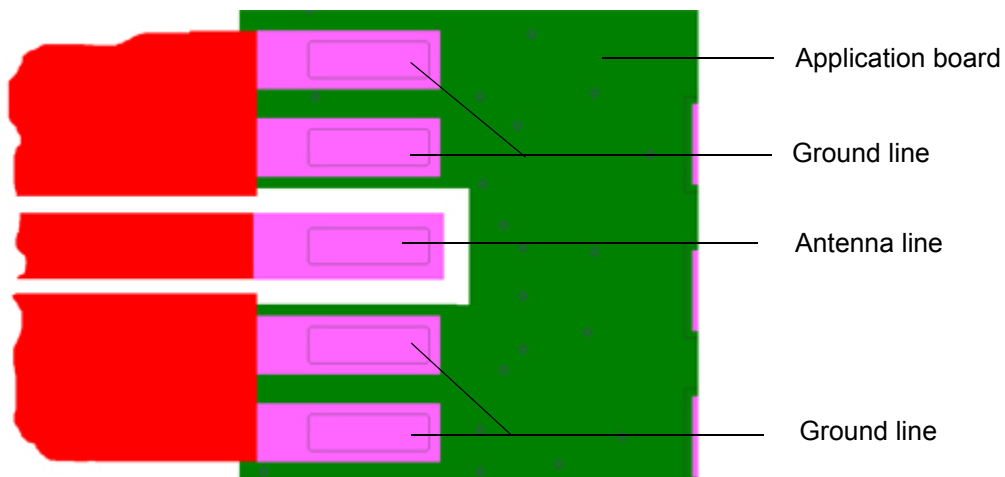
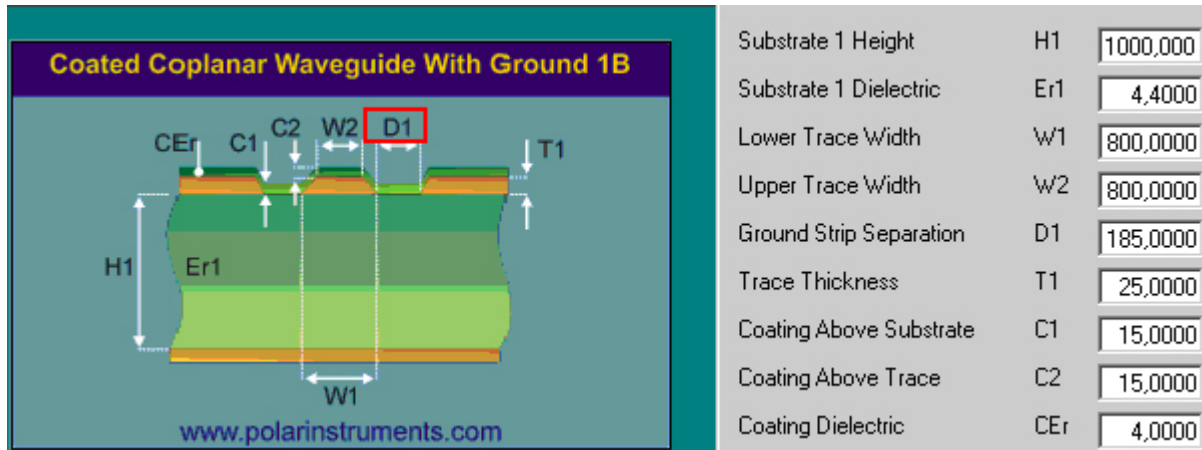


Figure 22: Micro-Stripline on 1.0mm standard FR4 2-layer PCB - example 1

2.2 RF Antenna Interface

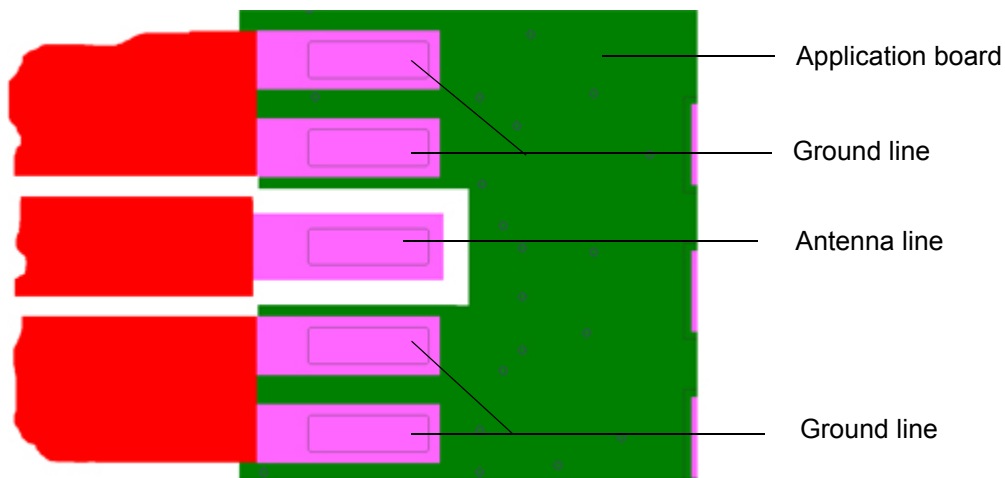
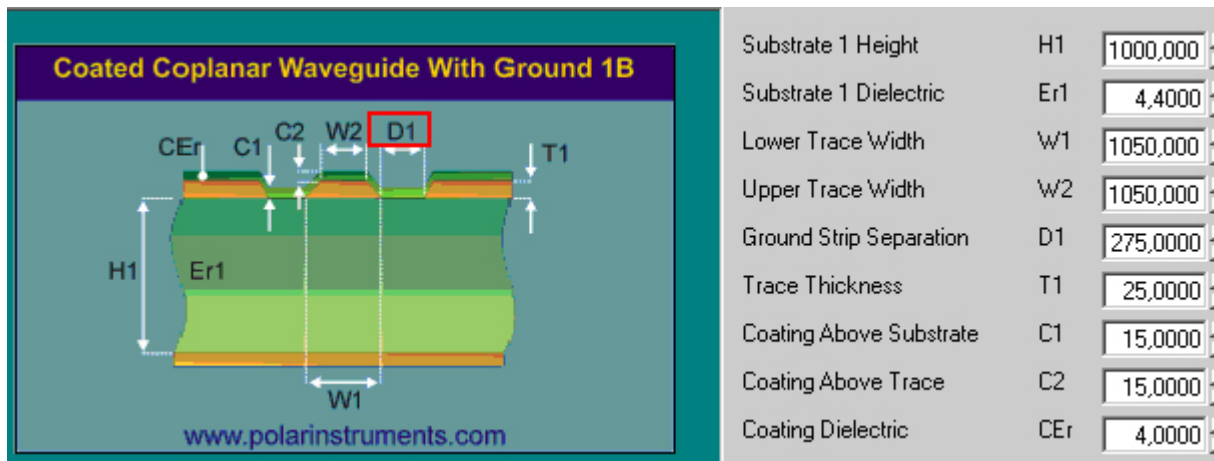


Figure 23: Micro-Stripline on 1.0mm Standard FR4 PCB - example 2

2.2 RF Antenna Interface

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

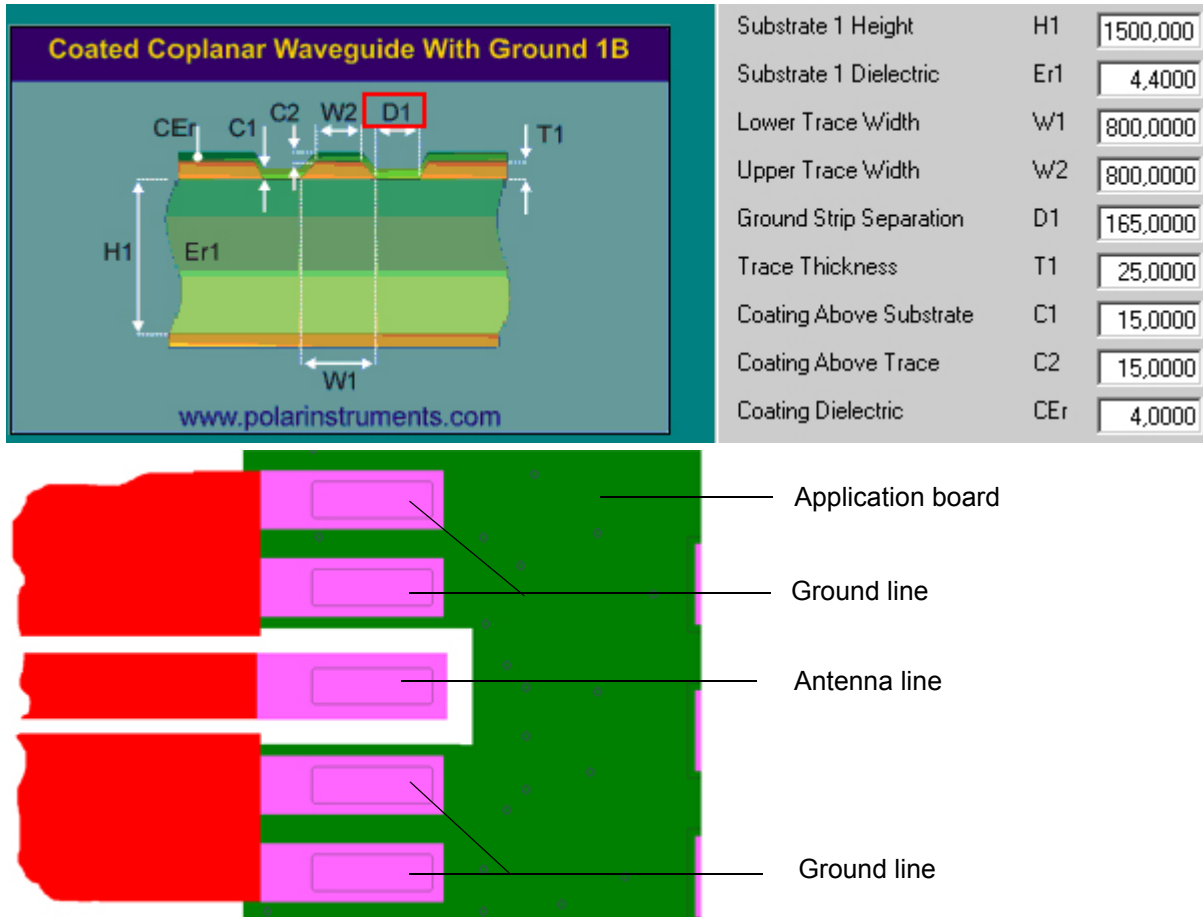


Figure 24: Micro-Stripline on 1.5mm Standard FR4 PCB - example 1

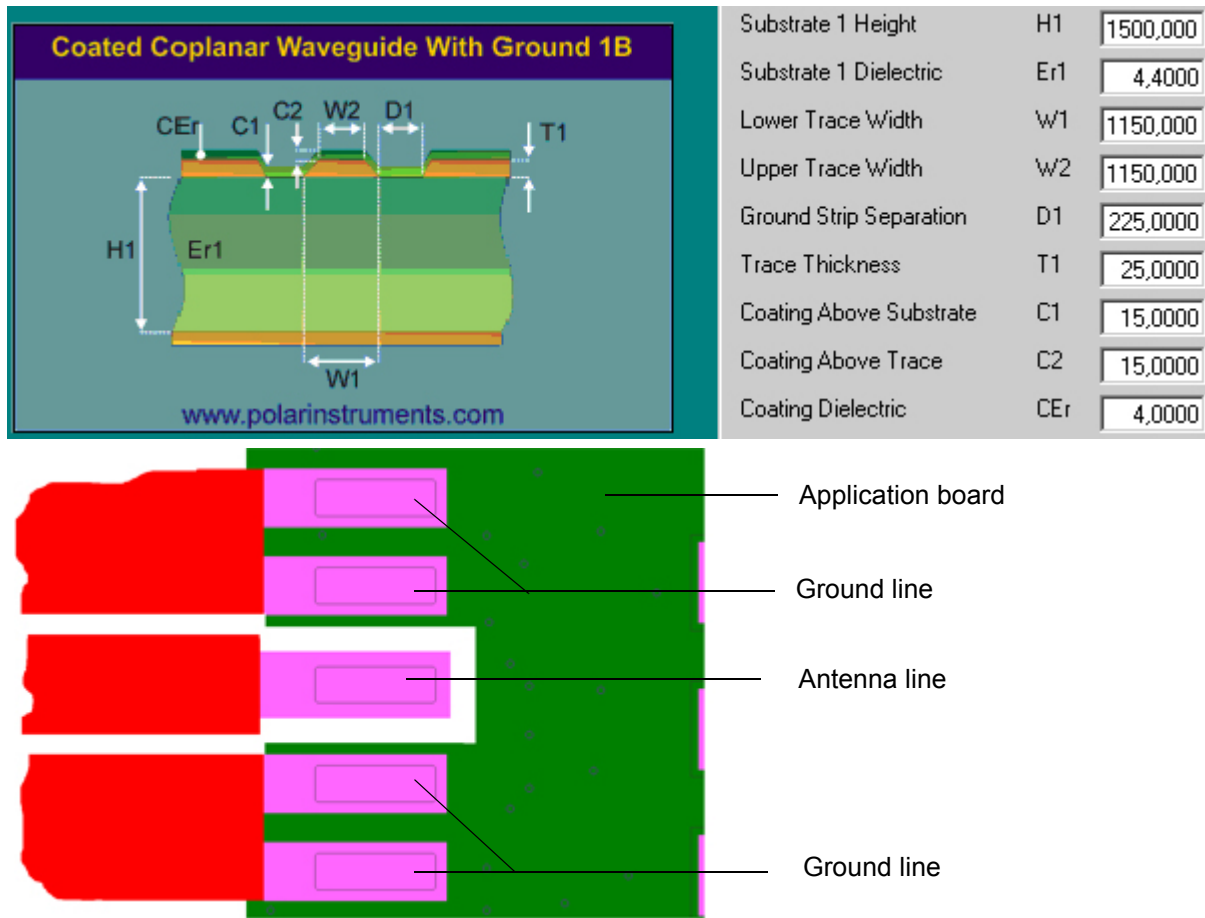


Figure 25: Micro-Stripline on 1.5mm Standard FR4 PCB - example 2

2.2.3.2 Routing Example

Interface to RF Connector

Figure 26 shows the connection of the module's antenna pad with an application PCB's coaxial antenna connector. Please note that the ELS61-E bottom plane appears mirrored, since it is viewed from ELS61-E top side. By definition the top of customer's board shall mate with the bottom of the ELS61-E module.

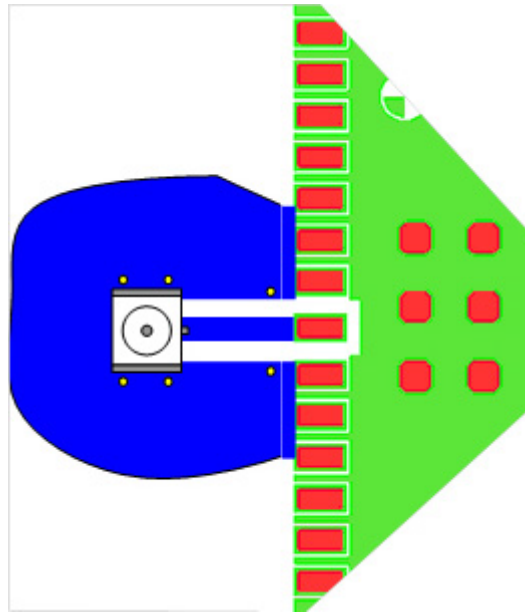


Figure 26: Routing to application's RF connector - top view

2.3 Sample Application

[Figure 27](#) shows a typical example of how to integrate a ELS61-E module with an application. Usage of the various host interfaces depends on the desired features of the application.

Because of the very low power consumption design, current flowing from any other source into the module circuit must be avoided, for example reverse current from high state external control lines. Therefore, the controlling application must be designed to prevent reverse current flow. Otherwise there is the risk of undefined states of the module during startup and shutdown or even of damaging the module.

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, VDDL, and 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 [\[3\]](#).

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.

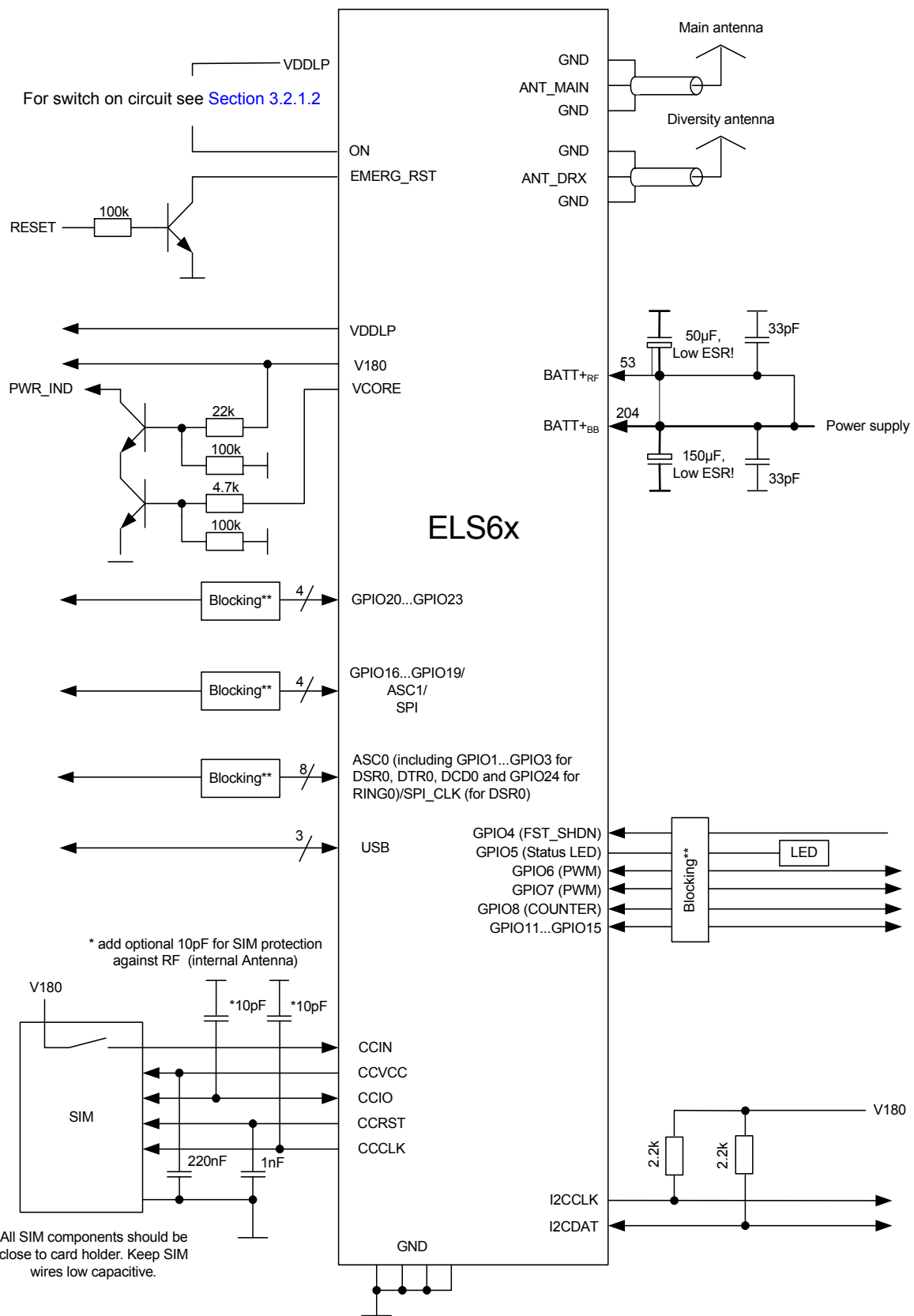
Depending on the micro controller used by an external application ELS61-E's digital input and output lines may require level conversion. [Section 2.3.1](#) shows a possible sample level conversion circuit.

Note: ELS61-E 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 27](#) 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 ELS61-E modules.

2.3 Sample Application



Blocking** = For more details see Section 3.8

Figure 27: Schematic diagram of ELS61-E sample application

2.3.1 Sample Level Conversion Circuit

Depending on the micro controller used by an external application ELS61-E's digital input and output lines (i.e., ASC0, ASC1 and GPIO lines) may require level conversion. The following [Figure 28](#) shows a sample circuit with recommended level shifters for an external application's micro controller (with VLOGIC between 3.0V...3.6V). The level shifters can be used for digital input and output lines with $V_{OHmax}=1.85V$ or $V_{IHmax}=1.85V$.

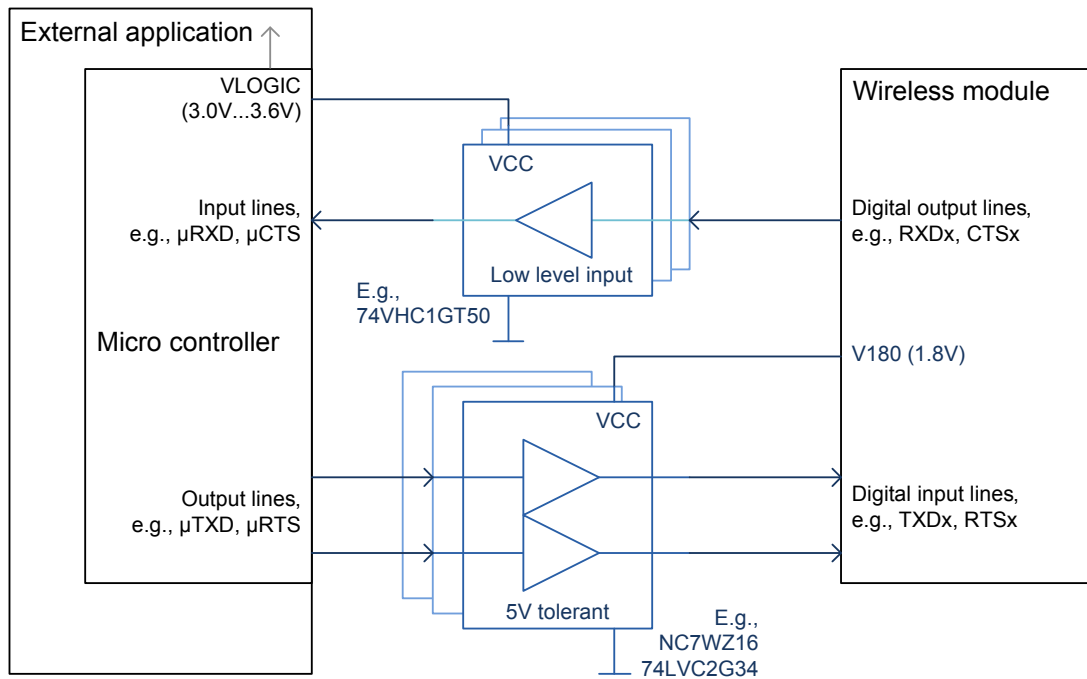


Figure 28: Sample level conversion circuit

3 Operating Characteristics

3.1 Operating Modes

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

Table 9: Overview of operating modes

Mode	Function	
Normal operation	GSM / GPRS / LTE SLEEP	Power saving set automatically when no call is in progress and the USB connection is suspended by host or not present and no active communication via ASC0.
	GSM / GPRS / LTE IDLE	Power saving disabled or an USB connection not suspended, but no call in progress.
	GSM TALK/ GSM DATA	Connection between two subscribers is in progress. Power consumption depends on the GSM network coverage and several connection settings (e.g. DTX off/on, FR/EFR/HR, hopping sequences and antenna connection). The following applies when power is to be measured in TALK_GSM mode: DTX off, FR and no frequency hopping.
	GPRS DATA	GPRS data transfer in progress. Power consumption depends on network settings (e.g. power control level), uplink / downlink data rates and GPRS configuration (e.g. used multislot settings).
	EGPRS DATA	EGPRS data transfer in progress. Power consumption depends on network settings (e.g. power control level), uplink / downlink data rates and EGPRS configuration (e.g. used multislot settings).
	LTE DATA	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. Airplane mode can be controlled by AT command (see [1]).	

3.2 Power Up/Power Down Scenarios

In general, be sure not to turn on ELS61-E while it is beyond the safety limits of voltage and temperature stated in [Section 2.1.2.1](#). ELS61-E immediately switches off after having started and detected these inappropriate conditions. In extreme cases this can cause permanent damage to the module.

3.2.1 Turn on ELS61-E

ELS61-E can be turned on as described in the following sections:

- Connecting the operating voltage BATT+ (see [Section 3.2.1.1](#)).
- Hardware driven switch on by ON line: Starts Normal mode (see [Section 3.2.1.2](#)).

After startup or restart, the module will send the URC ^SYSSTART that notifies the host application that the first AT command can be sent to the module (see also [\[1\]](#)).

3.2.1.1 Connecting ELS61-E BATT+ Lines

[Figure 29](#) and [Figure 30](#) show sample external application circuits that allow to connect (and also to temporarily disconnect) the module's BATT+ lines from the external application's power supply.

[Figure 29](#) illustrates the application of power employing an externally controlled microcontroller. [Figure 30](#) as an alternative shows the power application with an external voltage supervisory circuit instead of a microcontroller. The voltage supervisory circuit ensures that the power is disconnected and applied again depending on given thresholds.

The transistor T2 mentioned in [Figure 29](#) and [Figure 30](#) should have an R_{DS_ON} value $\leq 50\text{m}\Omega$ in order to minimize voltage drops.

Such circuits could be useful to maximize power savings for battery driven applications or to completely switch off and restart the module after a firmware update.

After connecting the BATT+ lines the module can then be (re-)started as described in [Section 3.2.1.2](#) and [Section 3.2.2](#).

3.2 Power Up/Power Down Scenarios

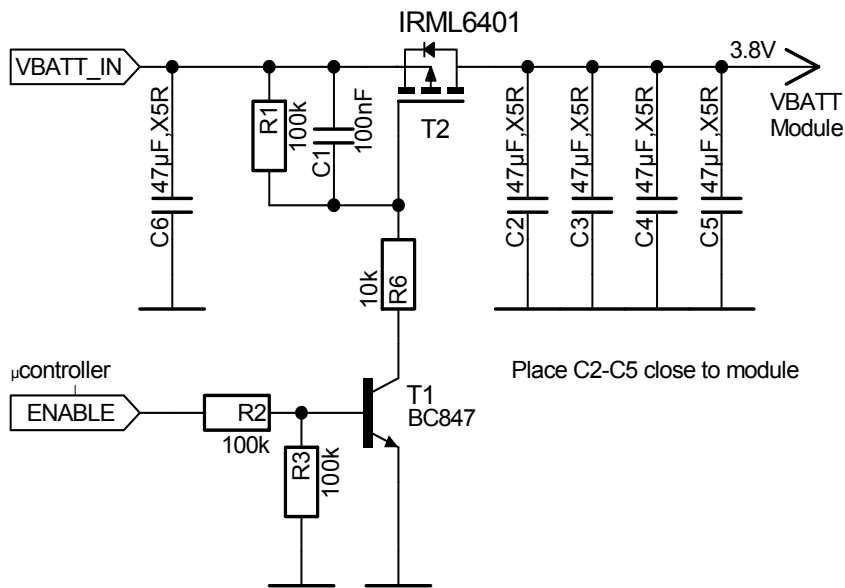


Figure 29: Sample circuit for applying power using an external µC

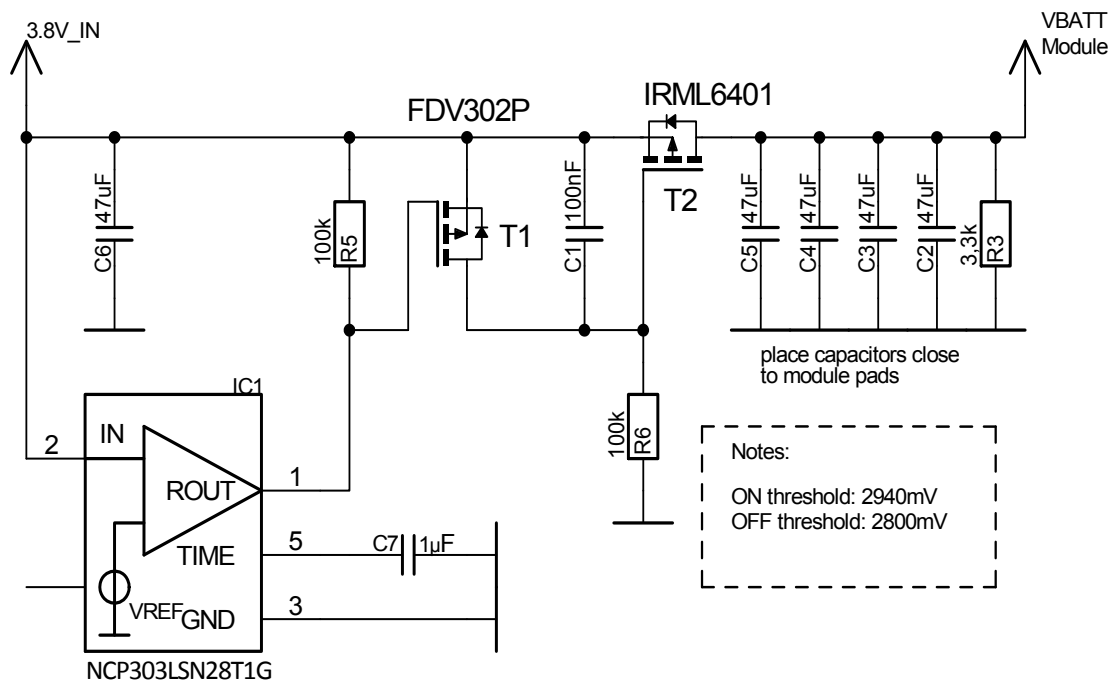


Figure 30: Sample circuit for applying power using an external voltage supervisory circuit

3.2.1.2 Switch on ELS61-E Using ON Signal

When the operating voltage BATT+ is applied, ELS61-E can be switched on by means of the ON signal.

The ON signal is an edge triggered signal and only allows the input voltage level of the VDDL P signal. The module starts into normal mode on detecting the rising edge of the ON signal.

The following [Figure 31](#) shows recommendations for possible switch-on circuits.

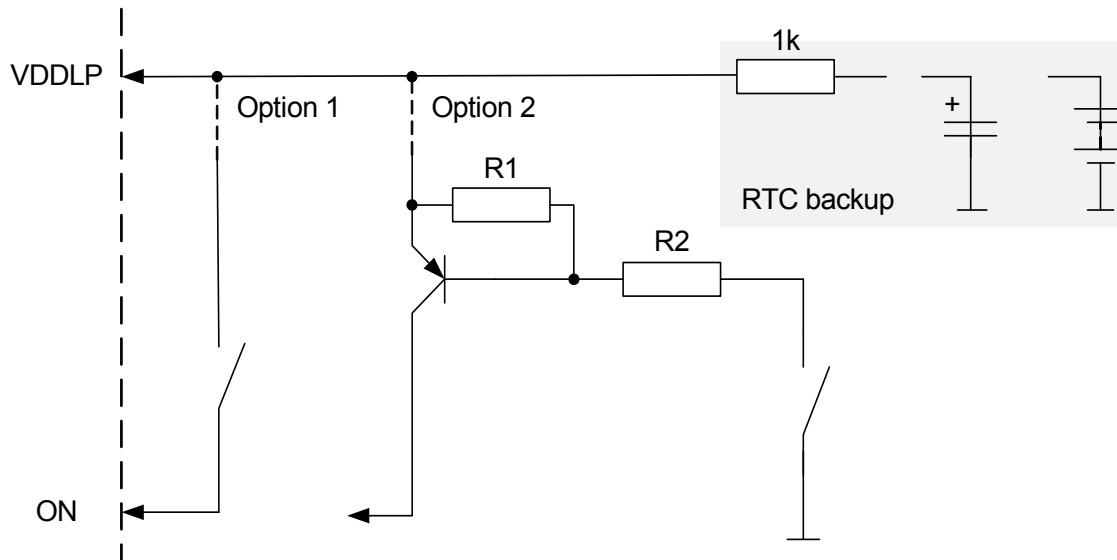


Figure 31: ON circuit options

It is recommended to set a serial 1kOhm resistor between the ON circuit and the external capacitor or battery at the VDDL P power supply (i.e., RTC backup circuit). This serial resistor protection is necessary in case the capacitor or battery has low power (is empty).

With Option 2 the typical resistor values are: R1 = 150k and R2 = 22k. But the resistor values depend on the current gain from the employed PNP resistor.

3.2 Power Up/Power Down Scenarios

Please note that the ON signal is an edge triggered signal. This implies that a milli-second high pulse on the signal line suffices to almost immediately switch on the module, as shown in [Figure 32](#). After module startup the ON signal should always be set to low to prevent possible back powering at this pad.

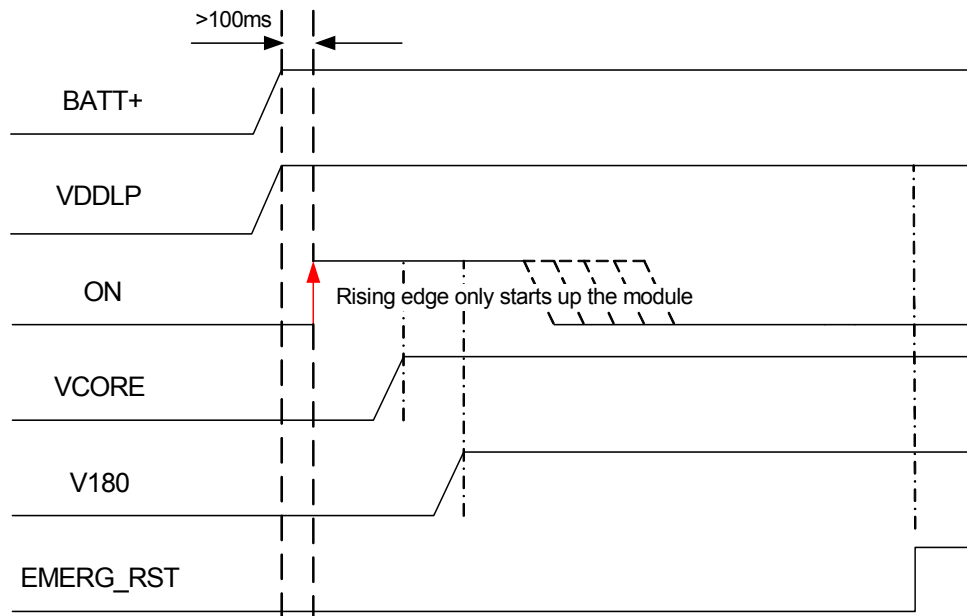


Figure 32: ON timing

3.2.2 Restart ELS61-E

After startup ELS61-E can be re-started as described in the following sections:

- Software controlled reset by AT+CFUN command: Starts Normal mode (see [Section 3.2.2.1](#)).
- Hardware controlled reset by EMERG_RST line: Starts Normal mode (see [Section 3.2.2.2](#)).

3.2.2.1 Restart ELS61-E via AT+CFUN Command

To reset and restart the ELS61-E module use the command AT+CFUN. See [\[1\]](#) for details.

3.2.2.2 Restart ELS61-E Using EMERG_RST

The EMERG_RST signal is internally connected to the central GSM processor. A low level for more than 10ms sets the processor and with it all the other signal pads to their respective reset state. The reset state is described in [Section 3.2.3](#) as well as in the figures showing the startup behavior of an interface.

After releasing the EMERG-RST line, i.e., with a change of the signal level from low to high, the module restarts. The other signals continue from their reset state as if the module was switched on by the ON signal.

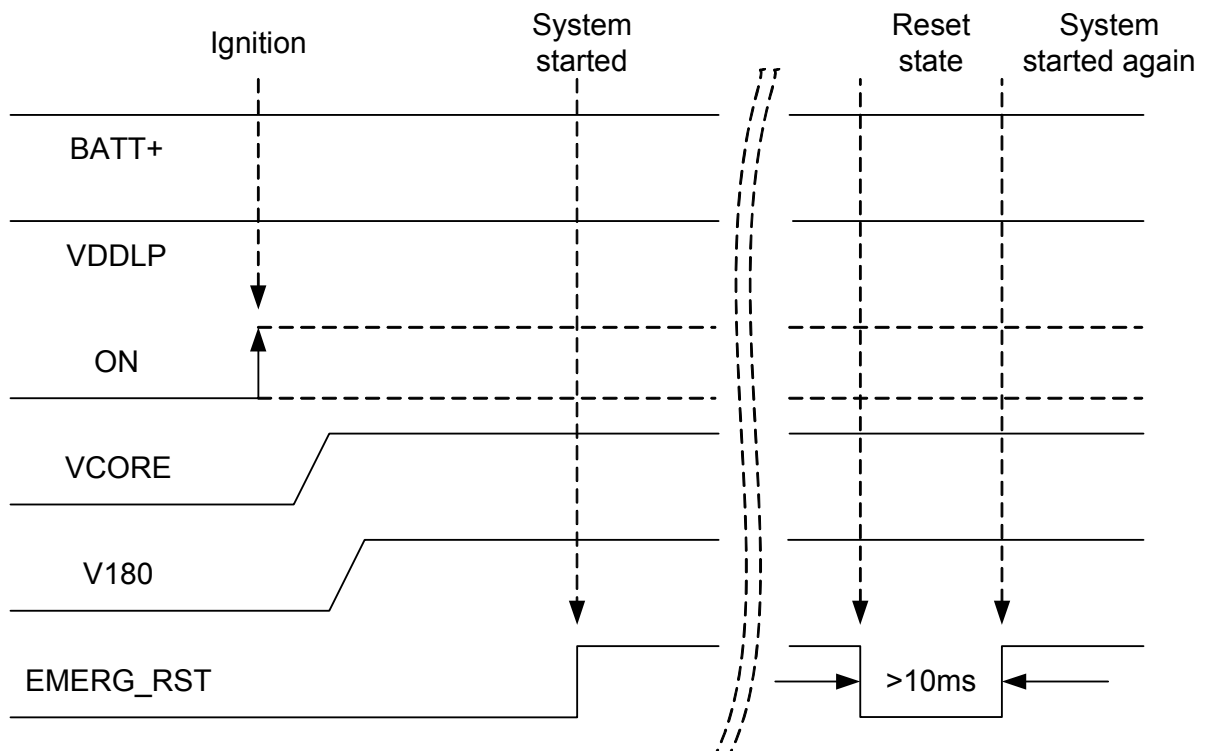


Figure 33: Emergency restart timing

It is recommended to control this EMERG_RST line with an open collector transistor or an open drain field-effect transistor.

Caution: Use the EMERG_RST line only when, due to serious problems, the software is not responding for more than 5 seconds. Pulling the EMERG_RST line causes the loss of all information stored in the volatile memory. Therefore, this procedure is intended only for use in case of emergency, e.g. if ELS61-E does not respond, if reset or shutdown via AT command fails.

3.2.3 Signal States after Startup

Table 10 lists the states each interface signal passes through during reset phase and the first firmware initialization. For further firmware startup initializations the values may differ because of different GPIO line configurations.

The reset state is reached with the rising edge of the EMERG_RST signal - either after a normal module startup (see Section 3.2.1.2) or after a reset (see Section 3.2.2.2). After the reset state has been reached the firmware initialization state begins. The firmware initialization is completed as soon as the ASC0 interface lines CTS0, DSR0 and RING0 as well as the ASC1 interface line CTS1 have turned low (see Section 2.1.4 and Section 2.1.5). Now, the module is ready to receive and transmit data.

Table 10: Signal states

Signal name	Reset state	First start up configuration
CCIO	L	O / L
CCRST	L	O / L
CCCLK	L	O / L
CCIN	T / 100k PD	I / 100k PU
RXD0	T / PU	O / H
TXD0	T / PD	I
CTS0	T / PU	O / H
RTS0	T / PU	I / PD
GPIO1	T / PD	T / PD
GPIO2	T / PD	T / PD
GPIO3	T / PD	T / PD
GPIO4	T / PD	T / PD
GPIO5	T / PD	T / PD
GPIO6	T / PD	T / PD
GPIO7	T / PD	T / PD
GPIO8	T / PD	T / PD
GPIO11-GPIO15	T / PD	T / PD
GPIO16	T / PD	T / PD
GPIO17	T / PD	T / PD
GPIO18	T / PD	T / PD
GPIO19	T / PD	T / PD
GPIO20	T / PD	T / PD
GPIO21	T / PD	T / PD
GPIO22	T / PD	T / PD
GPIO23	T / PD	T / PD
GPIO24	T / PD	T / PD
I2CCLK	T	T / OD
I2CDAT	T	T / OD

Abbreviations used in above Table 10:

L = Low level H = High level T = Tristate I = Input	O = Output OD = Open Drain PD = Pull down, 200µA at 1.9V PU = Pull up, -240µA at 0V
--	--

3.2.4 Turn off ELS61-E

To switch the module off the following procedures may be used:

- *Software controlled shutdown procedure*: Software controlled by sending an AT command over the serial application interface. See [Section 3.2.4.1](#).
- *Hardware controlled shutdown procedure*: Hardware controlled by disconnecting the module's power supply lines BATT+ (see [Section 3.2.1.1](#)).
- *Automatic shutdown (software controlled)*: See [Section 3.2.5](#)
 - Takes effect if ELS61-E board temperature or voltage levels exceed a critical limit.

3.2.4.1 Switch off ELS61-E Using AT Command

The best and safest approach to powering down ELS61-E is to issue the appropriate AT command. This procedure lets ELS61-E log off from the network and allows the software to enter into a secure state and save data before disconnecting the power supply. The mode is referred to as Power Down mode. In this mode, only the RTC stays active. After sending the switch off command AT^SMSO, be sure not to enter any further AT commands until the module was restarted.

CAUTION: Be sure not to disconnect the operating voltage V_{BATT+} before V180 pad has gone low. Otherwise you run the risk of losing data, or in some cases even to render the module inoperable.

To monitor the V180 line, it is recommended to implement a power indication circuit as described in [Section 2.1.13.2](#).

While ELS61-E is in Power Down mode the application interface is switched off and must not be fed from any other voltage source. Therefore, your application must be designed to avoid any current flow into any digital pads of the application interface.

3.2 Power Up/Power Down Scenarios

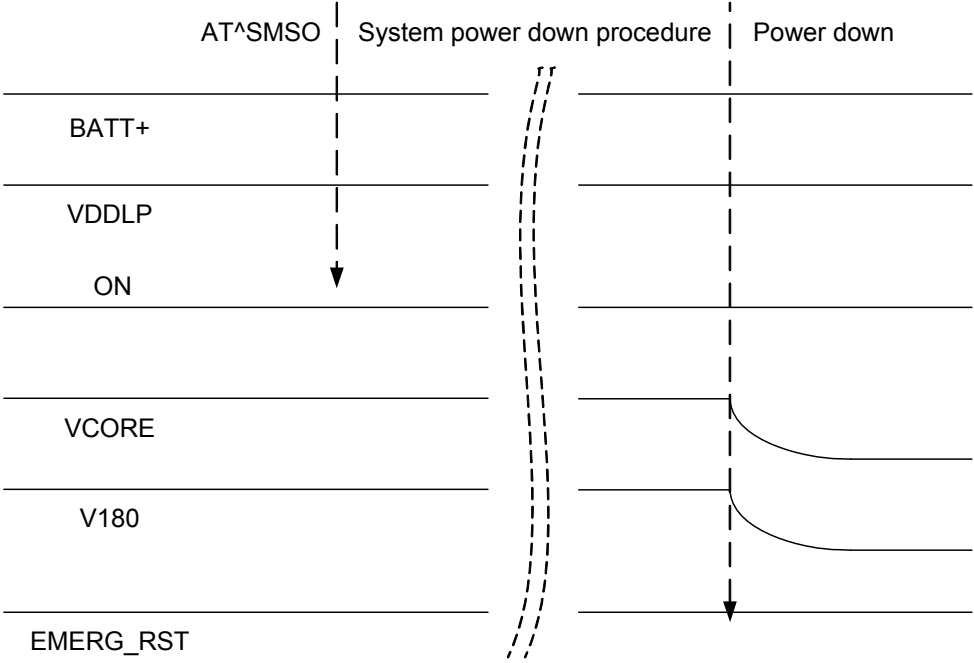


Figure 34: Switch off behavior

3.2.5 Automatic Shutdown

Automatic shutdown takes effect if the following event occurs:

- ELS61-E board is exceeding the critical limits of overtemperature or undertemperature (see [Section 3.2.5.1](#))
- Undervoltage or overvoltage is detected (see [Section 3.2.5.2](#) and [Section 3.2.5.3](#))

The automatic shutdown procedure is equivalent to the power-down initiated with an AT command, i.e. ELS61-E logs off from the network and the software enters a secure state avoiding loss of data.

3.2.5.1 Thermal Shutdown

The board temperature is constantly monitored by an internal NTC resistor located on the PCB. The values detected by the NTC resistor are measured directly on the board and therefore, are not fully identical with the ambient temperature.

Each time the board temperature goes out of range or back to normal, ELS61-E instantly displays an alert (if enabled).

- URCs indicating the level "1" or "-1" allow the user to take appropriate precautions, such as protecting the module from exposure to extreme conditions. The presentation of the URCs depends on the settings selected with the AT^SCTM write command (for details see [\[1\]](#)):
AT^SCTM=1: Presentation of URCs is always enabled.
AT^SCTM=0 (default): Presentation of URCs is enabled during the 2 minute guard period after start-up of ELS61-E. After expiry of the 2 minute guard period, the presentation of URCs will be disabled, i.e. no URCs with alert levels "1" or "-1" will be generated.
- URCs indicating the level "2" or "-2" are instantly followed by an orderly shutdown. The presentation of these URCs is always enabled, i.e. they will be output even though the factory setting AT^SCTM=0 was never changed.

The maximum temperature ratings are stated in [Section 3.6](#). Refer to [Table 11](#) for the associated URCs.

Table 11: Temperature dependent behavior

Sending temperature alert (2min after ELS61-E start-up, otherwise only if URC presentation enabled)	
^SCTM_B: 1	Board close to overtemperature limit.
^SCTM_B: -1	Board close to undertemperature limit.
^SCTM_B: 0	Board back to non-critical temperature range.
Automatic shutdown (URC appears no matter whether or not presentation was enabled)	
^SCTM_B: 2	Alert: Board equal or beyond overtemperature limit. ELS61-E switches off.
^SCTM_B: -2	Alert: Board equal or below undertemperature limit. ELS61-E switches off.

3.2.5.2 Undervoltage Shutdown

The undervoltage shutdown threshold is the specified minimum supply voltage $V_{\text{BATT+}}$ given in [Table 2](#). When the average supply voltage measured by ELS61-E approaches the undervoltage shutdown threshold (i.e., 0.05V offset) the module will send the following URC:

^SBC: Undervoltage Warning

The undervoltage warning is sent only once - until the next time the module is close to the undervoltage shutdown threshold.

If the voltage continues to drop below the specified undervoltage shutdown threshold, the module will send the following URC:

^SBC: Undervoltage Shutdown

This alert is sent only once before the module shuts down cleanly without sending any further messages.

This type of URC does not need to be activated by the user. It will be output automatically when fault conditions occur.

Note: For battery powered applications it is strongly recommended to implement a BATT+ connecting circuit as described in [Section 3.2.1.1](#) in order to not only be able save power, but also to restart the module after an undervoltage shutdown where the battery is deeply discharged. Also note that the undervoltage threshold is calculated for max. 400mV voltage drops during transmit burst. Power supply sources for external applications should be designed to tolerate 400mV voltage drops without crossing the lower limit of 3.0 V. For external applications operating at the limit of the allowed tolerance the default undervoltage threshold may be adapted by subtracting an offset. For details see [\[1\]](#): AT^SCFG= "MEShutdown/sVsup/threshold".

3.2.5.3 Overvoltage Shutdown

The overvoltage shutdown threshold is the specified maximum supply voltage $V_{\text{BATT+}}$ given in [Table 2](#). When the average supply voltage measured by ELS61-E approaches the overvoltage shutdown threshold (i.e., 0.05V offset) the module will send the following URC:

^SBC: Overvoltage Warning

The overvoltage warning is sent only once - until the next time the module is close to the overvoltage shutdown threshold.

If the voltage continues to rise above the specified overvoltage shutdown threshold, the module will send the following URC:

^SBC: Overvoltage Shutdown

This alert is sent only once before the module shuts down cleanly without sending any further messages.

This type of URC does not need to be activated by the user. It will be output automatically when fault conditions occur.

Keep in mind that several ELS61-E components are directly linked to BATT+ and, therefore, the supply voltage remains applied at major parts of ELS61-E. Especially the power amplifier linked to BATT+_{RF} is very sensitive to high voltage and might even be destroyed.

3.3 Automatic GPRS Multislot Class Change

Temperature control is also effective for operation in GPRS Multislot Class 10 or 12. If the board temperature increases to 75°C while data is transmitted over GPRS, the module automatically reverts from GPRS Multislot Class 12 (4Tx) or Class 10 (2Tx) to Class 8 (1Tx). This reduces the power consumption and, consequently, causes the board's temperature to decrease. Once the temperature drops to a 70°C, ELS61-E returns to the higher Multislot Class. If the temperature stays at the critical level or even continues to rise, ELS61-E will not switch back to the higher class.

After a transition from Multislot Class 12 or 10 to Multislot 8 a possible switchback to Multislot Class 12 or 10 is blocked for one minute.

Please note that there is not one single cause of switching over to a lower GPRS Multislot Class. Rather it is the result of an interaction of several factors, such as the board temperature that depends largely on the ambient temperature, the operating mode and the transmit power. Furthermore, take into account that there is a delay until the network proceeds to a lower or, accordingly, higher Multislot Class. The delay time is network dependent. In extreme cases, if it takes too much time for the network and the temperature cannot drop due to this delay, the module may even switch off as described in [Section 3.2.5.1](#).

3.4 Power Saving

ELS61-E can be configured in two ways to control power consumption:

- Using the AT command `AT^SPOW` it is possible to specify a so-called power saving mode for the module (`<mode> = 2`; for details on the command see [1]). The module's UART interfaces (ASC0 and ASC1) are then deactivated and will only periodically be activated to be able to listen to network paging messages as described in Section 3.4.1 and Section 3.4.2. See Section 3.4.3 for a description on how to immediately wake up ELS61-E again using RTS0.

Please note that the `AT^SPOW` setting has no effect on the USB interface. As long as the USB connection is active, the module will not change into its SLEEP state to reduce its functionality to a minimum and thus minimizing its current consumption. To enable switching into SLEEP mode, the USB connection must therefore either not be present at all or the USB host must bring its USB interface into Suspend state. Also, `VUSB_IN` should always be kept enabled for this functionality. See "Universal Serial Bus Specification Revision 2.0"¹ for a description of the Suspend state.

- Using the AT command `AT^SCFG="Radio/OutputPowerReduction"` it is possible for the module in GPRS and EGPRS multislots scenarios to reduce its output power according to 3GPP 45.005 section. By default a maximum power reduction is enabled. For details on the command see [1].

3.4.1 Power Saving while Attached to GSM Networks

The power saving possibilities while attached to a GSM network depend on the paging timing cycle of the base station. The duration of a power saving interval can be calculated using the following formula:

$$t = 4.615 \text{ ms (TDMA frame duration)} * 51 \text{ (number of frames)} * \text{DRX value.}$$

DRX (Discontinuous Reception) is a value from 2 to 9, resulting in paging intervals between 0.47 and 2.12 seconds. The DRX value of the base station is assigned by the GSM network operator.

In the pauses between listening to paging messages, the module resumes power saving, as shown in Figure 35.

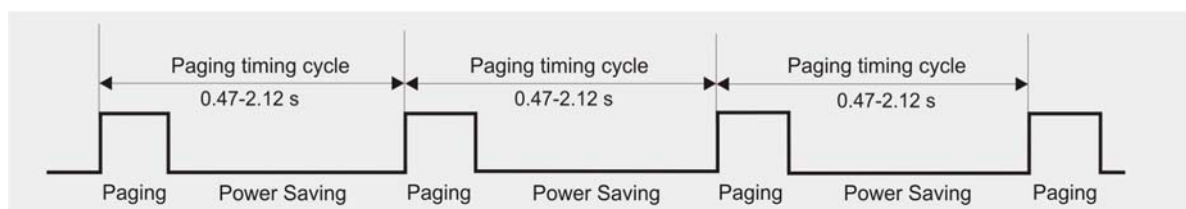


Figure 35: Power saving and paging in GSM networks

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

3.4 Power Saving

The varying pauses explain the different potential for power saving. The longer the pause the less power is consumed.

Generally, power saving depends on the module's application scenario and may differ from the above mentioned normal operation. The power saving interval may be shorter than 0.47 seconds or longer than 2.12 seconds.

3.4.2 Power Saving while Attached to LTE Networks

The power saving possibilities while attached to an LTE network depend on the paging timing cycle of the base station.

During normal LTE operation, i.e., the module is connected to an LTE network, the duration of a power saving period varies. It may be calculated using the following formula:

$$t = \text{DRX Cycle Value} * 10 \text{ ms}$$

DRX cycle value in LTE networks is any of the four values: 32, 64, 128 and 256, thus resulting in power saving intervals between 0.32 and 2.56 seconds. The DRX cycle value of the base station is assigned by the LTE network operator.

In the pauses between listening to paging messages, the module resumes power saving, as shown in [Figure 36](#).

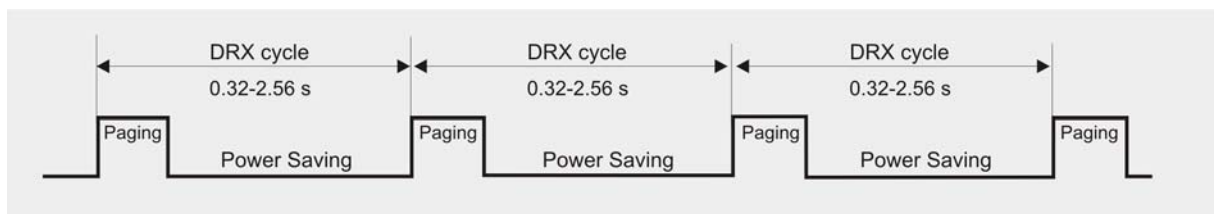


Figure 36: Power saving and paging in LTE networks

The varying pauses explain the different potential for power saving. The longer the pause the less power is consumed.

Generally, power saving depends on the module's application scenario and may differ from the above mentioned normal operation. The power saving interval may be shorter than 0.32 seconds or longer than 2.56 seconds.

3.4.3 Wake-up via RTS0

RTS0 can be used to wake up ELS61-E from SLEEP mode configured with AT^SPOW. Assertion of RTS0 (i.e., toggle from inactive high to active low) serves as wake up event, thus allowing an external application to almost immediately terminate power saving. After RTS0 assertion, the CTS0 line signals module wake up, i.e., readiness of the AT command interface. It is therefore recommended to enable RTS/CTS flow control (default setting).

Figure 37 shows the described RTS0 wake up mechanism.

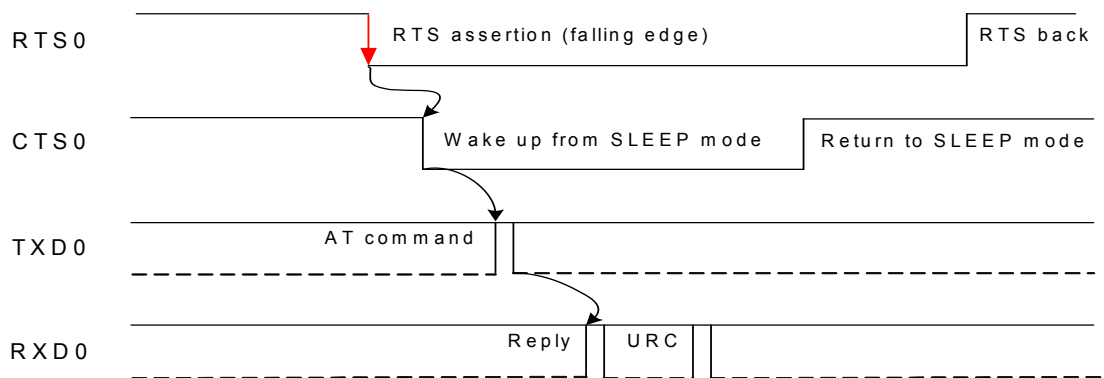


Figure 37: Wake-up via RTS0

3.5 Power Supply

ELS61-E needs to be connected to a power supply at the SMT application interface - 2 lines BATT+, 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 GSM/LTE 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 ELS61-E has to be a single voltage source at BATT+_{BB} and BATT+_{RF}. It must be able to provide the peak current during the uplink transmission.

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.

3.5.1 Power Supply Ratings

Table 12 and Table 13 assemble various voltage supply and current consumption ratings of the module.

Table 12: Voltage supply ratings

	Description	Conditions	Min	Typ	Max	Unit
BATT+	Supply voltage	Directly measured at Module. Voltage must stay within the min/max values, including voltage drop, ripple, spikes	3.0		4.5	V
	Maximum allowed voltage drop during transmit burst	Normal condition, power control level for Pout max			400	mV
	Voltage ripple	Normal condition, power control level for Pout max @ f ≤ 250 kHz @ f > 250 kHz			120 90	mV _{pp} mV _{pp}

3.5 Power Supply

Table 13: Current consumption ratings

	Description	Conditions	Typical rating	Unit	
$I_{VDDL P}$ @ 1.8V	OFF State supply current	RTC backup @ BATT+ = 0V	1.9	μ A	
I_{BATT+}^1 (i.e., sum of BATT+ _{BB} and BATT+ _{RF})	OFF State supply current	Power Down	82	μ A	
	Average GSM supply current	SLEEP ² @ DRX=9 (UART deactivated)	USB disconnected	1.6	mA
			USB suspended	1.6	mA
		SLEEP ² @ DRX=5 (UART deactivated)	USB disconnected	1.8	mA
			USB suspended	1.8	mA
		SLEEP ² @ DRX=2 (UART deactivated)	USB disconnected	2.1	mA
			USB suspended	2.1	mA
		IDLE @ DRX=2 (UART activated, but no communication)	USB disconnected	10.5	mA
			USB active	28	mA
		GPRS Data transfer GSM900; PCL=5; 1Tx/4Rx	ROPR=4 (max. reduction)	236	mA
			ROPR=0 (no reduction)	236	
		GPRS Data transfer GSM900; PCL=5; 2Tx/3Rx	ROPR=4 (max. reduction)	332	mA
			ROPR=0 (no reduction)	446	
		GPRS Data transfer GSM900; PCL=5; 4Tx/1Rx	ROPR=4 (max. reduction)	457	mA
			ROPR=0 (no reduction)	848	
		EDGE Data transfer GSM900; PCL=5; 1Tx/4Rx	ROPR=4 (max. reduction)	158	mA
			ROPR=0 (no reduction)	158	
		EDGE Data transfer GSM900; PCL=5; 2Tx/3Rx	ROPR=4 (max. reduction)	234	mA
			ROPR=0 (no reduction)	286	
		EDGE Data transfer GSM900; PCL=5; 4Tx/1Rx	ROPR=4 (max. reduction)	331	mA
ROPR=0 (no reduction)			522		

3.5 Power Supply

Table 13: Current consumption ratings

	Description	Conditions		Typical rating	Unit
I_{BATT+}^1 (i.e., sum of $BATT+_{BB}$ and $BATT+_{RF}$)	Average GSM supply current	GPRS Data transfer GSM1800; PCL=0; 1Tx/4Rx	ROPR=4 (max. reduction)	133	mA
			ROPR=0 (no reduction)	133	
		GPRS Data transfer GSM1800; PCL=0; 2Tx/3Rx	ROPR=4 (max. reduction)	186	mA
			ROPR=0 (no reduction)	239	
		GPRS Data transfer GSM1800; PCL=0; 4Tx/1Rx	ROPR=4 (max. reduction)	252	mA
			ROPR=0 (no reduction)	430	
		EDGE Data transfer GSM1800; PCL=0; 1Tx/4Rx	ROPR=4 (max. reduction)	114	mA
			ROPR=0 (no reduction)	114	
		EDGE Data transfer GSM1800; PCL=0; 2Tx/3Rx	ROPR=4 (max. reduction)	169	mA
			ROPR=0 (no reduction)	198	
		EDGE Data transfer GSM1800; PCL=0; 4Tx/1Rx	ROPR=4 (max. reduction)	244	mA
			ROPR=0 (no reduction)	347	

3.5 Power Supply

Table 13: Current consumption ratings

	Description	Conditions	Typical rating	Unit	
I_{BATT+}^1 (i.e., sum of $BATT+_{BB}$ and $BATT+_{RF}$)	Peak current during GSM transmit burst	GPRS Data transfer GSM900; PCL=5; 4Tx/1Rx	@ 50Ω	2.4	A
			@ total mismatch	2.2	A
		GPRS Data transfer GSM1800; PCL=0; 4Tx/1Rx	@ 50Ω	2.2	A
			@ total mismatch	2.4	A
	Average LTE supply current	SLEEP ² @ "Paging Occasions" = 256	USB disconnected	1.9	mA
			USB suspended	1.9	mA
	Data transfer @ maximum Pout	SLEEP ² @ "Paging Occasions" = 128	USB disconnected	2.2	mA
			USB suspended	2.2	mA
		SLEEP ² @ "Paging Occasions" = 64	USB disconnected	2.8	mA
			USB suspended	2.85	mA
		SLEEP ² @ "Paging Occasions" = 32	USB disconnected	4.0	mA
			USB suspended	4.0	mA
		IDLE @ DRX=6 (UART active, but no communication)	USB disconnected	12	mA
			USB active	30	mA
		LTE Data transfer Band 1	@ 50 Ohm	510	mA
			@ total mismatch	654	mA
	LTE Data transfer Band 3		452	mA	
LTE Data transfer Band 8		488	mA		
LTE Data transfer Band 20		435	mA		

1. With an impedance of $Z_{LOAD}=50\Omega$ at the antenna connector. Measured at 25°C at 4.5V - except for Power Down ratings that were measured at 3.0V.
2. Measurements start 6 minutes after switching ON the module,
Averaging times: SLEEP mode - 3 minutes, transfer modes - 1.5 minutes
Communication tester settings: no neighbour cells, no cell reselection etc., RMC (reference measurement channel)

3.5.2 Minimizing Power Losses

When designing the power supply for your application please pay specific attention to power losses. Ensure that the input voltage $V_{\text{BATT+}}$ never drops below 3.3V on the ELS61-E board, not even in a GSM transmit burst where current consumption can rise (for peak values see the power supply ratings listed in [Section 3.5.1](#)).

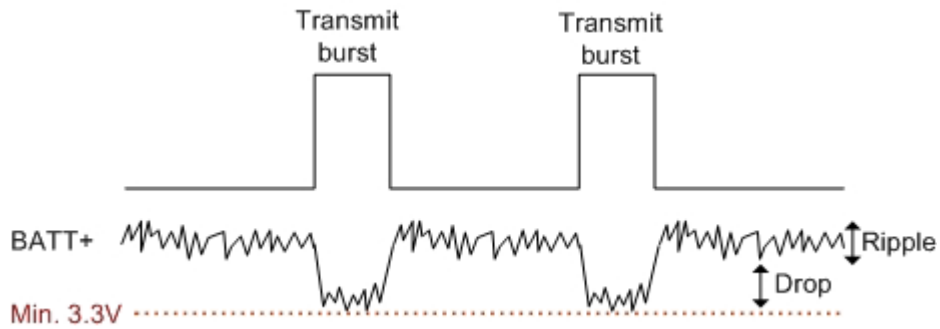


Figure 38: Power supply limits during transmit burst

3.5.3 Measuring the Supply Voltage ($V_{\text{BATT+}}$)

To measure the supply voltage $V_{\text{BATT+}}$ it is possible to define two reference points GND and BATT+. GND should be the module's shielding, while BATT+ should be a test pad on the external application the module is mounted on. The external BATT+ reference point has to be connected to and positioned close to the SMT application interface's BATT+ pads 53 (BATT+_{RF}) or 204 (BATT+_{BB}) as shown in [Figure 39](#).

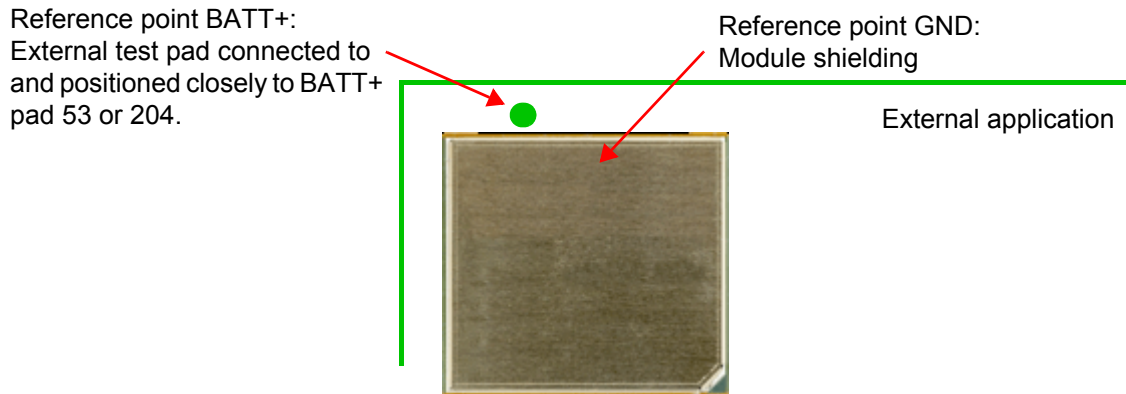


Figure 39: Position of reference points BATT+ and GND

3.5.4 Monitoring Power Supply by AT Command

To monitor the supply voltage you can also use the $\text{AT}^{\wedge}\text{SBV}$ command which returns the value related to the reference points BATT+ and GND.

The module continuously measures the voltage at intervals depending on the operating mode of the RF interface. The duration of measuring ranges from 0.5 seconds in TALK/DATA mode to 50 seconds when ELS61-E is in IDLE mode or Limited Service (deregistered). The displayed voltage (in mV) is averaged over the last measuring period before the $\text{AT}^{\wedge}\text{SBV}$ command was executed.

If the measured voltage drops below or rises above the voltage shutdown thresholds, the module will send an $\text{AT}^{\wedge}\text{SBC}$ URC and shut down (for details see [Section 3.2.5](#)).

3.6 Operating Temperatures

Please note that the module's lifetime, i.e., the MTTF (mean time to failure) may be reduced, if operated outside the extended temperature range.

Table 14: Board temperature

Parameter	Min	Typ	Max	Unit
Normal operation	-30	+25	+85	°C
Extended operation ¹	-40		+90	°C
Automatic shutdown ² Temperature measured on ELS61-E board	<-40	---	>+90	°C

1. 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.

2. Due to temperature measurement uncertainty, a tolerance of $\pm 3^{\circ}\text{C}$ on the thresholds may occur.

See also [Section 3.2.5](#) for information about the NTC for on-board temperature measurement, automatic thermal shutdown and alert messages.

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.

For more information regarding the module's thermal behavior please refer to [\[4\]](#).

3.7 Electrostatic Discharge

The module is not protected against Electrostatic Discharge (ESD) in general. Consequently, it is subject to ESD handling precautions that typically apply to ESD sensitive components. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates a ELS61-E module.

An example for an enhanced ESD protection for the SIM interface is given in [Section 2.1.6.1](#).

ELS61-E has been tested according to group standard ETSI EN 301 489-1 (see [Table 21](#)) and test standard EN 61000-4-2. Electrostatic values can be gathered from the following table.

Table 15: Electrostatic values

Specification/Requirements	Contact discharge	Air discharge
EN 61000-4-2		
Antenna interfaces	±1kV	n.a.
Antenna interfaces with ESD protection (see Section 3.7.1)	±4kV	±8kV
BATT+	±4kV	±8kV
JEDEC JESD22-A114D (Human Body Model, Test conditions: 1.5 kΩ, 100 pF)		
All other interfaces	±1kV	n.a.

Note: The values may vary with the individual application design. For example, it matters whether or not the application platform is grounded over external devices like a computer or other equipment, such as the Gemalto reference application described in [Chapter 5](#).

3.7.1 ESD Protection for Antenna Interfaces

The following [Figure 40](#) shows how to implement an external ESD protection for the RF antenna interfaces (ANT_MAIN and ANT_DRX) with either a T pad or PI pad attenuator circuit (for RF line routing design see also [Section 2.2.3](#)).

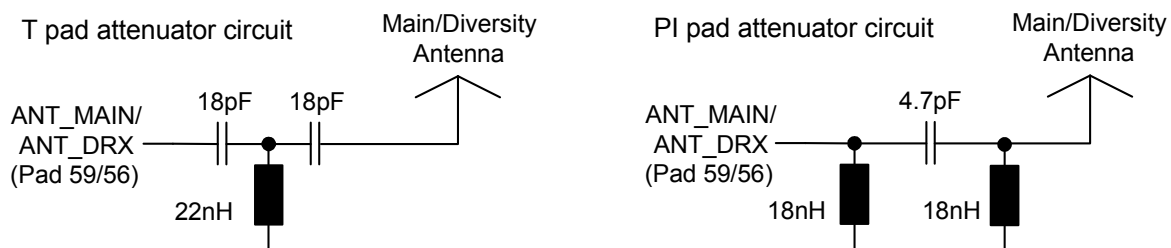


Figure 40: ESD protection for RF antenna interface

Recommended inductor types for the above sample circuits: Size 0402 SMD from Panasonic ELJRF series (22nH and 18nH inductors) or Murata LQW15AN18NJ00 (18nH inductors only).

3.8 Blocking against RF on Interface Lines

To reduce EMI issues there are serial resistors, or capacitors to GND, implemented on the module for the ignition, emergency restart, and SIM interface lines (cp. [Section 2.3](#)). However, all other signal lines have no EMI measures on the module and there are no blocking measures at the module's interface to an external application.

Dependent on the specific application design, it might be useful to implement further EMI measures on some signal lines at the interface between module and application. These measures are described below.

There are five possible variants of EMI measures (A-E) that may be implemented between module and external application depending on the signal line (see [Figure 41](#) and [Table 16](#)). Pay attention not to exceed the maximum input voltages and prevent voltage overshots if using inductive EMC measures.

The maximum value of the serial resistor should be lower than $1\text{k}\Omega$ on the signal line. The maximum value of the capacitor should be lower than 50pF on the signal line. Please observe the electrical specification of the module's SMT application interface and the external application's interface.

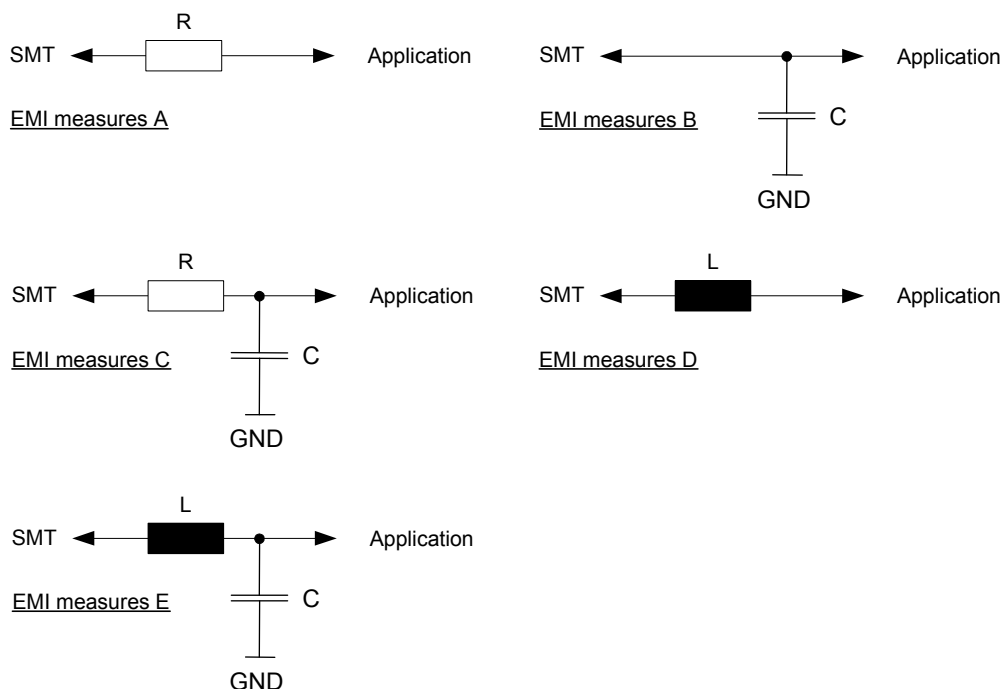


Figure 41: EMI circuits

Note: In case the application uses an internal RF antenna that is implemented close to the ELS61-E module, Gemalto strongly recommends sufficient EMI measures, e.g. of type B or C, for each digital input or output.

3.8 Blocking against RF on Interface Lines

The following table lists for each signal line at the module's SMT application interface the EMI measures that may be implemented.

Table 16: EMI measures on the application interface

Signal name	EMI measures					Remark
	A	B	C	D	E	
CCIN	x			x		
CCRST		x				The external capacitor should be not higher than 10pF. The value of the capacitor depends on the external application.
CCIO		x				
CCCLK		x				
RXD0	x	x	x	x	x	
TXD0	x	x	x	x	x	
CTS0	x	x	x	x	x	
RTS0	x	x	x	x	x	
GPIO1/DTR0	x	x	x	x	x	
GPIO2/DCD0	x	x	x	x	x	
GPIO3/DSR0/SPI_CLK	x	x	x	x	x	
GPIO4/FST_SHDN	x	x	x	x	x	
GPIO5/LED	x	x	x	x	x	
GPIO6/PWM2	x	x	x	x	x	
GPIO7/PWM1	x	x	x	x	x	
GPIO8/COUNTER	x	x	x	x	x	
GPIO11-GPIO15	x	x	x	x	x	
GPIO16/RXD1/MOSI	x	x	x	x	x	
GPIO17/TXD1/MISO	x	x	x	x	x	
GPIO18/RTS1	x	x	x	x	x	
GPIO19/CTS1/SPI_CS	x	x	x	x	x	
GPIO20	x	x	x	x	x	
GPIO21	x	x	x	x	x	
GPIO22	x	x	x	x	x	
GPIO23	x	x	x	x	x	
GPIO24/RING0	x	x	x	x	x	
I2CDAT		x		x		The rising signal edge is reduced with an additional capacitor.
I2CCLK		x		x		
V180		x		x	x	
VCORE		x		x	x	
BATT ⁺ _{RF} (pad 53)		x	x			Measures required if BATT ⁺ _{RF} is close to internal RF antenna - e.g., 39pF blocking capacitor to ground
BATT ⁺ _{BB} (pad 204)		x	x			

3.9 Reliability Characteristics

The test conditions stated below are an extract of the complete test specifications.

Table 17: Summary of reliability test conditions

Type of test	Conditions	Standard
Vibration	Frequency range: 10-20Hz; acceleration: 5g Frequency range: 20-500Hz; acceleration: 20g Duration: 20h per axis; 3 axes	DIN IEC 60068-2-6 ¹
Shock half-sinus	Acceleration: 500g Shock duration: 1ms 1 shock per axis 6 positions (\pm x, y and z)	DIN IEC 60068-2-27
Dry heat	Temperature: $+70 \pm 2^{\circ}\text{C}$ Test duration: 16h Humidity in the test chamber: $< 50\%$	EN 60068-2-2 Bb ETS 300 019-2-7
Temperature change (shock)	Low temperature: $-40^{\circ}\text{C} \pm 2^{\circ}\text{C}$ High temperature: $+85^{\circ}\text{C} \pm 2^{\circ}\text{C}$ Changeover time: $< 30\text{s}$ (dual chamber system) Test duration: 1h Number of repetitions: 100	DIN IEC 60068-2-14 Na ETS 300 019-2-7
Damp heat cyclic	High temperature: $+55^{\circ}\text{C} \pm 2^{\circ}\text{C}$ Low temperature: $+25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ Humidity: $93\% \pm 3\%$ Number of repetitions: 6 Test duration: 12h + 12h	DIN IEC 60068-2-30 Db ETS 300 019-2-5
Cold (constant exposure)	Temperature: $-40 \pm 2^{\circ}\text{C}$ Test duration: 16h	DIN IEC 60068-2-1

1. For reliability tests in the frequency range 20-500Hz the Standard's acceleration reference value was increased to 20g.

4 Mechanical Dimensions, Mounting and Packaging

4.1 Mechanical Dimensions of ELS61-E

Figure 42 shows the top and bottom view of ELS61-E and provides an overview of the board's mechanical dimensions. For further details see Figure 43.

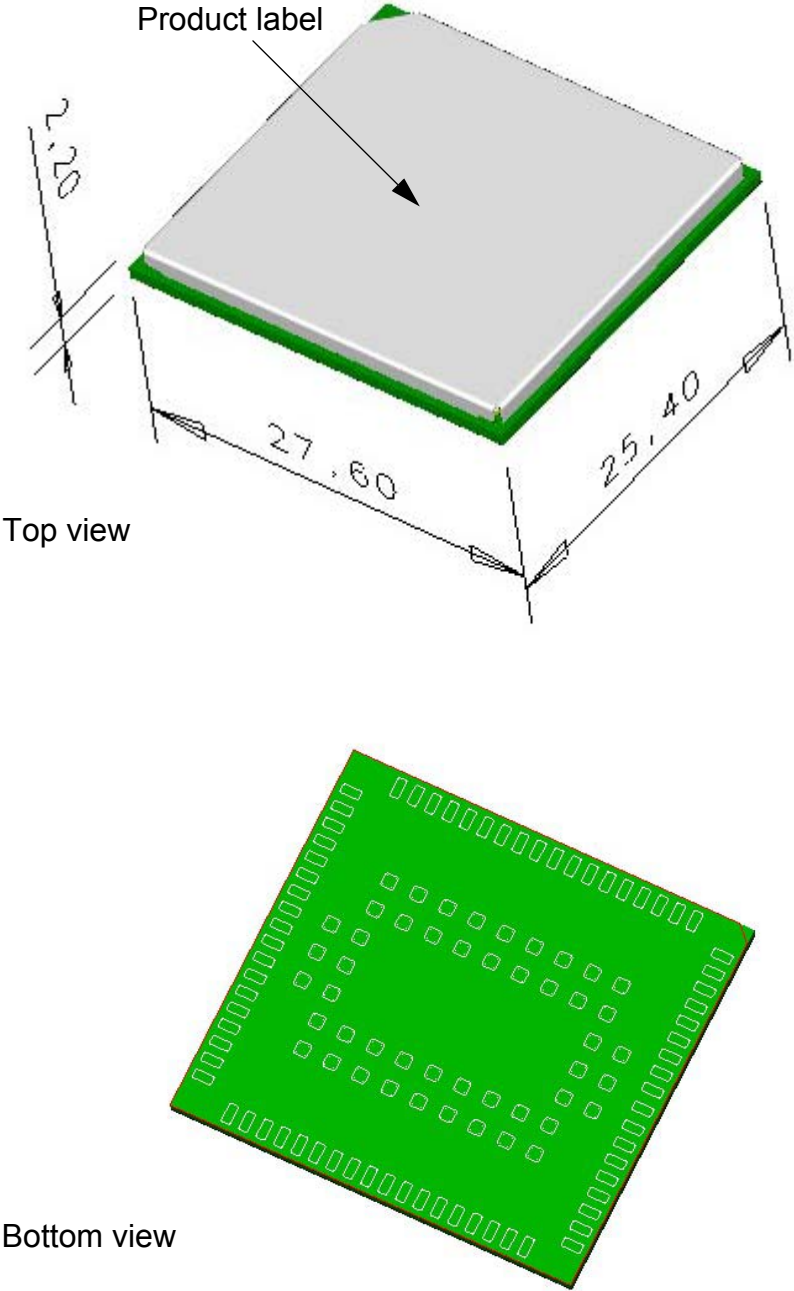


Figure 42: ELS61-E– top and bottom view

4.2 Mounting ELS61-E onto the Application Platform

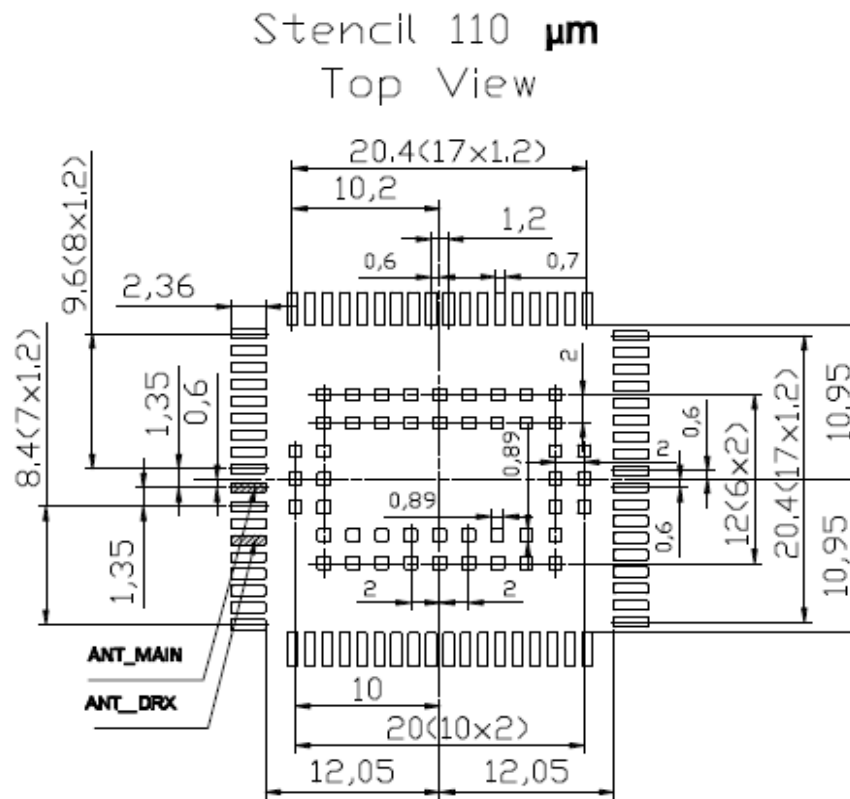


Figure 45: Recommended design for 110µm micron thick stencil (top view)

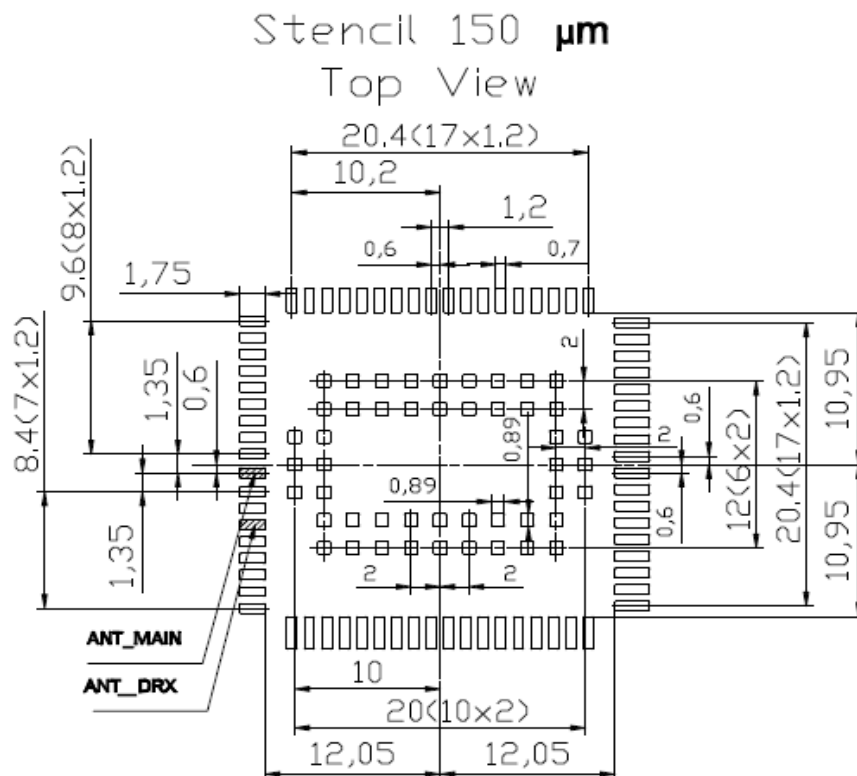


Figure 46: Recommended design for 150µm micron thick stencil (top view)

4.2.1.2 Board Level Characterization

Board level characterization issues should also be taken into account if devising an SMT process.

Characterization tests should attempt to optimize the SMT process with regard to board level reliability. This can be done by performing the following physical tests on sample boards: Peel test, bend test, tensile pull test, drop shock test and temperature cycling. Sample surface mount checks are described in [\[3\]](#).

It is recommended to characterize land patterns before an actual PCB production, taking individual processes, materials, equipment, stencil design, and reflow profile into account. For land and stencil pattern design recommendations see also [Section 4.2.1.1](#). Optimizing the solder stencil pattern design and print process is necessary to ensure print uniformity, to decrease solder voids, and to increase board level reliability.

Daisy chain modules for SMT characterization are available on request. For details refer to [\[3\]](#).

Generally, solder paste manufacturer recommendations for screen printing process parameters and reflow profile conditions should be followed. Maximum ratings are described in [Section 4.2.3](#).

4.2.2 Moisture Sensitivity Level

ELS61-E comprises components that are susceptible to damage induced by absorbed moisture.

Gemalto M2M's ELS61-E module complies with the latest revision of the IPC/JEDEC J-STD-020 Standard for moisture sensitive surface mount devices and is classified as MSL 4.

For additional moisture sensitivity level (MSL) related information see [Section 4.2.4](#) and [Section 4.3.2](#).

4.2.3 Soldering Conditions and Temperature

4.2.3.1 Reflow Profile

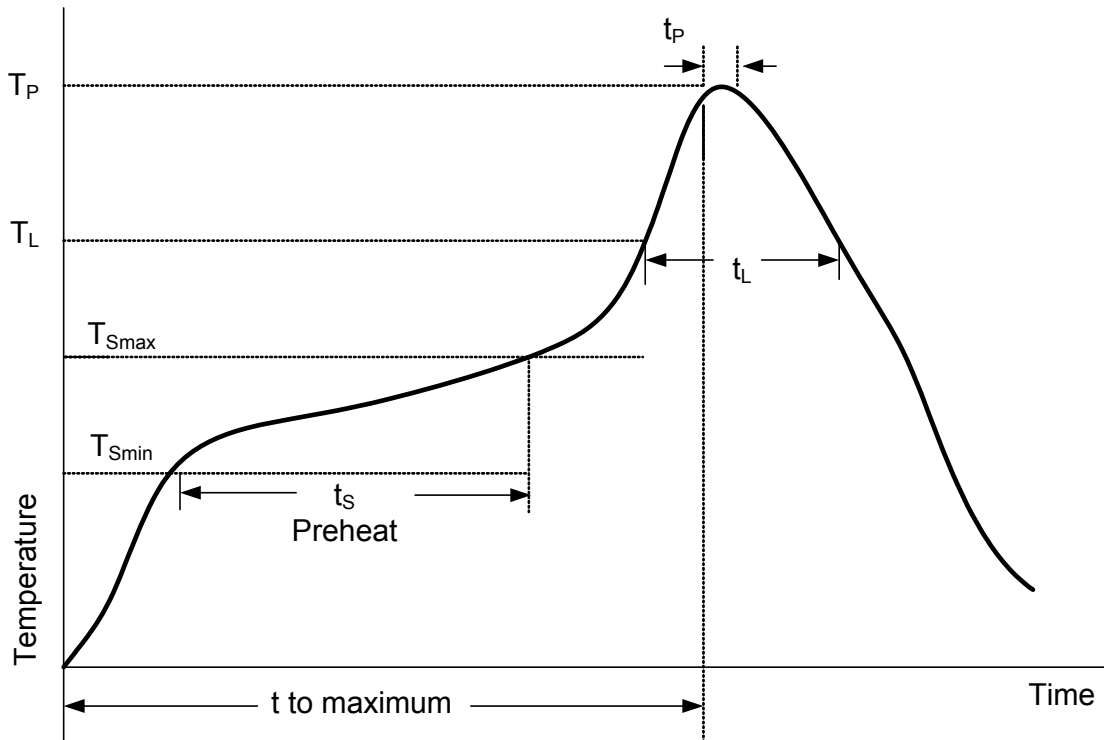


Figure 47: Reflow Profile

Table 18: Reflow temperature ratings¹

Profile Feature	Pb-Free Assembly
Preheat & Soak Temperature Minimum (T_{Smin}) Temperature Maximum (T_{Smax}) Time (t_{Smin} to t_{Smax}) (t_s)	150°C 200°C 60-120 seconds
Average ramp up rate (T_L to T_P)	3K/second max.
Liquidous temperature (T_L) Time at liquidous (t_L)	217°C 60-90 seconds
Peak package body temperature (T_P)	245°C +0/-5°C
Time (t_p) within 5 °C of the peak package body temperature (T_P)	30 seconds max.
Average ramp-down rate (T_P to T_L)	3 K/second max.
Time 25°C to maximum temperature	8 minutes max.

1. Please note that the reflow profile features and ratings listed above are based on the joint industry standard IPC/JEDEC J-STD-020D.1, and are as such meant as a general guideline. For more information on reflow profiles and their optimization please refer to [3].

4.2.3.2 Maximum Temperature and Duration

The following limits are recommended for the SMT board-level soldering process to attach the module:

- A maximum module temperature of 240°C. This specifies the temperature as measured at the module's top side.
- A maximum duration of 15 seconds at this temperature.

Please note that while the solder paste manufacturers' recommendations for best temperature and duration for solder reflow should generally be followed, the limits listed above must not be exceeded.

ELS61-E is specified for one soldering cycle only. Once ELS61-E is removed from the application, the module will very likely be destroyed and cannot be soldered onto another application.

4.2.4 Durability and Mechanical Handling

4.2.4.1 Storage Conditions

ELS61-E modules, as delivered in tape and reel carriers, must be stored in sealed, moisture barrier anti-static bags. The conditions stated below are only valid for modules in their original packed state in weather protected, non-temperature-controlled storage locations. Normal storage time under these conditions is 12 months maximum.

Table 19: Storage conditions

Type	Condition	Unit	Reference
Air temperature: Low High	-25 +40	°C	IPC/JEDEC J-STD-033A
Humidity relative: Low High	10 90 at 40°C	%	IPC/JEDEC J-STD-033A
Air pressure: Low High	70 106	kPa	IEC TR 60271-3-1: 1K4 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 Heat	1120 600	W/m ²	ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb 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: Displacement Acceleration Frequency range	1.5 5 2-9 9-200	mm m/s ² Hz	IEC TR 60271-3-1: 1M2
Shocks: Shock spectrum Duration Acceleration	semi-sinusoidal 1 50	ms m/s ²	IEC 60068-2-27 Ea

4.2.4.2 Processing Life

ELS61-E must be soldered to an application within 72 hours after opening the moisture barrier bag (MBB) it was stored in.

As specified in the IPC/JEDEC J-STD-033 Standard, the manufacturing site processing the modules should have ambient temperatures below 30°C and a relative humidity below 60%.

4.2.4.3 Baking

Baking conditions are specified on the moisture sensitivity label attached to each MBB (see [Figure 52](#) for details):

- It is *not necessary* to bake ELS61-E, if the conditions specified in [Section 4.2.4.1](#) and [Section 4.2.4.2](#) were not exceeded.
- It is *necessary* to bake ELS61-E, if any condition specified in [Section 4.2.4.1](#) and [Section 4.2.4.2](#) was exceeded.

If baking is necessary, the modules must be put into trays that can be baked to at least 125°C. Devices should not be baked in tape and reel carriers at any temperature.

4.2.4.4 Electrostatic Discharge

Electrostatic discharge (ESD) may lead to irreversable damage for the module. It is therefore advisable to develop measures and methods to counter ESD and to use these to control the electrostatic environment at manufacturing sites.

Please refer to [Section 3.7](#) for further information on electrostatic discharge.

4.3 Packaging

4.3 Packaging

4.3.1 Tape and Reel

The single-feed tape carrier for ELS61-E is illustrated in Figure 48. The figure also shows the proper part orientation. The tape width is 44mm and the ELS61-E modules are placed on the tape with a 32-mm pitch. The reels are 330mm in diameter with a core diameter of 100mm. Each reel contains 500 modules.

4.3.1.1 Orientation

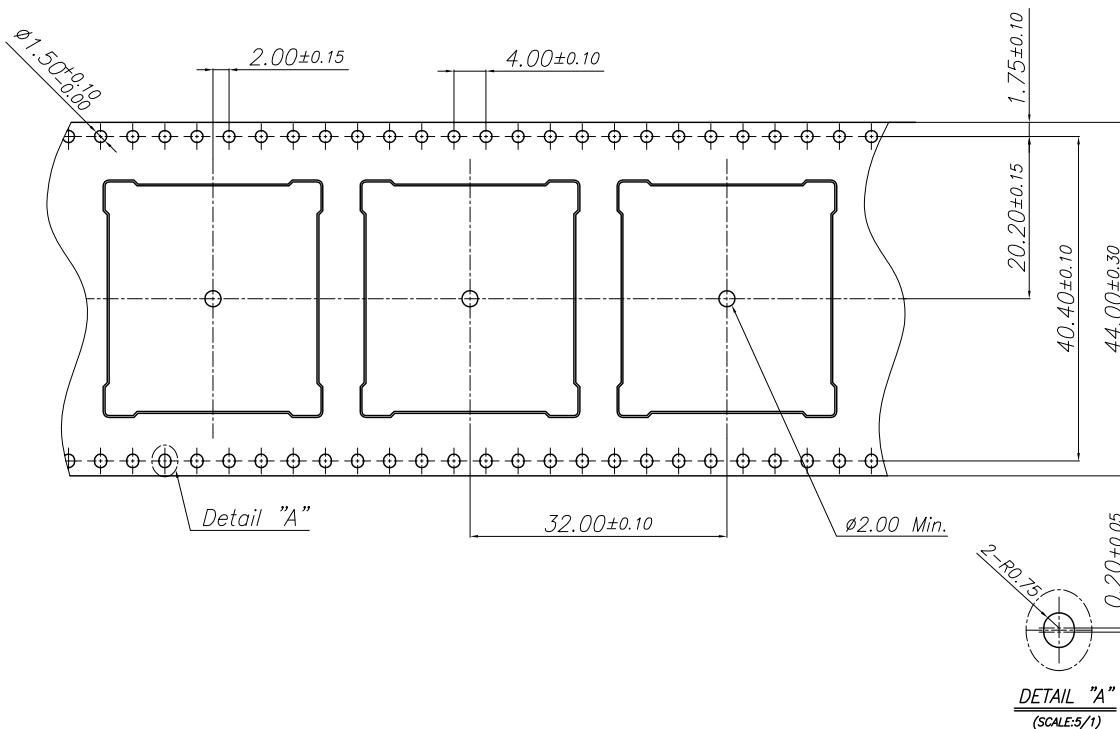


Figure 48: Carrier tape

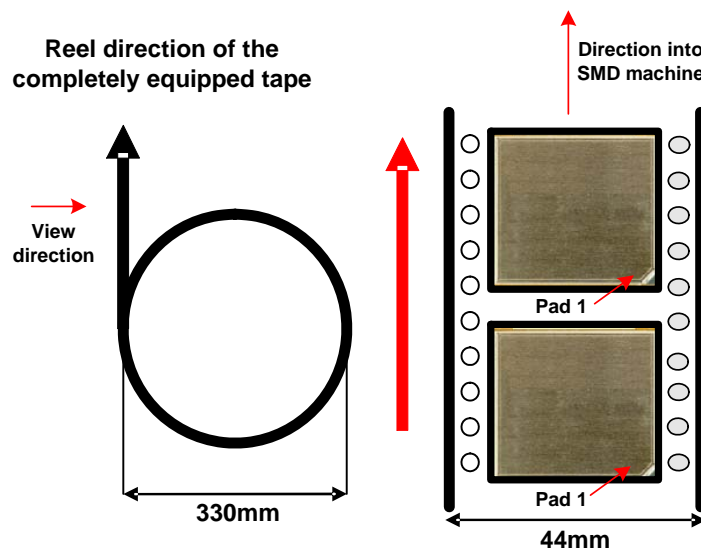


Figure 49: Reel direction

4.3.1.2 Barcode Label

A barcode label provides detailed information on the tape and its contents. It is attached to the reel.

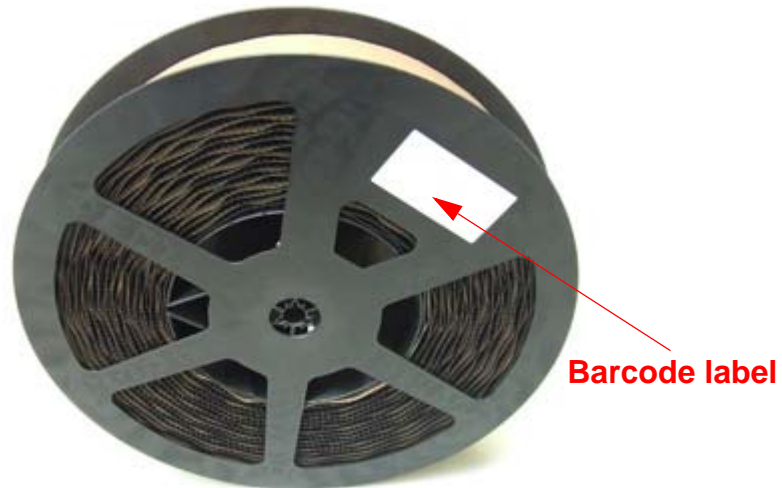


Figure 50: Barcode label on tape reel

4.3.2 Shipping Materials

ELS61-E is distributed in tape and reel carriers. The tape and reel carriers used to distribute ELS61-E are packed as described below, including the following required shipping materials:

- Moisture barrier bag, including desiccant and humidity indicator card
- Transportation box

4.3.2.1 Moisture Barrier Bag

The tape reels are stored inside a moisture barrier bag (MBB), together with a humidity indicator card and desiccant pouches - see [Figure 51](#). The bag is ESD protected and delimits moisture transmission. It is vacuum-sealed and should be handled carefully to avoid puncturing or tearing. The bag protects the ELS61-E modules from moisture exposure. It should not be opened until the devices are ready to be soldered onto the application.

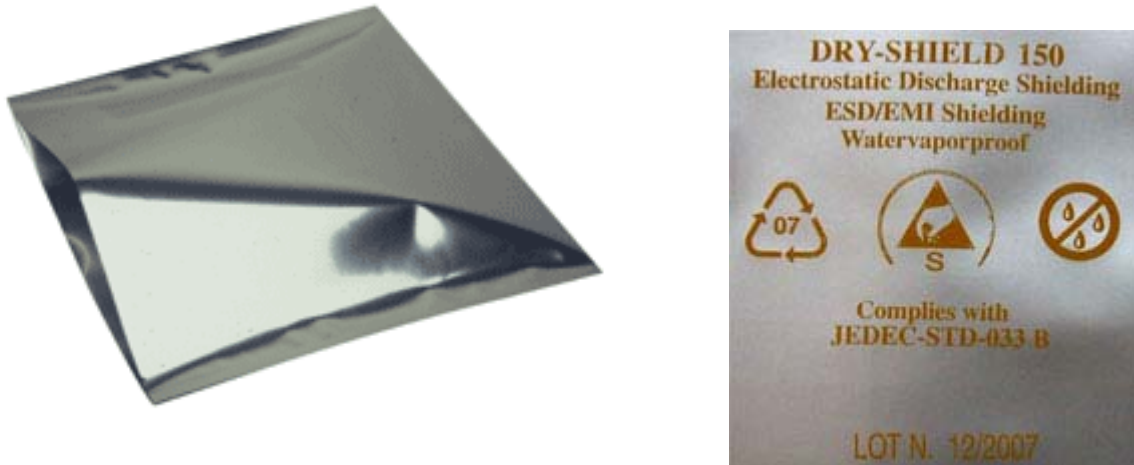


Figure 51: Moisture barrier bag (MBB) with imprint

The label shown in [Figure 52](#) summarizes requirements regarding moisture sensitivity, including shelf life and baking requirements. It is attached to the outside of the moisture barrier bag.

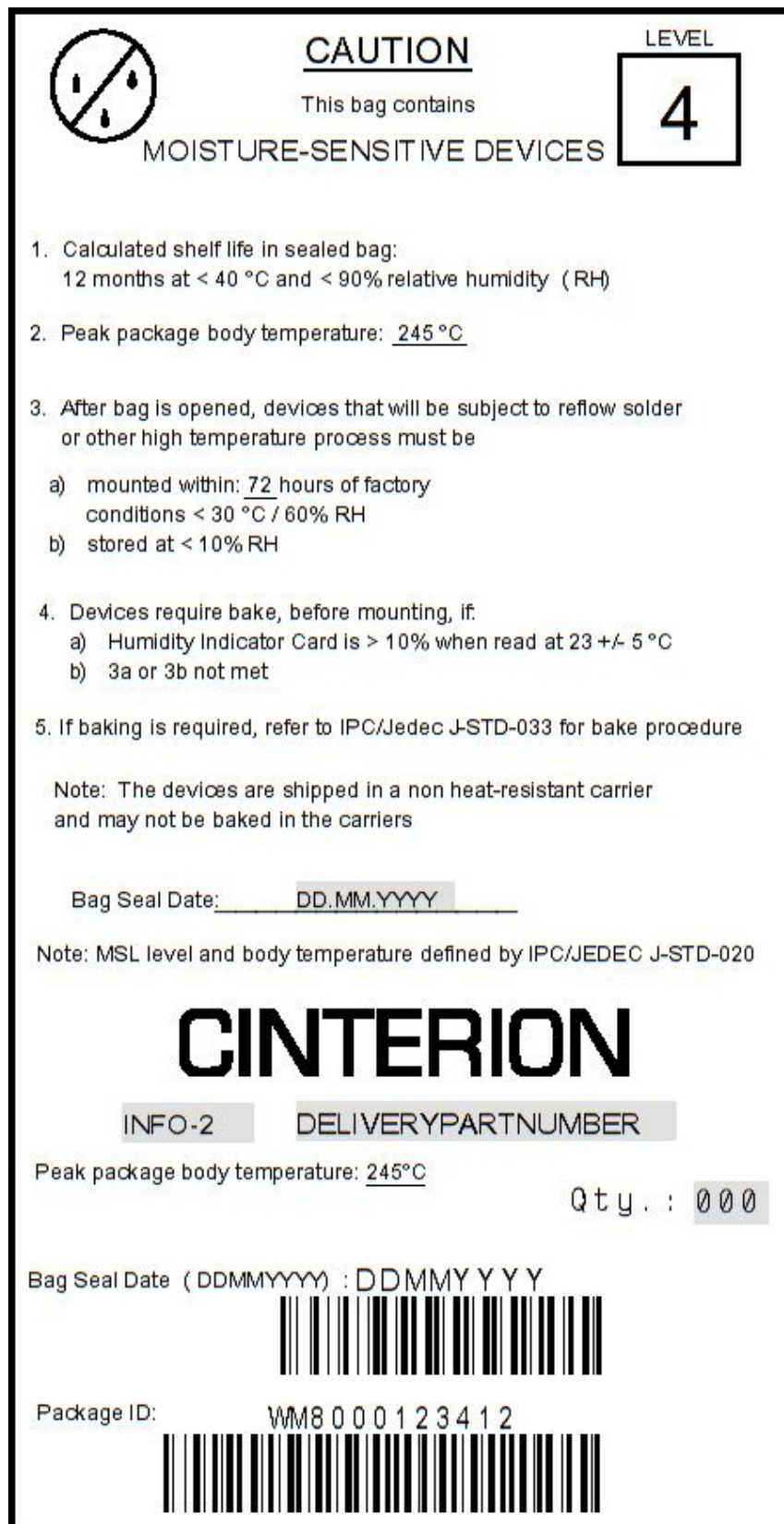


Figure 52: Moisture Sensitivity Label

4.3 Packaging

MBBs contain one or more desiccant pouches to absorb moisture that may be in the bag. The humidity indicator card described below should be used to determine whether the enclosed components have absorbed an excessive amount of moisture.

The desiccant pouches should not be baked or reused once removed from the MBB.

The humidity indicator card is a moisture indicator and is included in the MBB to show the approximate relative humidity level within the bag. Sample humidity cards are shown in [Figure 53](#). If the components have been exposed to moisture above the recommended limits, the units will have to be rebaked.

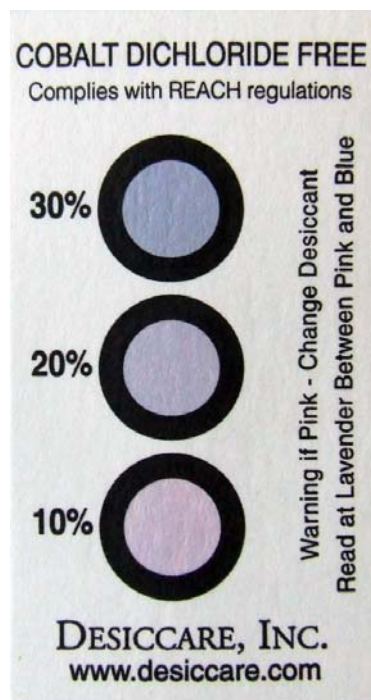


Figure 53: Humidity Indicator Card - HIC

A baking is required if the humidity indicator inside the bag indicates 10% RH or more.

4.3.2.2 Transportation Box

Tape and reel carriers are distributed in a box, marked with a barcode label for identification purposes. A box contains two reels with 500 modules each.

4.3.3 Trays

If small module quantities are required, e.g., for test and evaluation purposes, ELS61-E may be distributed in trays (for dimensions see [Figure 54](#)). The small quantity trays are an alternative to the single-feed tape carriers normally used. However, the trays are not designed for machine processing. They contain modules to be (hand) soldered onto an external application (for information on hand soldering see [\[4\]](#)).

Trays are packed and shipped in the same way as tape carriers, including a moisture barrier bag with desiccant and humidity indicator card as well as a transportation box (see also [Section 4.3.2](#)).

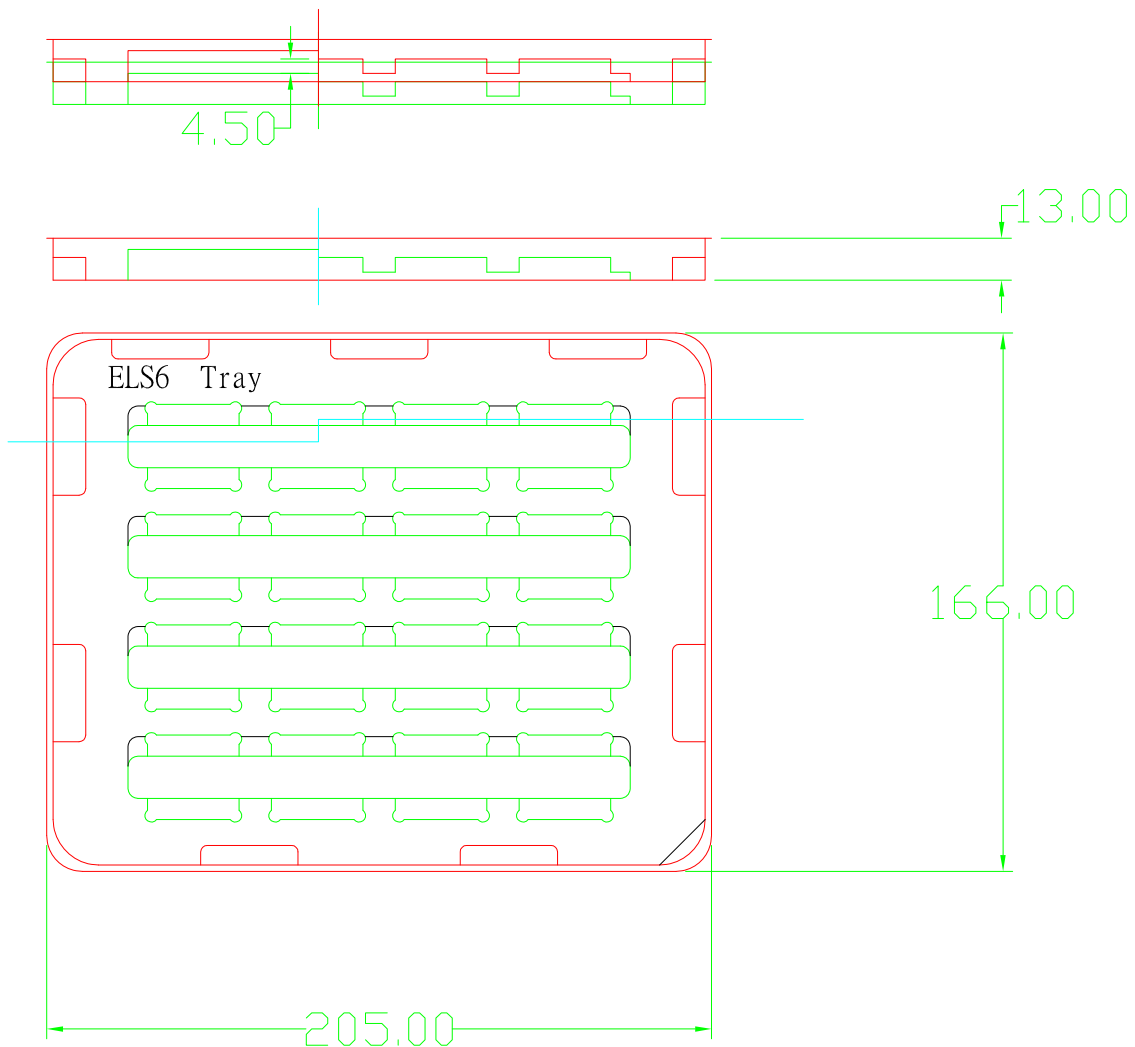


Figure 54: Tray dimensions

5 Regulatory and Type Approval Information

5.1 Directives and Standards

ELS61-E 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 "ELS61-E Hardware Interface Description".¹

Table 20: Directives


1999/05/EC	Directive of the European Parliament and of the council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (in short referred to as R&TTE Directive 1999/5/EC). The product is labeled with the CE conformity mark CE1588
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 21: Standards of European type approval

3GPP TS 51.010-1	Digital cellular telecommunications system (Release 9); Mobile Station (MS) conformance specification;
GCF-CC V3.61.2	Global Certification Forum - Certification Criteria
EN 301 511 V12.1.1	Global System for Mobile communications (GSM); Harmonized standard for mobile stations in the GSM 900 and DCS 1800 bands covering essential requirements under article 3.2 of the R&TTE directive (1999/5/EC)
EN 301 908-01 V7.1.1	Electromagnetic compatibility and Radio spectrum Matters (ERM); Base Stations (BS) and User Equipment (UE) for IMT-2000 Third Generation cellular networks; Part 1: Harmonized EN for IMT-2000, introduction and common requirements of article 3.2 of the R&TTE Directive
EN 301 908-13 V7.1.1	IMT-2000 Cellular Networks; Harmonized En Covering the Essential Requirements of Article 3.2 of the R&TTE Directive; Part 13: Evolved Universal Terrestrial Radio Access (E-UTRA) User Equipment (UE)
ETSI EN 301 489-01 V1.9.2	Electromagnetic Compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common Technical Requirements
ETSI EN 301 489-07 V1.3.1	Electromagnetic Compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 7: Specific conditions for mobile and portable radio and ancillary equipment of digital cellular radio telecommunications systems (GSM and DCS)
ETSI EN 301 489-24 V1.5.1	Electromagnetic Compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 24: Specific conditions for IMT-2000 CDMA Direct Spread (UTRA) for Mobile and portable (UE) radio and ancillary equipment

1. Manufacturers of applications which can be used in the US shall ensure that their applications have a PTCRB approval. For this purpose they can refer to the PTCRB approval of the respective module.

5.1 Directives and Standards


Table 21: Standards of European type approval

EN 60950-1:2006 +A11:2009 +A1:2010 +A12:2011	Information technology equipment - Safety Part 1: General requirements (IEC 60950-1:2005, modified); Amendment A11: 2009; Amendment A1: 2010; Amendment A12: 2011
EN 62311:2008	Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz) [Superseded: CENELEC EN 50392]

Table 22: Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes

Table 23: 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 Gemalto M2M Hardware Interface Description.</p> <p>Please see Table 24 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> 

5.1 Directives and Standards

Table 24: 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)	○	○	○	○	○	○
电路模块 (Circuit Modules)	X	○	○	○	○	○
电缆及电缆组件 (Cables and Cable Assemblies)	○	○	○	○	○	○
塑料和聚合物部件 (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.

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 ELS61-E 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 European-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 European markets

EN 50360 Product standard to demonstrate the compliance of mobile phones with the basic restrictions related to human exposure to electromagnetic fields (300MHz - 3GHz)

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

5.3 Reference Equipment for Type Approval

The Gemalto M2M reference setup submitted to type approve ELS61-E (including a special approval adapter for the DSB75) is shown in the following figure¹:

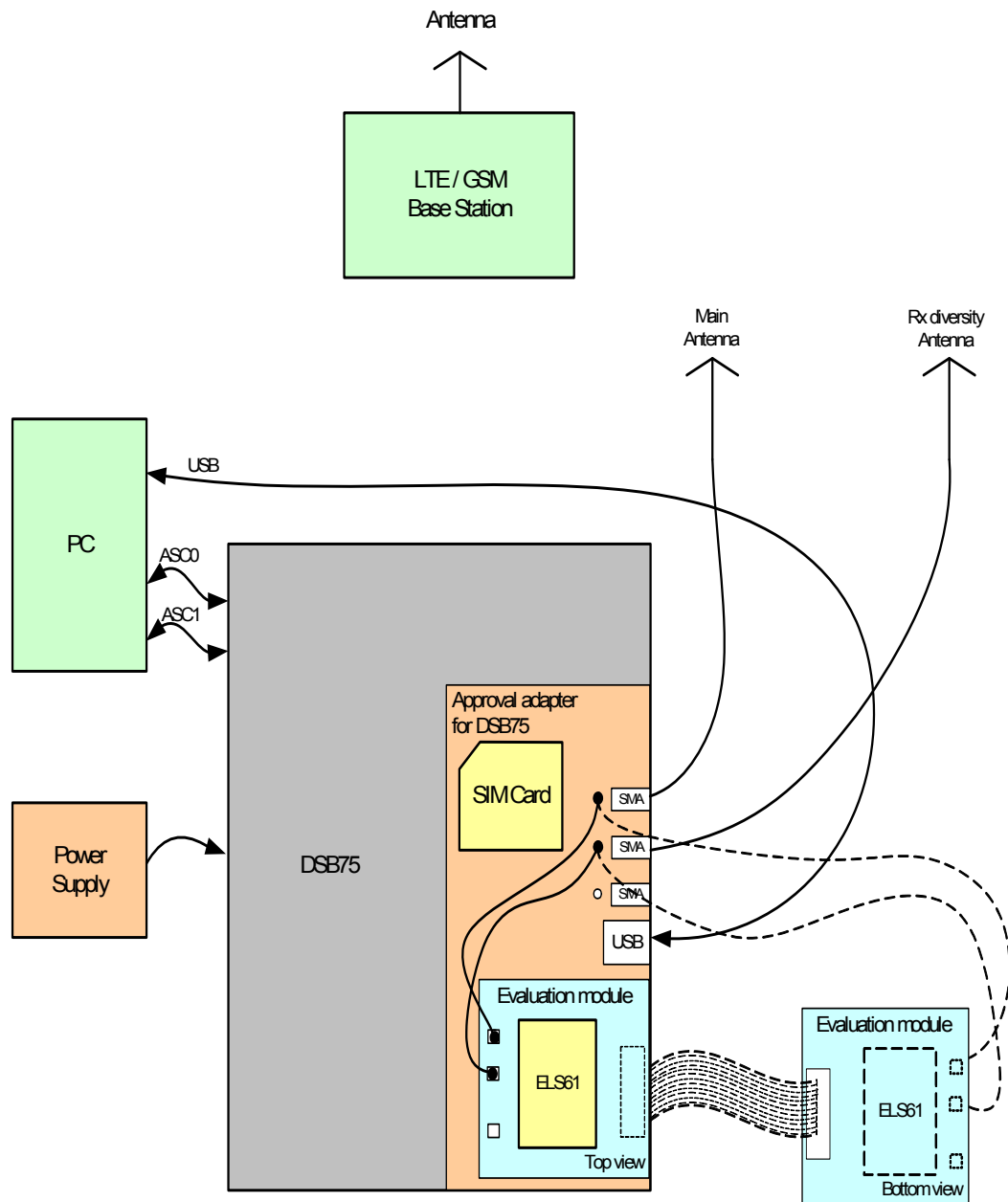


Figure 55: Reference equipment for Type Approval

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 test equipment instead of employing the SMA antenna connectors on the ELS61-E-DSB75 adapter as shown in Figure 55. The following products are recommended:

Hirose SMA-Jack/U.FL-Plug conversion adapter HRMJ-U.FLP(40)

(for details 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/pdfs/wmod3&4T.pdf>)

6 Document Information

6.1 Revision History

Preceding document: "Cinterion® ELS61-E Hardware Interface Description" Version 00.301.

New document: "Cinterion® ELS61-E Hardware Interface Description" Version 01.000.

Chapter	What is new
3.2.4.1	Add description for how to monitor module power supply status.
3.4.1	Update data in Table 13 .

New document: "Cinterion® ELS61-E Hardware Interface Description" Version 00.301.

Chapter	What is new
--	Initial document setup.

6.2 Related Documents

- [1] ELS61-E AT Command Set
- [2] ELS61-E Release Note
- [3] Application Note 48: SMT Module Integration
- [4] Application Note 40: Thermal Solutions
- [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 ELS61-E
B	Thermistor Constant
BER	Bit Error Rate
BIP	Bearer Independent Protocol
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
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
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

6.3 Terms and Abbreviations







Abbreviation	Description
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
I/O	Input/Output
IC	Integrated Circuit
IMEI	International Mobile Equipment Identity
ISO	International Standards Organization
ITU	International Telecommunications Union
kbits	kbits per second
LED	Light Emitting Diode
Li-Ion/Li+	Lithium-Ion
Li battery	Rechargeable Lithium Ion or Lithium Polymer battery
LPM	Link Power Management
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
PCN	Personal Communications Network, also referred to as DCS 1800
PCS	Personal Communication System, also referred to as GSM 1900
PDU	Protocol Data Unit
PLL	Phase Locked Loop

6.3 Terms and Abbreviations

Abbreviation	Description
PPP	Point-to-point protocol
PSK	Phase Shift Keying
PSU	Power Supply Unit
PWM	Pulse Width Modulation
R&TTE	Radio and Telecommunication Terminal Equipment
RAM	Random Access Memory
RF	Radio Frequency
RLS	Radio Link Stability
RMS	Root Mean Square (value)
RoHS	Restriction of the use of certain hazardous substances in electrical and electronic equipment.
ROM	Read-only Memory
RTC	Real Time Clock
RTS	Request to Send
Rx	Receive Direction
SAR	Specific Absorption Rate
SAW	Surface Accoustic Wave
SELV	Safety Extra Low Voltage
SIM	Subscriber Identification Module
SMD	Surface Mount Device
SMS	Short Message Service
SMT	Surface Mount Technology
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
TA	Terminal adapter (e.g. GSM module)
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 ELS61-E. 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.

	<p>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.</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>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 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.</p>
	<p>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.</p>

7 Appendix

7.1 List of Parts and Accessories

Table 25: List of parts and accessories

Description	Supplier	Ordering information
ELS61-E	Gemalto M2M	Standard module Gemalto M2M IMEI: Packaging unit (ordering) number: L30960-N4450-A100 Module label number: S30960-S4450-A100-1
ELS61-E Evaluation Module	Gemalto M2M	Ordering number: L30960-N4451-A100(ELS61-E)
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 ELS61-E evaluation modules onto DSB75	Gemalto M2M	Ordering number: L30960-N0010-A100
Approval adapter for mounting ELS61-E evaluation modules onto DSB75	Gemalto M2M	Ordering number: L30960-N2301-A100
Votronic Handset	Votronic / Gemalto M2M	Gemalto M2M ordering number: L36880-N8301-A107 Votronic ordering number: HH-SI-30.3/V1.1/0 Votronic Entwicklungs- und Produktionsgesellschaft für elektronische Geräte mbH Saarbrücker Str. 8 66386 St. Ingbert Germany Phone: +49-(0)6 89 4 / 92 55-0 Fax: +49-(0)6 89 4 / 92 55-88 Email: contact@votronic.com
SIM card holder incl. push button ejector and slide-in tray	Molex	Ordering numbers: 91228 91236 Sales contacts are listed in Table 26 .

7.1 List of Parts and Accessories

Table 26: 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 2014 annual revenues of €2.5 billion and blue-chip customers in over 180 countries. Our 14,000 employees operate out of 99 offices, 34 personalization and data centers, and 24 research and software development centers located in 46 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.

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