Cinterion® ENS22-E

Hardware Interface Description

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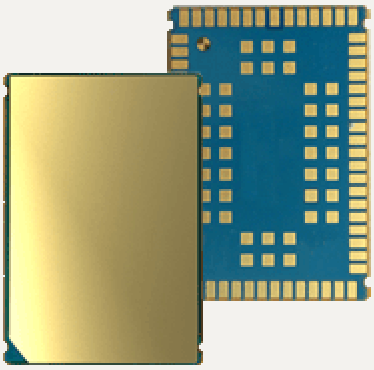

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1 Introduction

This document[1] describes the hardware of the Cinterion® ENS22-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
General	
Frequency bands	Band 3, 1800 MHz (LTE Cat. NB1/NB2) Band 5, 850 MHz (LTE Cat. NB1/NB2) Band 8, 900 MHz (LTE Cat. NB1/NB2) Band 20, 800 MHz (LTE Cat. NB1/NB2) Band 28, 700 MHz (LTE Cat. NB1/NB2)
Output power (according to 3GPP TS 36521-1 R13)	Class 3 23dBm ±2.7dB
Power supply	Normal operation: 3.1V to 4.2V Extended operation: 2.8V to 4.2V (restrictions in output power)
Operating temperature (board temperature)	Normal operation: -30°C to +85°C Extended operation: -40°C to +85°C
Physical	Dimensions: 27.6mm x 18.8mm x 2.5mm Weight: 2.2g
SMS	Point-to-point MT and MO PDU mode
Software	
AT commands	Hayes 3GPP TS 27.007, TS 27.005, Gemalto M2M
Firmware update	Update from host application over ASC0.
Interfaces	
Module interface	Surface mount device with solderable connection pads (SMT application interface). Land grid array (LGA) technology ensures high solder joint reliability and allows the use of an optional module mounting socket.

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

Feature	Implementation
2 serial interfaces	ASC0 (RING0, DSR0, DCD0, and DTR0 shared with GPIO lines): • 8-wire modem interface with status and control lines, unbalanced asynchronous • Adjustable baud rates: 1,200 bps to 921,600 bps • Supports RTS0/CTS0 hardware flow control (by configuration option) ASC1 (shared with GPIO lines): • 4-wire modern interface, unbalanced asynchronous • Adjustable baud rates: 1,200 bps to 921,600 bps • Supports RTS1/CTS1 hardware flow control (by configuration option)
UICC interface	Support SIM/USIM cards: 3V, 1.8V
Internal SIM interface (eSIM option)	Support eSIM: internal SIM interface
GPIO interface	13 GPIO lines comprising: 8 lines shared with ASC0, ASC1 lines 5 GPIO lines not shared
Antenna interface pads	50Ω
Power on, Power off, and Reset	
Power on and power off	Switch on by hardware signal ON Switch off by AT command
Reset	Emergency reset by hardware signal EMERG_RST
Evaluation kit	
Evaluation module	Cinterion® ENS22-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 Cinterion® ENS22-E evaluation module to the DSB75.
LGA DevKit	LGA DevKit designed to test Gemalto M2M LGA modules from Industrial and Industrial Plus families.

1.2 Cinterion® ENS22-E System Overview

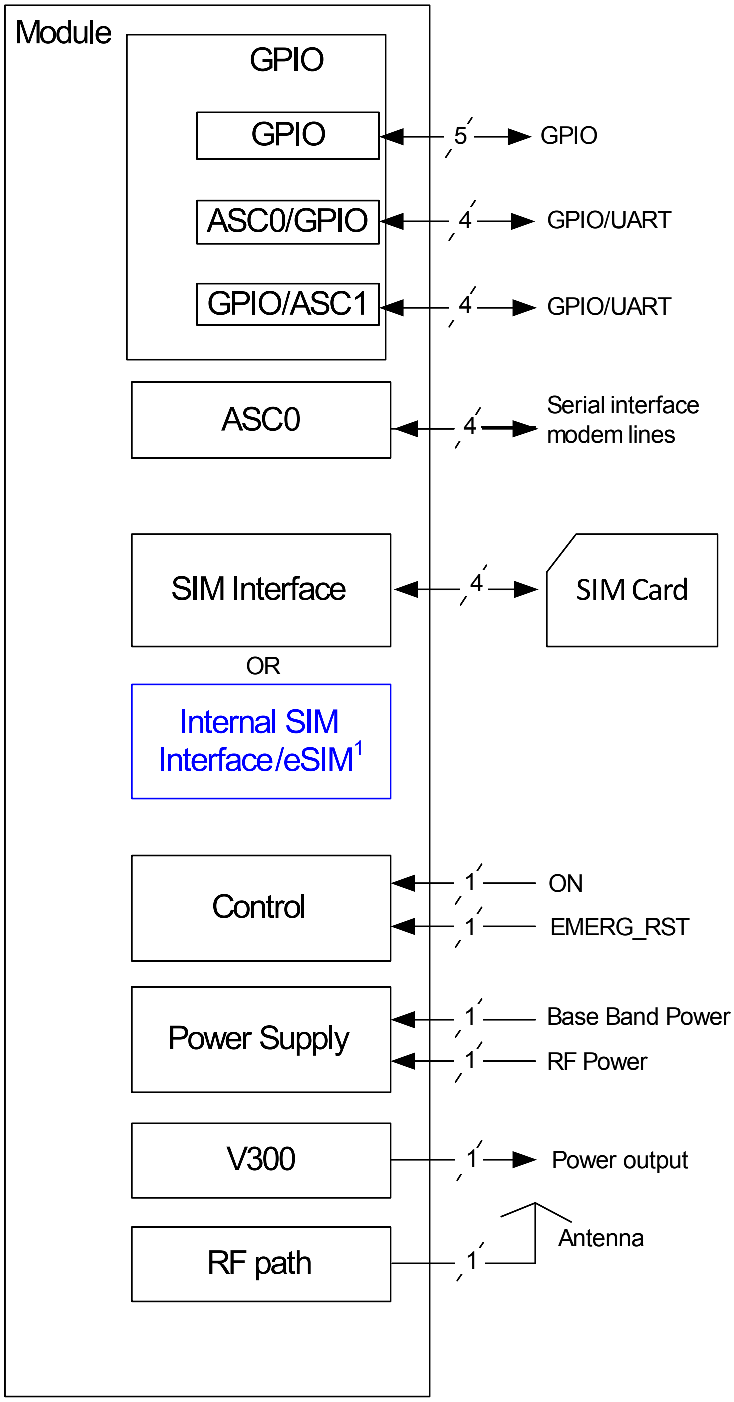


Figure 1: Cinterion® ENS22-E system overview

1. For eSIM option only. The SIM interface is replaced by the internal SIM interface.

1.3 Circuit Concept

Figure 2 and Figure 3 show block diagrams of the Cinterion® ENS22-E module and illustrate the major functional components.

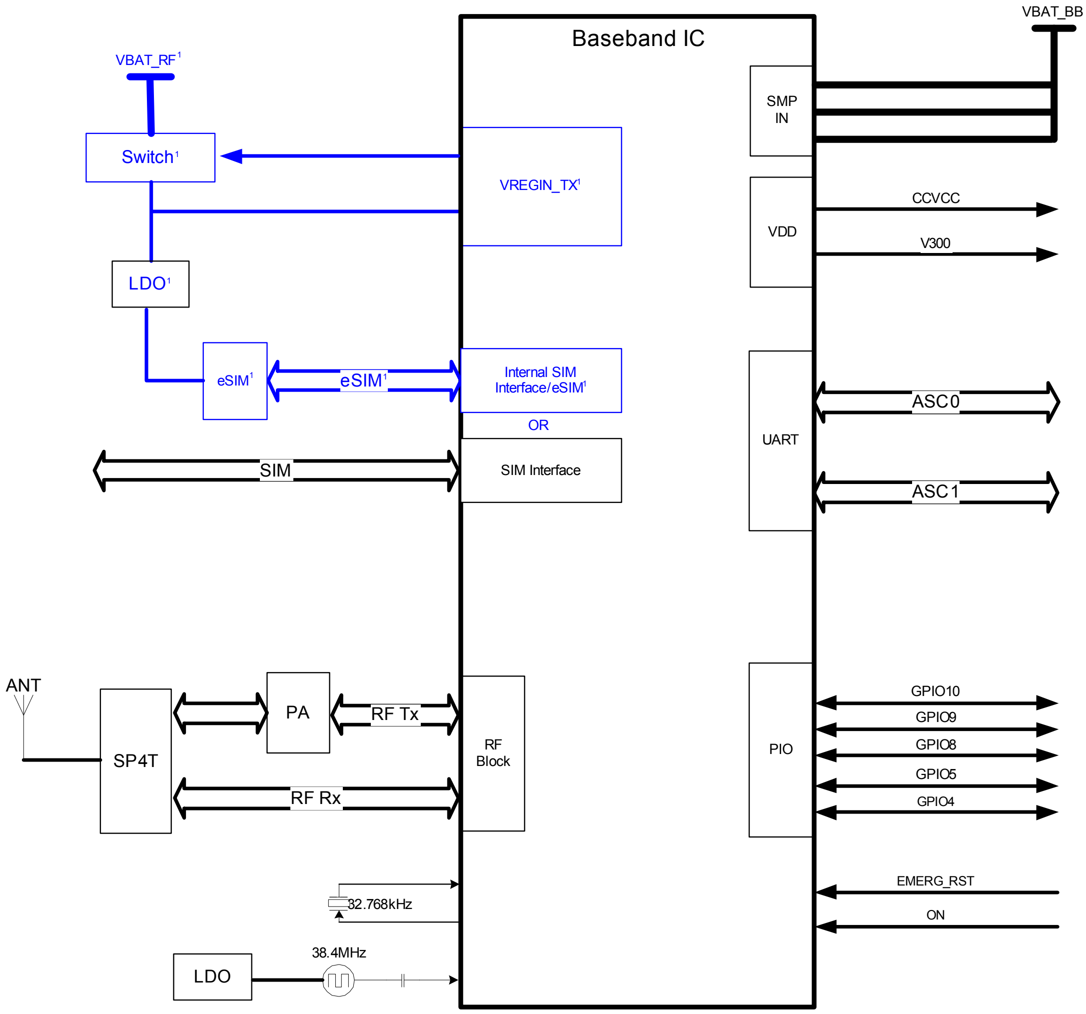


Figure 2: Cinterion® ENS22-E block diagram

1. For eSIM option only. The SIM interface is replaced by the internal SIM interface.

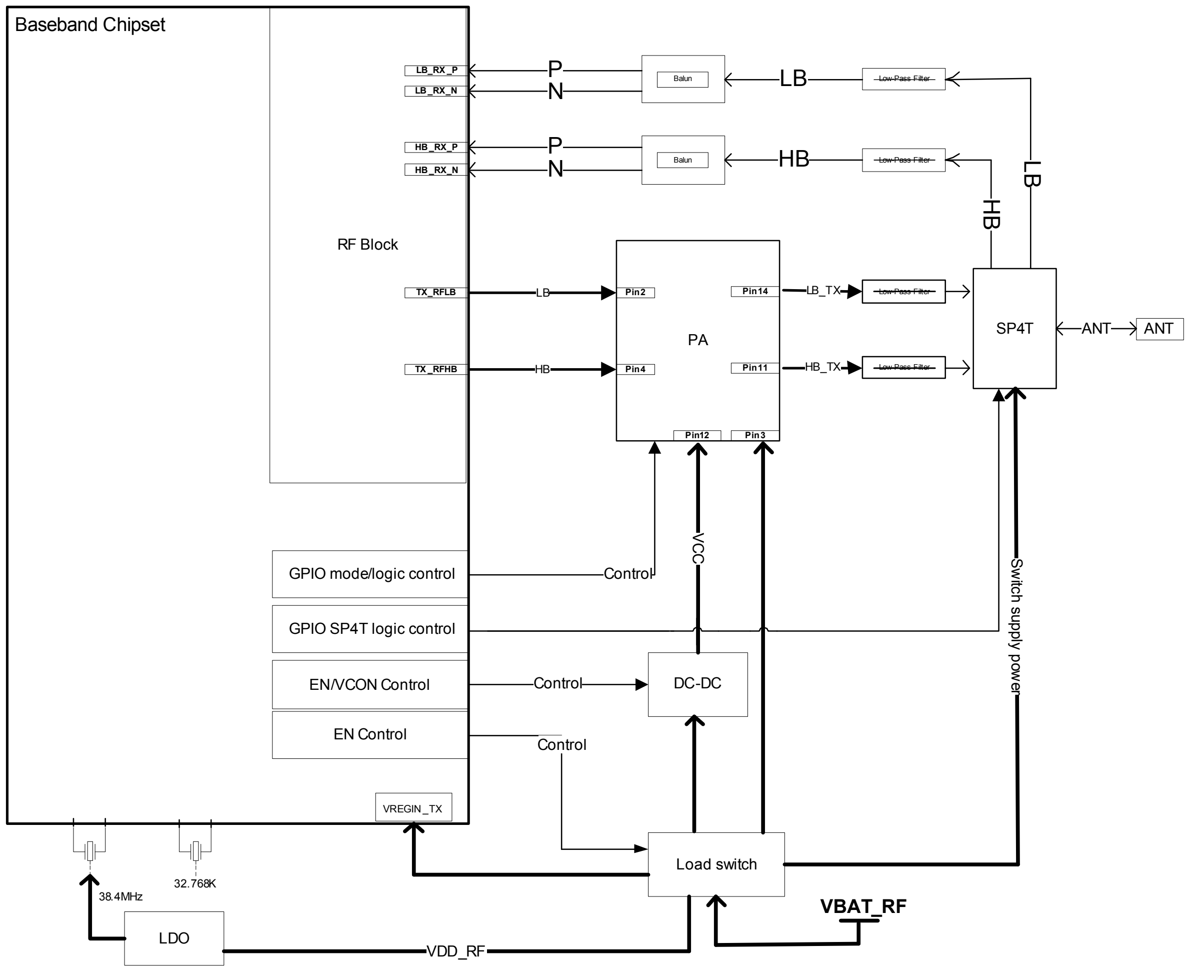


Figure 3: Cinterion® ENS22-E RF section block diagram

2 Interface Characteristics

Cinterion® ENS22-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 Cinterion® ENS22-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)

Table 1: Pad assignments

Pad no.	Signal name	Pad no.	Signal name	Pad no.	Signal name
1	NC	24	NC	47	GND
2	NC	25	NC	48	GND
3	NC	26	NC	49	GND
4	GND	27	GPIO10	50	GND
5	$BATT+_{BB}$	28	GPIO9	51	GND
6	GND	29	GPIO17/TXD1	52	GND
7	NC	30	GPIO16/RXD1	53	$BATT+_{RF}$
8	ON	31	GPIO18/RTS1	54	GND
9	GND	32	GPIO19/CTS1	55	GND
10	V300	33	EMERG_RST	56	GND
11	RXD0	34	GND	57	GND
12	CTS0	35	Do not use[2]	58	GND
13	TXD0	36	GPIO8	59	RF_OUT
14	GPIO24/RING0	37	NC	60-64	GND
15	RTS0	38	NC	65	NC
16	NC	39	GPIO5	66	NC
17	CCRST[1]	40	GPIO4	67-74	GND
18	Do not use[2]	41	GPIO3/DSR0	75	NC
19	CCIO[1]	42	GPIO2/DCD0	76	NC
20	CCVCC[1]	43	GPIO1/DTR0	77-97	GND
21	CCCLK[1]	44	NC	98	NC
22	NC	45	NC	99	GND
23	NC	46	NC	100-106	GND

1. For eSIM option, the signal is Do not use.
2. Design reserved function, do not connect to any external application.

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 Cinterion® ENS22-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	$V_I max = 4.2V$ $V_I norm = 3.6V$ $V_I min = 3.1V$	Cinterion® ENS22-E supports a lowest power supply voltage of 2.8V, but some functions may degrade in RF and BB. For example, the output voltage of V300 may fall below 2.8V. Minimum voltage must not fall below 2.8V, including drop, ripple, and spikes.
Power Supply	GND		Ground	Application Ground.
External Supply Voltage	V300	O	Normal operation: $V_O norm = 3.0V$ $I_O max = -5mA$	
Ignition	ON	I	$V_{IH} max = 4.2V$ $V_{IH} norm = 3.6V$ $V_{IH} min = 2.8V$ $V_{IL} max = 0.6V$ __|¯¯|__ high impulse width > 100ms	This signal switches on the module.
Emergency Restart	EMERG_RST	I	$C_I \approx 1nF$ $V_{OH} norm = 3.0V$ $V_{IH} min = 2.1V$ $V_{IL} max = 0.6V$ at ~10µA ¯¯|__|¯¯ low impulse width > 100ns	This line must be driven low by an open drain or open collector driver connected to GND. If unused keep line open.

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
Serial Interface ASC0	RXD0	O	V_{OL}max = 0.3V V_{OH}min = 2.4V V_{OH}max = 3.3V	If unused keep lines open. RXD0/TXD0 transferring only is not supported, unless RTS0 is set to low. RTS0 is mandatory if SLEEP or SUSPEND mode is needed for power saving. Note that some ASC0 lines are configurable as GPIO lines. If configured as GPIO lines, the GPIO lines are assigned as follows: DTR0 --> GPIO1 DCD0 --> GPIO2 DSR0 --> GPIO3 RING0--> GPIO24
	CTS0	O		
	DSR0	O		
	DCD0	O		
	RING0	O		
	TXD0	I	V_{IL}max = 0.6V V_{IH}min = 2.1V V_{IH}max = 3.3V	
	RTS0	I		
	DTR0	I		
Serial Interface ASC1	RXD1	O	V_{OL}max = 0.3V V_{OH}min = 2.4V V_{OH}max = 3.3V V_{IL}max = 0.6V V_{IH}min = 2.1V V_{IH}max = 3.3V	If unused keep line open. RXD1/TXD1 transferring only is not supported, unless RTS1 is set to low. 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		
	RTS1	I		
	CTS1	O		

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
3V SIM Card Interface	CCRST	O	V_{OL}max = 0.30V V_{OH}min = 2.4V V_{OH}max = 3.3V	Maximum cable length or copper track to SIM card holder should not exceed 100mm.
	CCIO	I/O	V_{IL}max = 0.3V V_{IH}min = 2.4V V_{IH}max = 3.3V V_{OL}max = 0.6V V_{OH}min = 2.1V V_{OH}max = 3.3V	
	CCCLK	O	V_{OL}max = 0.30V V_{OH}min = 2.4V V_{OH}max = 3.3V	
	CCVCC	O	$V_O$min= 2.7V $V_O$typ = 3.0V $V_O$max = 3.3V $I_O$max = -5mA	
1.8V SIM Card Interface	CCRST	O	V_{OL}max = 0.3V V_{OH}min = 1.44V V_{OH}max = 2.1V	Maximum cable length or copper track to SIM card holder should not exceed 100mm.
	CCIO	I/O	V_{IL}max = 0.36V V_{IH}min = 1.26V V_{IH}max = 1.98V V_{OL}max = 0.3V V_{OH}min = 1.44V V_{OH}max = 2.1V	
	CCCLK	O	V_{OL}max = 0.3V V_{OH}min = 1.44V V_{OH}max = 2.1V	
	CCVCC	O	$V_O$min = 1.5V $V_O$typ = 1.80V $V_O$max = 2.1V $I_O$max = -5mA	
GPIO Interface	GPIO1-GPIO3	IO	V_{OL}max = 0.3V V_{OH}min = 2.4V V_{OH}max = 3.3V V_{IL}max = 0.6V V_{IH}min = 2.1V V_{IH}max = 3.3V	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. GPIO16-GPIO19: ASC1 GPIO24: ASC0 control line RING0
	GPIO4	IO		
	GPIO5	IO		
	GPIO8	IO		
	GPIO9-GPIO10	IO		
	GPIO16-GPIO19	IO		
	GPIO24	IO		

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 Cinterion® ENS22-E.

Table 3: Absolute maximum rating

Parameter	Min	Max	Unit
Supply voltage $BATT+_{BB}$, $BATT+_{RF}$	-0.3	+4.25	V
Voltage at V300 in normal operation	-0.3	+3.3	V
Current at V300 in normal operation		-5	mA
Voltage at all digital lines in Deep Sleep mode	-0.3	+0.3	V
Voltage at digital lines in normal operation	-0.3	V300	V
Voltage at SIM/USIM interface, CCVCC in normal operation	-0.3	+3.3	V

2.1.3 Serial Interface ASC0

Cinterion® ENS22-E offers a high speed serial modem interface ASC0 for data exchange between the module and the application.

Cinterion® ENS22-E is designed for an 8-wire unbalanced, asynchronous modem interface ASC0 conforming to ITU-T V.24 protocol DCE signaling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0V (for low data bit or active state) and 3V (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 5.

Cinterion® ENS22-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

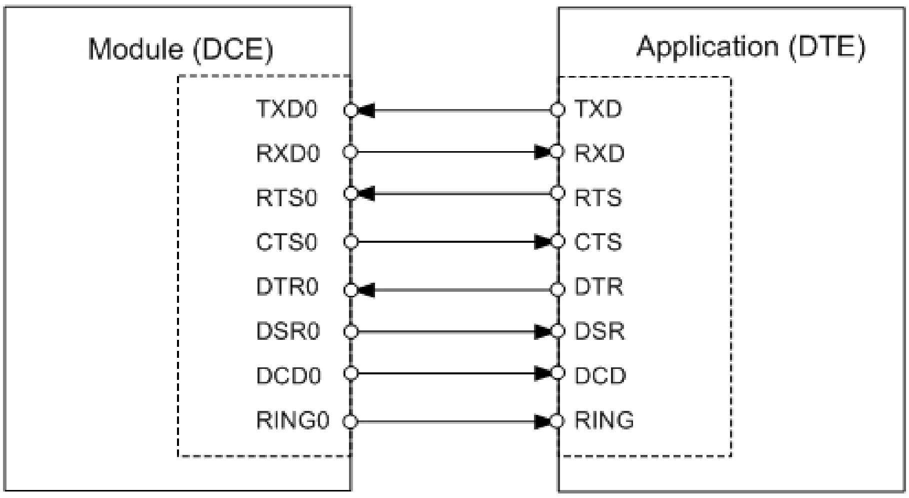


Figure 5: Serial interface ASC0

Features:
- Includes the data lines TXD0 and RXD0, the status lines RTS0 and CTS0, in addition, the modem control lines DTR0, DSR0, DCD0 and RING0.
- The RING0 signal serves to indicate messages and other types of Unsolicited Result Codes (URCs). 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 (see AT+ICF in [1]).
- ASC0 can be operated at fixed bit rates from 1,200bps up to 921,600bps.
- Wake up from SLEEP mode by RTS0 activation (high to low transition; see Section 3.3.4.1).

Notes:
- The ASC0 modem control lines DTR0, DCD0, DSR0 and RING0 are configurable as GPIO lines. If configured as GPIO lines, these ASC0 lines are assigned as follows: DTR0 --> GPIO1, DCD0 --> GPIO2, DSR0 --> GPIO3 and RING0 --> GPIO24. Configuration is done by AT command (see [1]). The configuration is non-volatile and becomes active after a module restart.
- In order to adjust overshoot and undershoot, it is recommended to increase matching resistance on the communication line.
- RXD0/TXD0 transferring only is not supported, unless RTS0 is set to low.
- RTS0 is mandatory if SLEEP or SUSPEND mode is needed for power saving.

2.1.4 Serial Interface ASC1

Four Cinterion® ENS22-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 signaling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0V (for low data bit or active state) and 3V (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 6.

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

Cinterion® ENS22-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

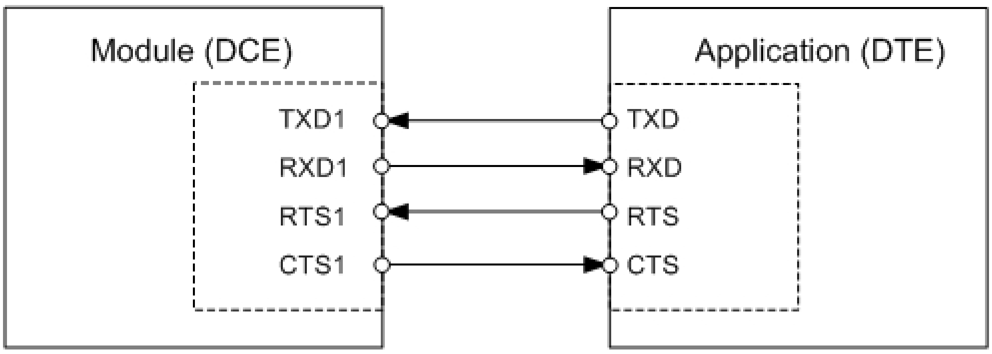


Figure 6: Serial interface ASC1

Features
- Includes only the data lines TXD1 and RXD1 plus RTS1 and CTS1 for hardware handshake.
- Configured for 8 data bits, no parity and 1 stop bits (see AT+ICF in [1]).
- ASC1 can be operated at fixed bit rates from 1,200 bps to 921,600 bps.

Notes:
- It is not supported to wake up the module from SLEEP mode by RTS1. Always wake up the module by RTS0 (high to low transition; see Section 3.3.4.1). To use ASC1, keep RTS0 low to ensure the module stays awake.
- In order to adjust overshoot and undershoot, it is recommended to increase matching resistance on the communication line.
- RXD1/TXD1 transferring only is not supported, unless RTS1 is set to low.

2.1.5 UICC/SIM/USIM Interface

Cinterion® ENS22-E has an integrated UICC/SIM/USIM interface that is wired to the host interface in order to be connected to an external SIM card holder. Four 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.

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

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

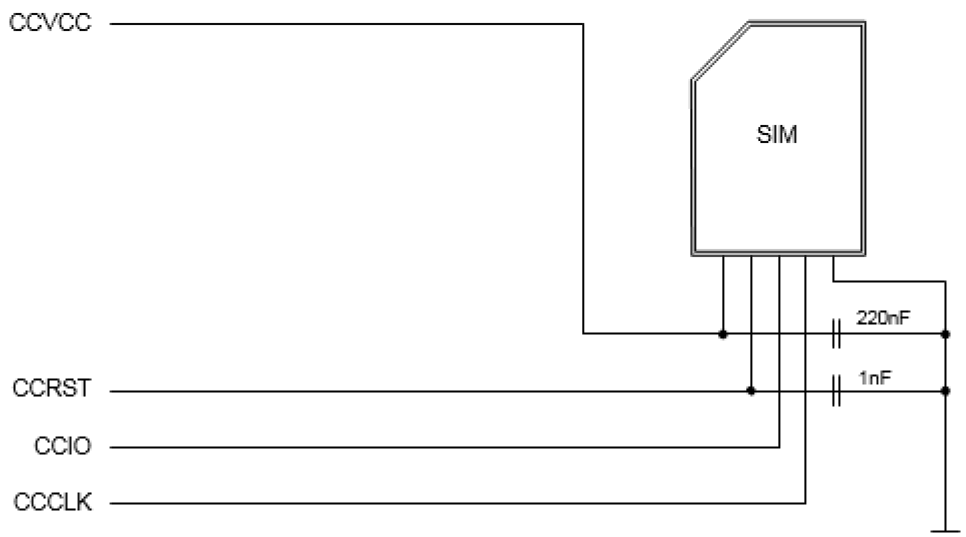


Figure 7: External UICC/SIM/USIM card holder circuit

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 2.1.5.1.

2.1.5.1 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 8.

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

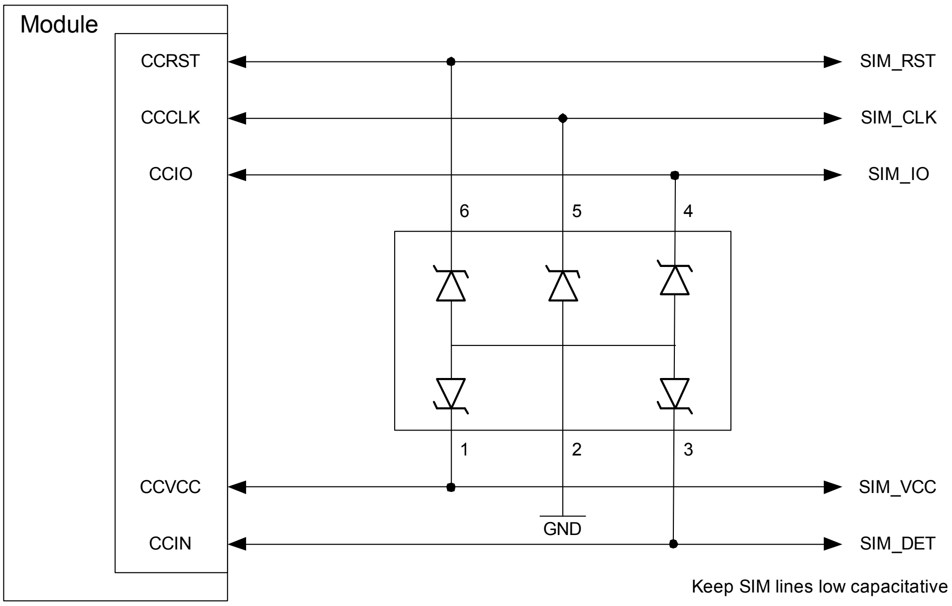


Figure 8: SIM interface - enhanced ESD protection

2.1.6 Internal SIM Interface (eSIM option)

Cinterion® ENS22-E internal SIM interface (eSIM option) is internally connected to the module's SIM interface lines, without any external SIM card holder connection.

The figure below shows a circuit to connect to eSIM.

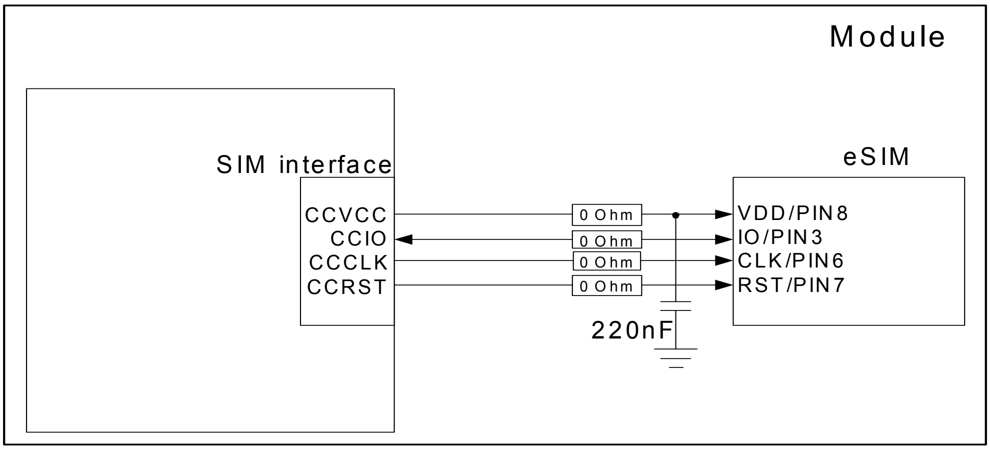


Figure 9: Cinterion® ENS22-E eSIM option

2.1.7 GPIO Interface

Cinterion® ENS22-E offers a GPIO interface with 13 GPIO lines. The GPIO lines are shared with other interfaces or functions: ASC0 (see Section 2.1.3), ASC1 (see Section 2.1.4).

The following table shows the configuration variants for the GPIO pads.

Table 5: GPIO lines and possible alternative assignment

GPIO	ASC0	ASC1
GPIO1	DTR0	
GPIO2	DCD0	
GPIO3	DSR0	
GPIO4		
GPIO5		
GPIO8		
GPIO9		
GPIO10		
GPIO16		RXD1
GPIO17		TXD1
GPIO18		RTS1
GPIO19		CTS1
GPIO24	RING0	

After startup, the above mentioned alternative GPIO line assignments can be configured using AT commands (see [1]).

2.1.8 Control Signals

2.1.8.1 Power Indication Circuit

In Power Down mode or SUSPEND mode, all digital pins are unpowered. Pulling these pins high will cause current leakage.

It is recommended to implement a power indication signal that reports the module's power state and shows whether it is active, in Power Down mode, or in SUSPEND mode. While the module is in Power Down mode or SUSPEND 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 10 denotes the module's active state with a low signal, and the module's Power Down and SUSPEND modes with a high signal or high impedance state.

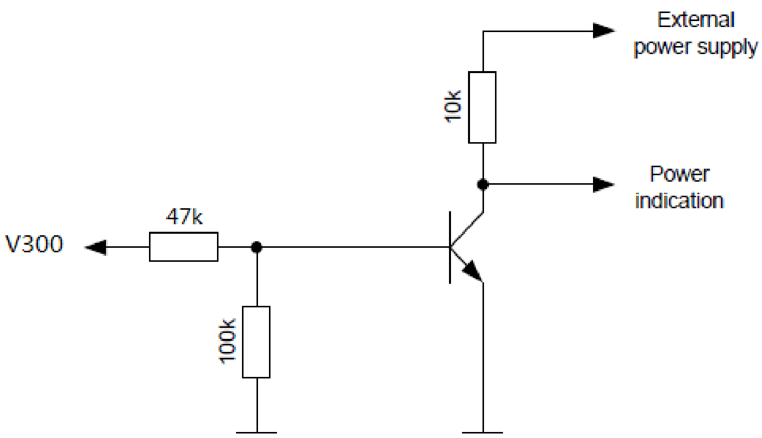


Figure 10: Power Indication Circuit

Note: V300 will be off in firmware update, so V300 cannot indicate the state of the circuit when the firmware is upgrading.

2.2 RF Antenna Interface

Cinterion® ENS22-E is an integrated NB-IoT transceiver, with necessary features to enable multi-mode, multi-band mobile cellular devices. The module can operate over 698-960 MHz and 1695-2180MHz with a 200 kHz system bandwidth. It is designed to communicate with mobile network operator (MNO) infrastructure equipment using the 3GPP NB-IoT radio protocol.

The RF interface has an impedance of 50Ω. Cinterion® ENS22-E is capable of sustaining a total mismatch at the antenna lines 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 Cinterion® ENS22-E module and should be placed in the host application if the antenna does not have an impedance of 50Ω.

Regarding the return loss, Cinterion® ENS22-E provides the following values in the active band:

Table 6: 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 7: RF Antenna interface (at operating temperature range)

Parameter	Conditions	Min.	Typical	Max.	Unit
Cat NB1/NB2 connectivity	Band 3, 5, 8, 20, 28				
Cat NB1/NB2 Frequency range Uplink (UE Tx)	NB-IoT Band 3	1710		1785	MHz
	NB-IoT Band 5	824		849	MHz
	NB-IoT Band 8	880		915	MHz
	NB-IoT Band 20	832		862	MHz
	NB-IoT Band 28	703		748	MHz
Cat NB1/NB2 Frequency range Downlink (UE Rx)	NB-IoT Band 3	1805		1880	MHz
	NB-IoT Band 5	869		894	MHz
	NB-IoT Band 8	925		960	MHz
	NB-IoT Band 20	791		821	MHz
	NB-IoT Band 28	758		803	MHz
Cat NB1/NB2 Receiver Input Sensitivity without repetitions -40°C ≤Board temperature ≤85°C	NB-IoT Band 3		-114		dBm
	NB-IoT Band 5		-114		dBm
	NB-IoT Band 8		-114		dBm
	NB-IoT Band 20		-114		dBm
	NB-IoT Band 28		-114		dBm
Cat NB1/NB2 RF Power @ ARP with 50Ω Load -40°C ≤Board temperature ≤85°C	NB-IoT Band 3	21.3	23	24.7	dBm
	NB-IoT Band 5	21.3	23	24.7	dBm
	NB-IoT Band 8	21.3	23	24.7	dBm
	NB-IoT Band 20	21.3	23	24.7	dBm
	NB-IoT Band 28	21.3	23	24.7	dBm

2.2.2 Antenna Installation

Figure 11 shows mechanical description of antenna interface. The antenna interface is typically connected by soldering the antenna pad (RF_OUT, Pad No. 59) directly to the application's PCB. Antenna interface allows to make a simple transition to different types of 50Ω lines.

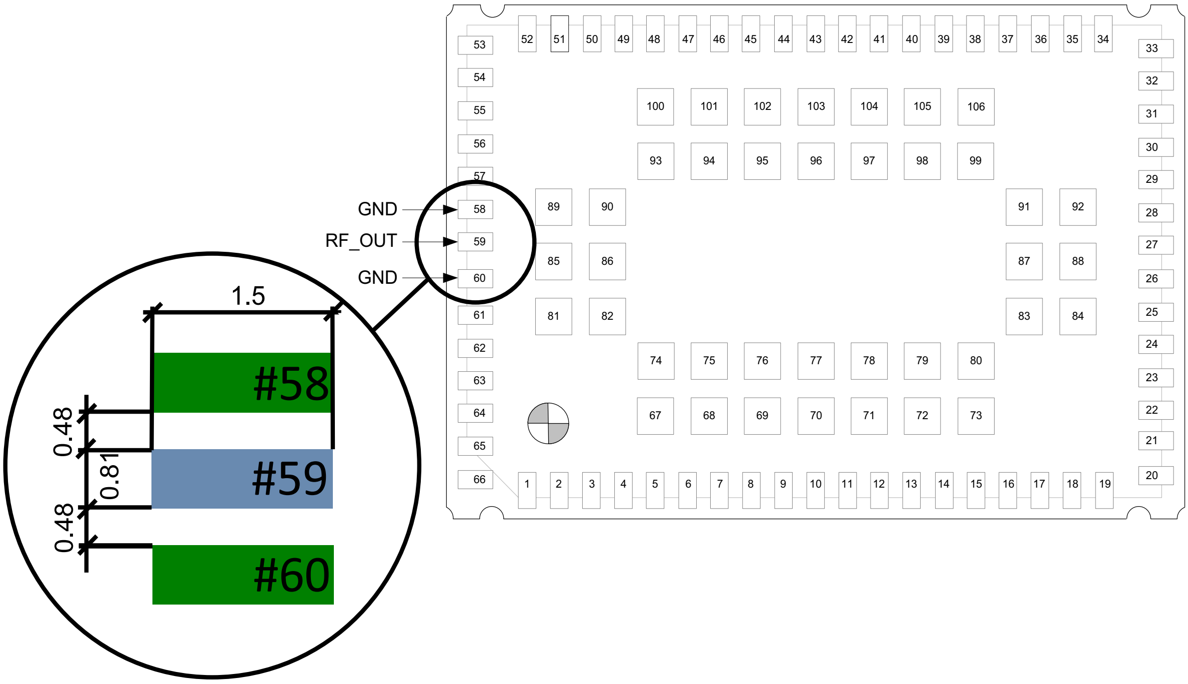


Figure 11: Antenna pads (dimensions in mm)

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.

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 for 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 Cinterion® ENS22-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

Figure 12 shows a line arrangement example for embedded stripline with 65µm FR4 prepreg (type: 1080) and 710µm FR4 core (4-layer PCB).

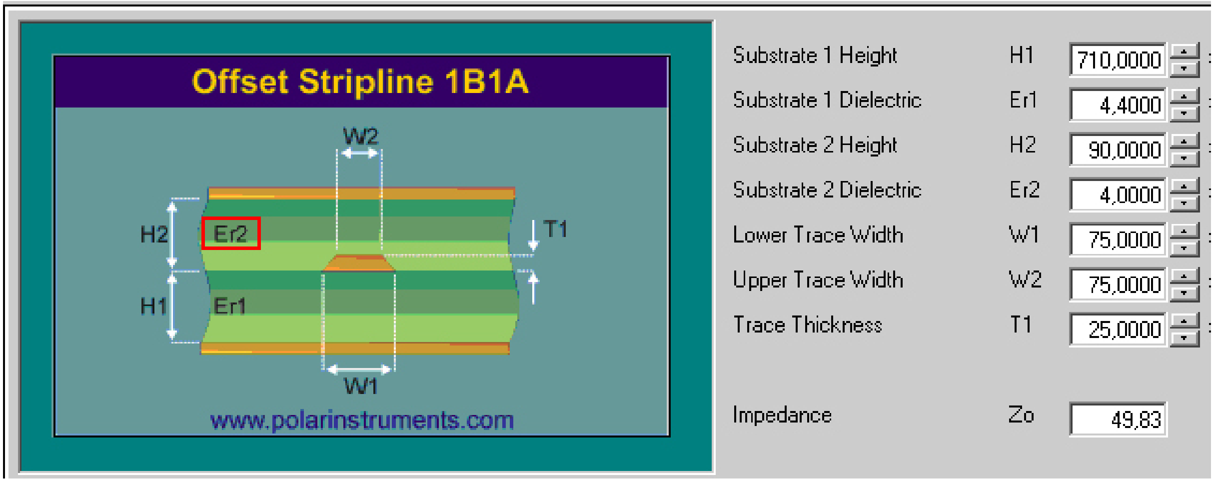


Figure 12: Embedded Stripline with 65µm prepreg (1080) and 710µm core

Micro-Stripline

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

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

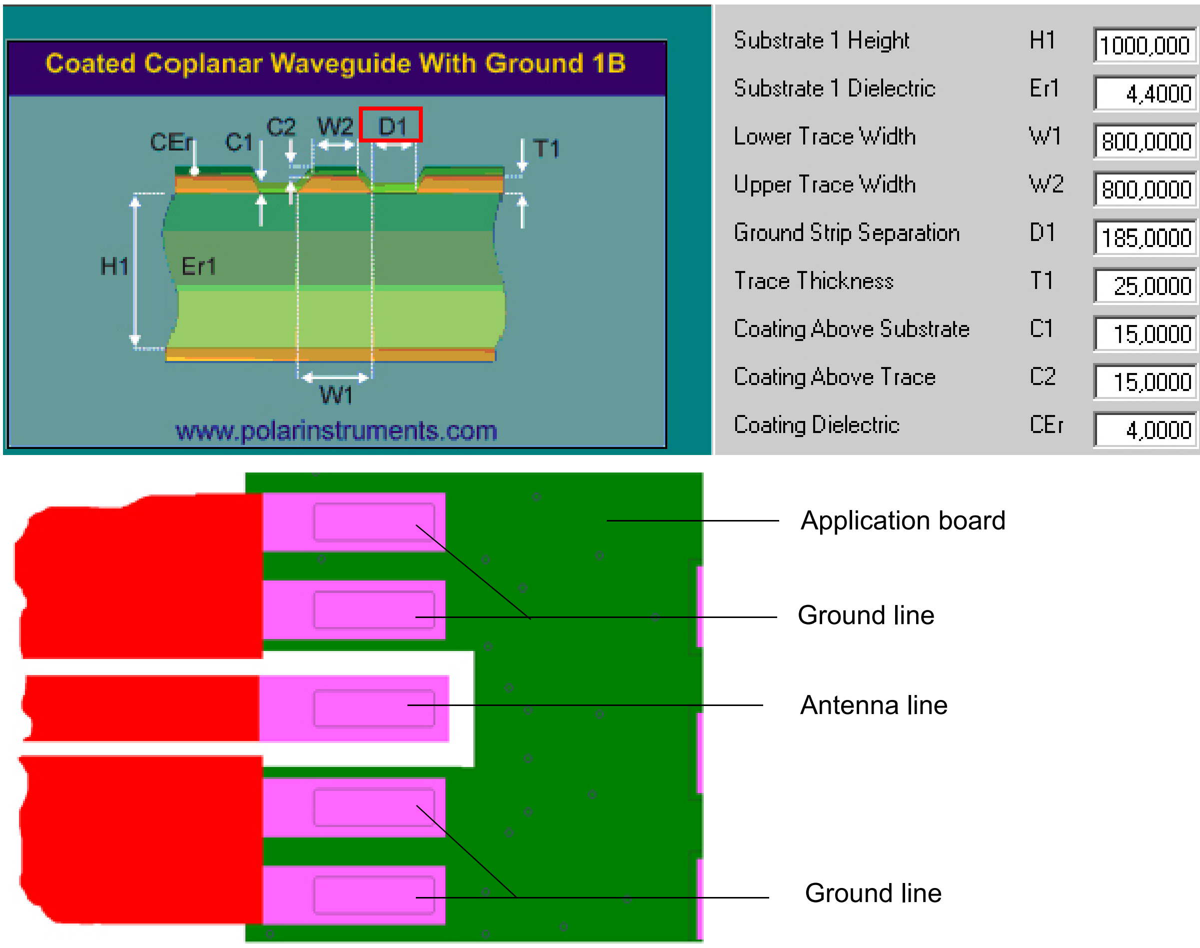


Figure 13: Micro-Stripline on 1.0mm standard FR4 2-layer PCB - Example 1

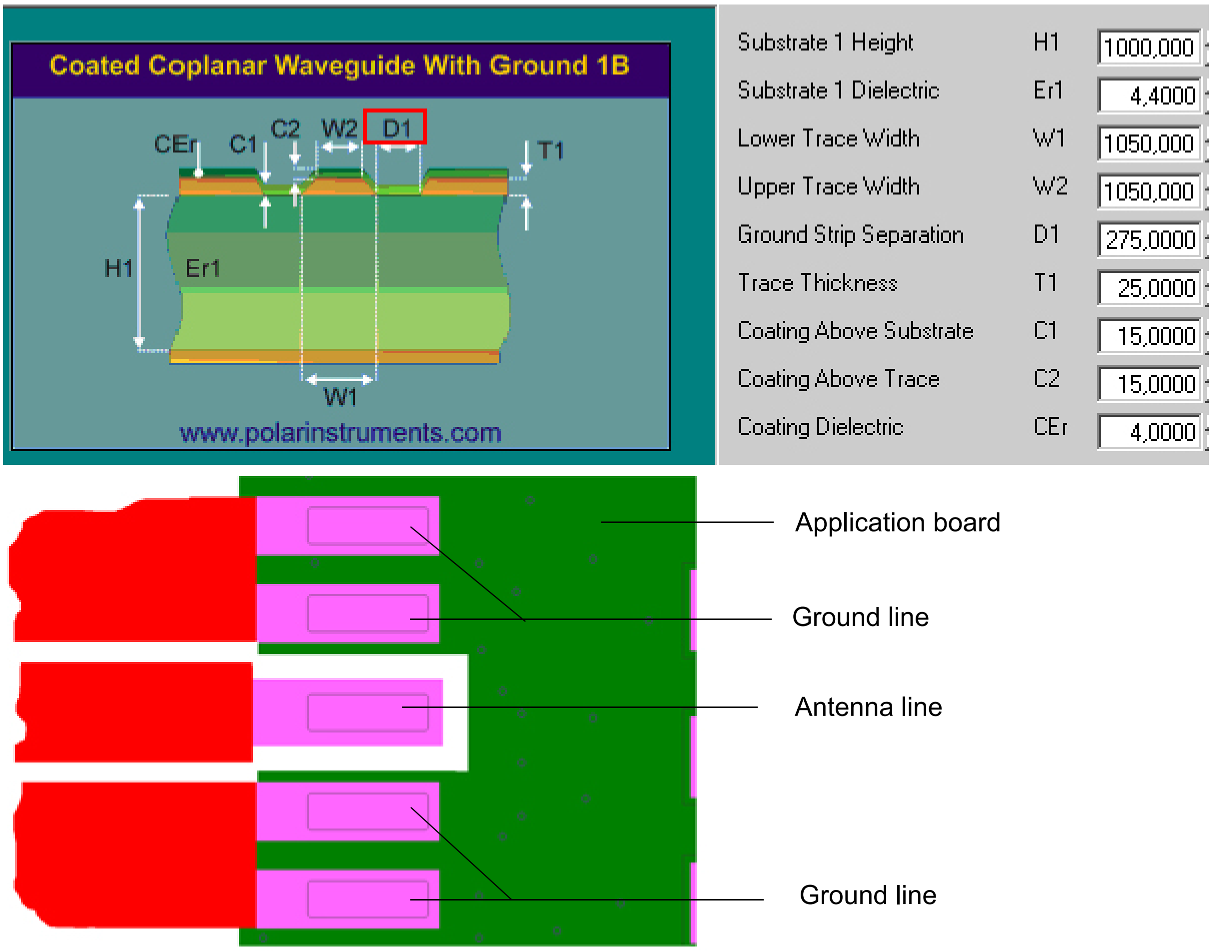


Figure 14: Micro-Stripline on 1.0mm Standard FR4 PCB - Example 2

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

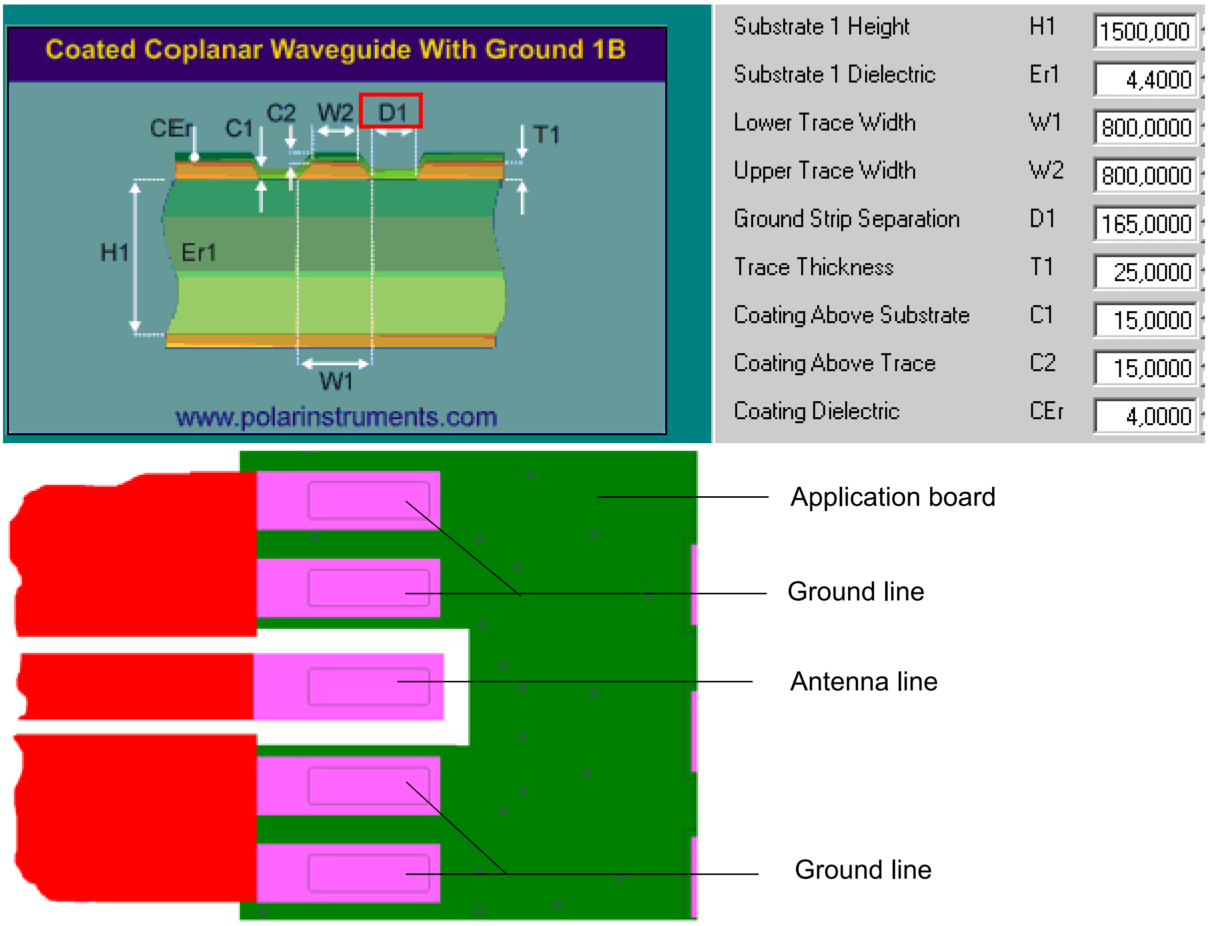


Figure 15: Micro-Stripline on 1.5mm Standard FR4 PCB - Example 1

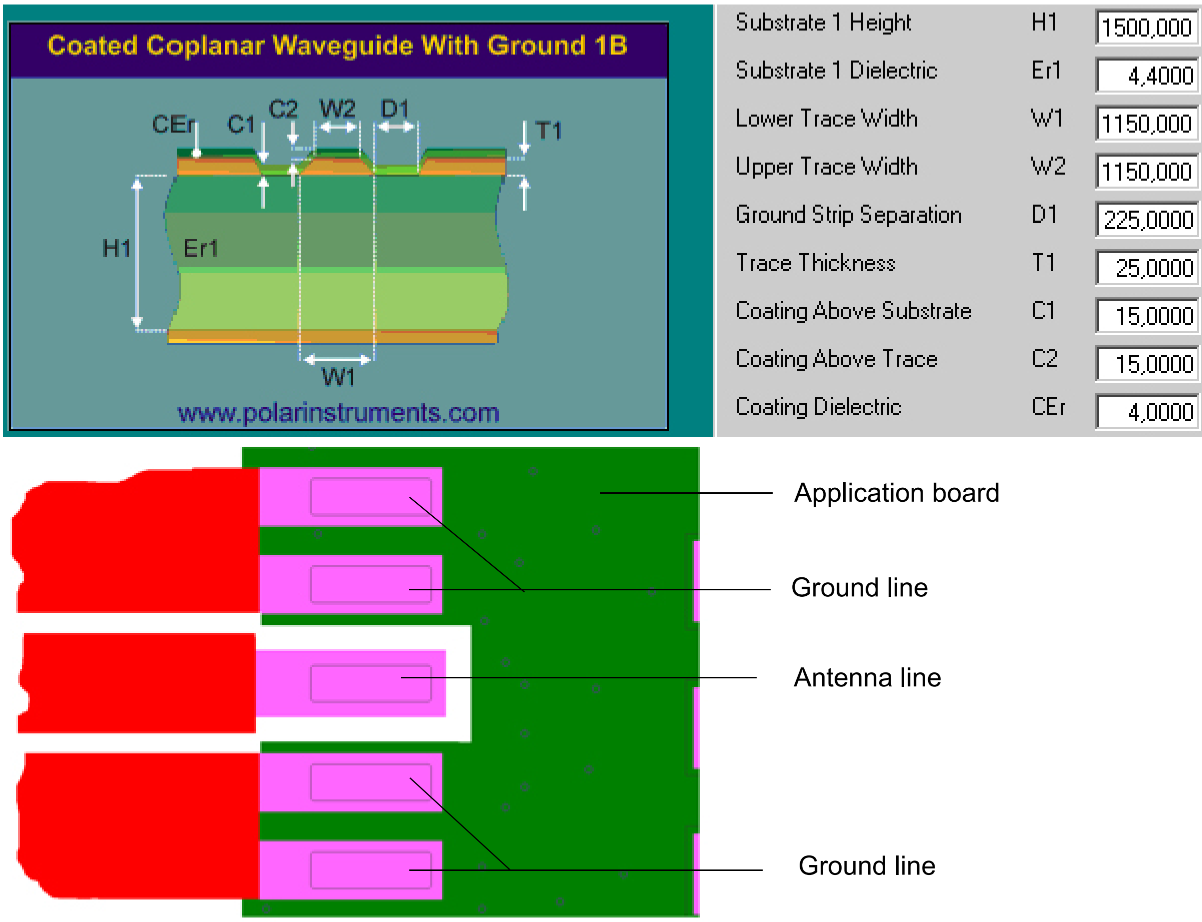


Figure 16: Micro-Stripline on 1.5mm Standard FR4 PCB - Example 2

2.2.3.2 Routing Example

Figure 17 shows the connection of the module‘s antenna pad with an application PCB‘s coaxial antenna connector. Please note that the Cinterion® ENS22-E bottom plane appears mirrored, since it is viewed from Cinterion® ENS22-E top side. By definition the top of customer's board shall mate with the bottom of the Cinterion® ENS22-E module.

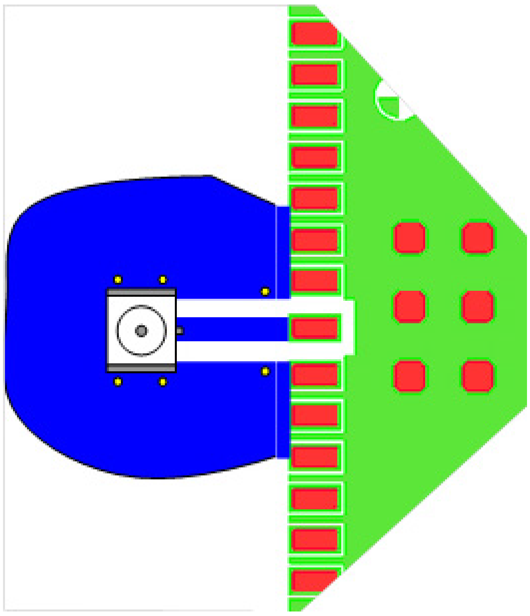


Figure 17: Routing to application‘s RF connector - top view

2.3 Sample Application

Figure 18 shows a typical example of how to integrate a Cinterion® ENS22-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.

Since the module is running at high RF power, it is designed to avoid self-interference inside the module. Customer application design must also use the best practices to avoid self interference.

While developing SMT applications it is strongly recommended to provide test points for certain signals, i.e., lines to and from the module - for debug and/or test purposes. The SMT application should allow for an easy access to these signals. For details on how to implement test points, see [4] and [5].

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, Cinterion® ENS22-E's digital input and output lines may require level conversion.

Disclaimer
No warranty, either stated or implied, is provided on the sample schematic diagram shown in Figure 18 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 Cinterion® ENS22-E modules.

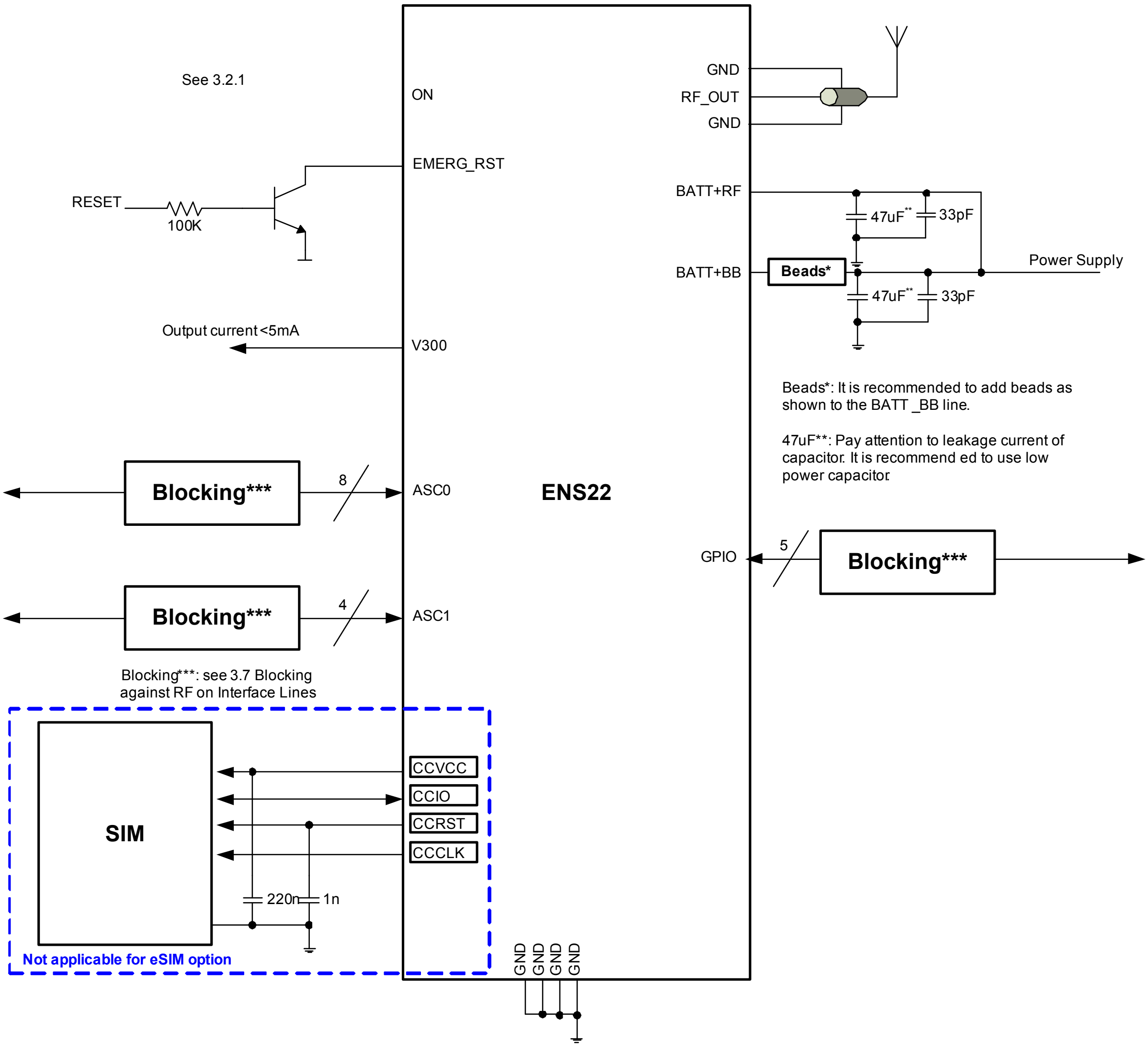


Figure 18: Schematic diagram of Cinterion® ENS22-E sample application

2.3.1 Sample Level Conversion Circuit

The following signals are mandatory for using the ASC0 and/or ASC1 interface.

Table 8: Mandatory signals for ASC0 and ASC1

Pad No.	Signal name	Description
11	RXD0	ASC0 RXD line
12	CTS0	ASC0 CTS line
13	TXD0	ASC0 TXD line
14	GPIO24/RING0	ASC0 RING line, shared with GPIO
15	RTS0	ASC0 RTS line
29	GPIO17/TXD1	ASC1 TXD line, shared with GPIO
30	GPIO16/RXD1	ASC1 RXD line, shared with GPIO
31	GPIO18/RTS1	ASC1 RTS line, shared with GPIO
32	GPIO19/CTS1	ASC1 CTS line, shared with GPIO

For these signals mentioned in Table 8, several circuits are recommended as following.

1. If the IO domain of the application is 3V, the signals mentioned in Table 8 can be connected via a serial resistor directly. See Figure 19.

   Table 9 contains additional signals which need a level conversation. See Figure 21.

   Note: This circuit is highly recommended for ultra-low power and cost optimized designs.

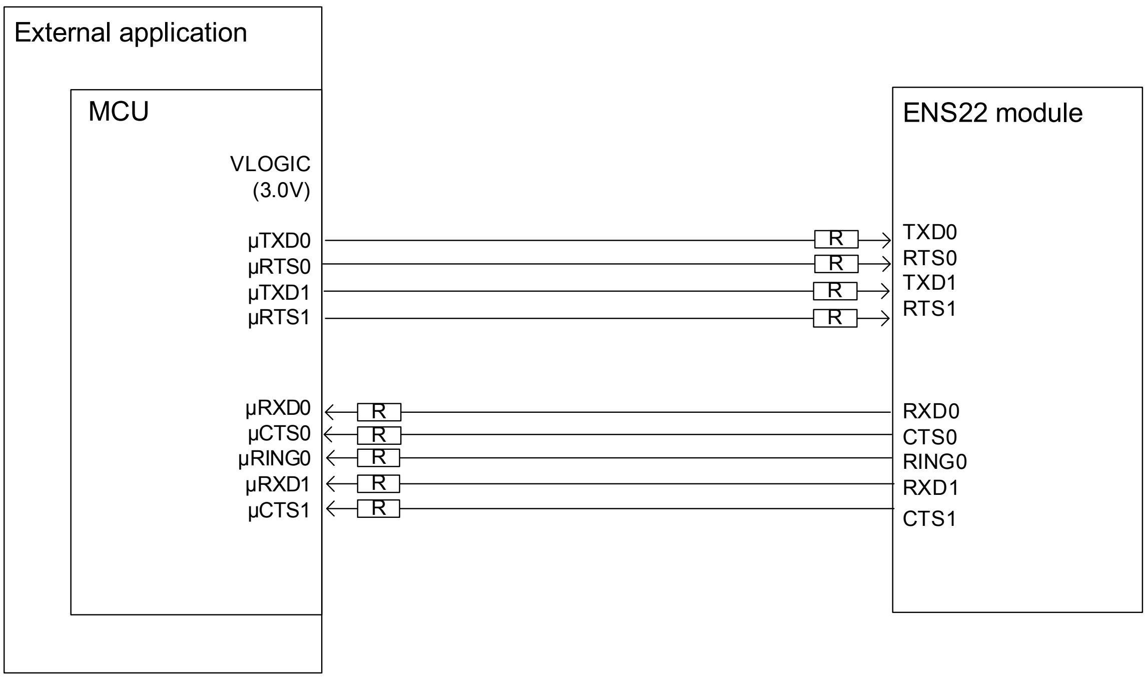


Figure 19: Sample circuit for Table 8 signals

2. If the IO domain of the application is not 3V the signals mentioned in Table 8 and Table 9 need level conversation. See Figure 20 or Figure 21.

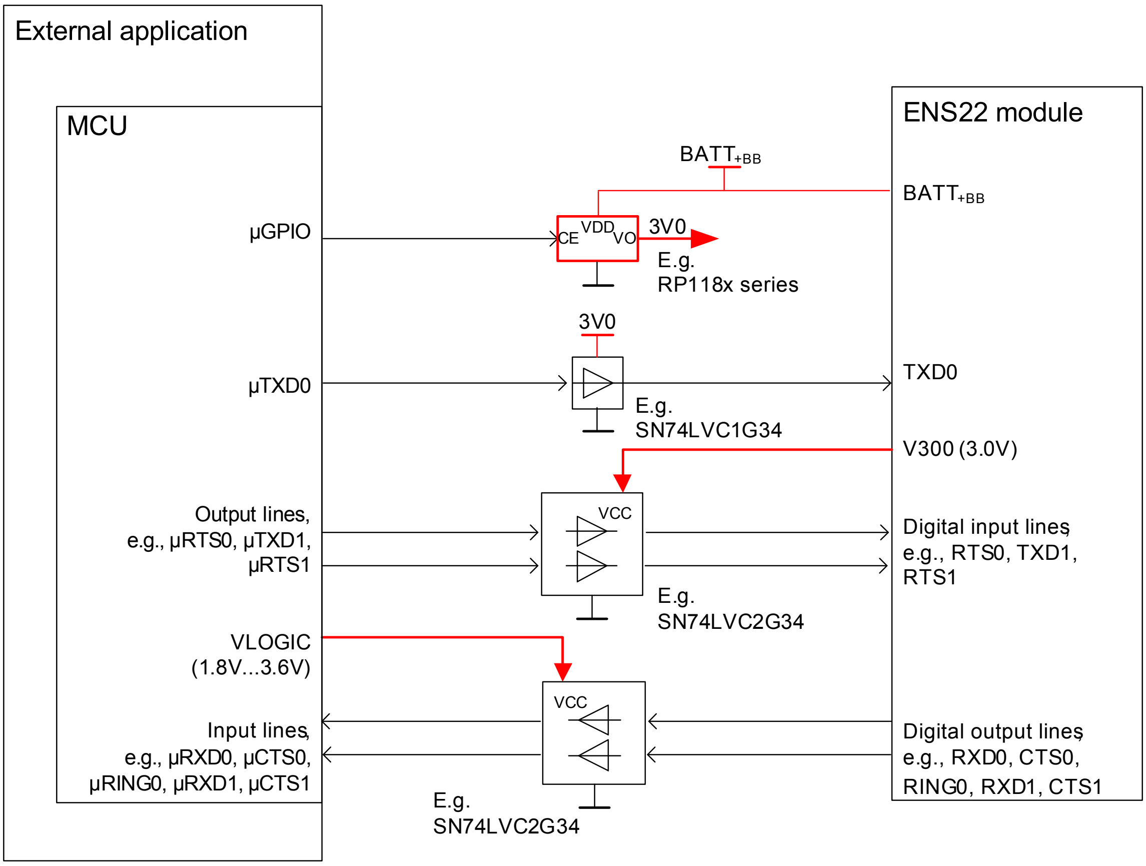


Figure 20: Sample level conversion circuit for Table 8 signals

Figure 20 illustrates the possible design of a 3V0 LDO, e.g. RP118x with 0.2uA (typical) for quiescent dissipation, and the switching state of LDO is controlled by MCU. The power supply voltage of TXD0 (ASC0's TXD signal line) in Figure 20 must be supplied by an external 3V LDO because in firmware update mode V300 is powered off. Do not use V300 related functions as the enablement of level conversion, e.g. power indicator (see Section 2.1.8.1).

In order to prevent back-feeding, the level conversion circuit must be added when the signals mentioned in Table 9 are used:

Table 9: Table of signals with required level conversion

Pad No.	Signal name	Description
27	GPIO10	
28	GPIO9	
36	GPIO8	GPIO
39	GPIO5	GPIO
40	GPIO4	GPIO
41	GPIO3/DSR0	ASC0 DSR line, shared with GPIO
42	GPIO2/DCD0	ASC0 DCD line, shared with GPIO
43	GPIO1/DTR0	ASC0 DTR line, shared with GPIO

Note: Even if the power supply voltage of MCU is 3V, the level conversion circuit is recommended for preventing back-feeding of Table 9 pins. Power supply of digital input lines must be V300. Figure 21 shows an universal circuit that is not optimized for ultra-low current consumption.

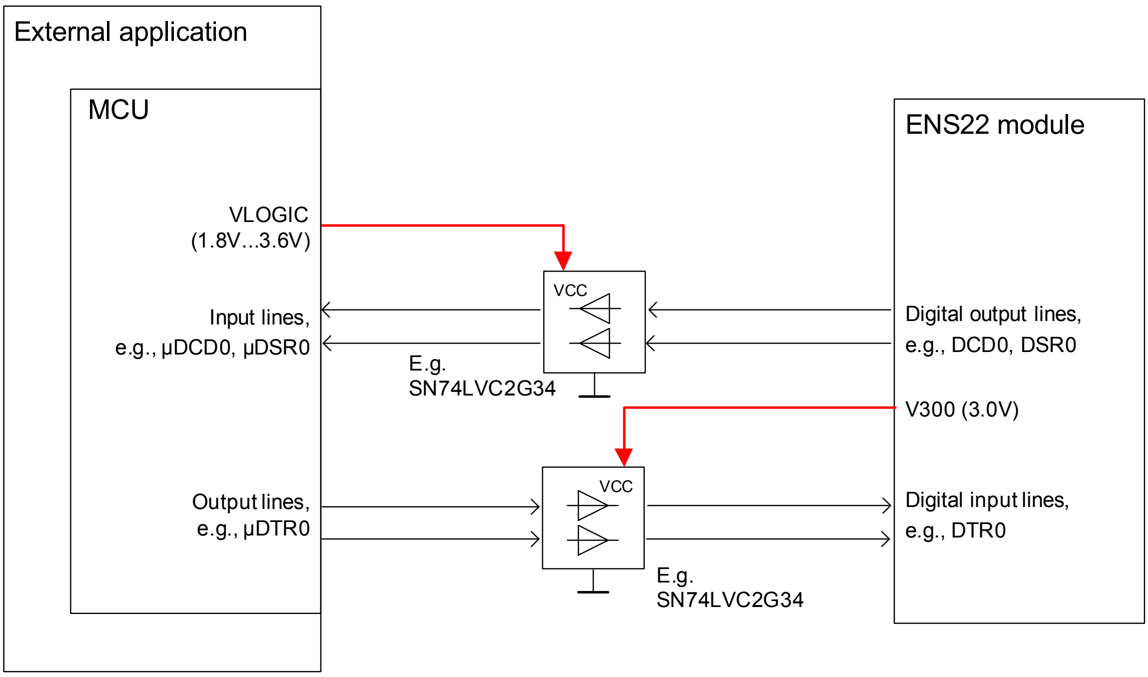


Figure 21: Universal level conversion circuit for Table 9 signals

3 Operating Characteristics

3.1 Operating Modes

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

Table 10: Overview of operating modes

Mode	Function	
Normal operation	Data transfer	LTE NB1/2 data transfer in progress.
	Idle	Software and interfaces are active and ready to send and receive, but no LTE NB1/2 data transfer is currently in progress. The module can be in DRX, eDRX or PSM mode.
SLEEP	Low power mode and there is no active communication on any serial interface (ASC0, ASC1). During SLEEP mode, the module is in a low power consumption state depending on paging cycles based on network defined DRX values, and optionally network negotiated eDRX (extended DRX) as well as 3GPP PSM values. The firmware is active to a minimum extent, and preserves the state it was in before entering the SLEEP mode. The module stays registered to the network. To allow SLEEP mode, the host application shall indicate via RTS0 line that it has no intention to send data.	
SUSPEND	Low power mode when almost all components are switched off - except for the internal RTC and interrupt triggered wake up mechanisms. The module keeps registered to the network. The module is in its lowest power consumption state. The module wakes up with its signal states being the same as for the first startup configuration, and does not preserve the signal states it had in before entering SUSPEND mode. The SUSPEND mode option can be enabled/disabled by AT commands (see [1]: AT^SCFG “MEopMode/PowerMgmt/Suspend”). The module shall enter SUSPEND mode only when the eDRX or PSM is enabled (i.e. configuration negotiated with the network allows it). To allow SUSPEND mode, the host application shall indicate via RTS0 line that it has no intention to send data. Device wakeup can be available via the ON Signal. Host wakeup can be available via RING0.	
Power Down	State after normal shutdown by sending the switch off command (see [1]: AT^SMSO). Software is not active. Interfaces are not accessible. Operating voltage remains applied.	

3.2 Power Up/Power Down Scenarios

In general, be sure not to turn on Cinterion® ENS22-E while it is beyond the safety limits of voltage and temperature stated in Section 2.1.2.1 and Section 3.5. Cinterion® ENS22-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 Cinterion® ENS22-E

After the operating voltage BATT+ is applied, Cinterion® ENS22-E can be switched on by means of the ON signal.

The ON signal is a high active pulse signal. Its range of input voltage level is from 2.8V to 4.2V, and the control signal of external application can be BATT+, GPIO from MCU, or other signals which can fulfill the requirement of an input voltage range of 2.8V to 4.2V. The module starts into normal mode on detecting a high level at the ON signal. It is recommended to use high level pulse of a minimum 100 ms. The following Figure 22 shows ON pin connection.

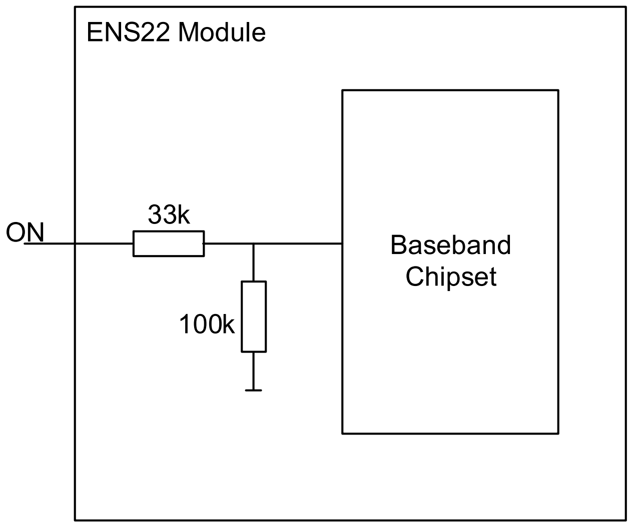


Figure 22: ON pin connection

The Figure 23 shows options for possible switch-on circuits.

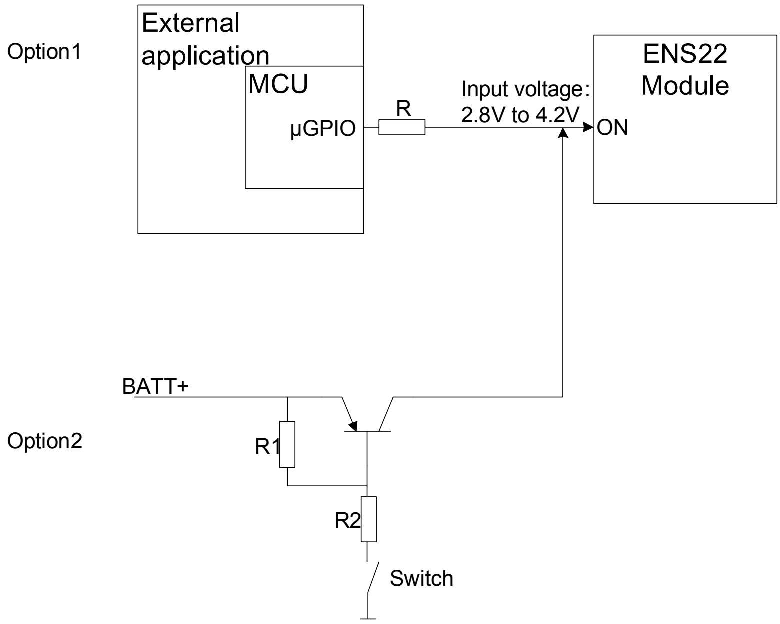


Figure 23: ON circuit options

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

Figure 24 shows the timing sequence when the module starts up. When the battery powers up, normally, it should wait at least 5 seconds before using ON function.

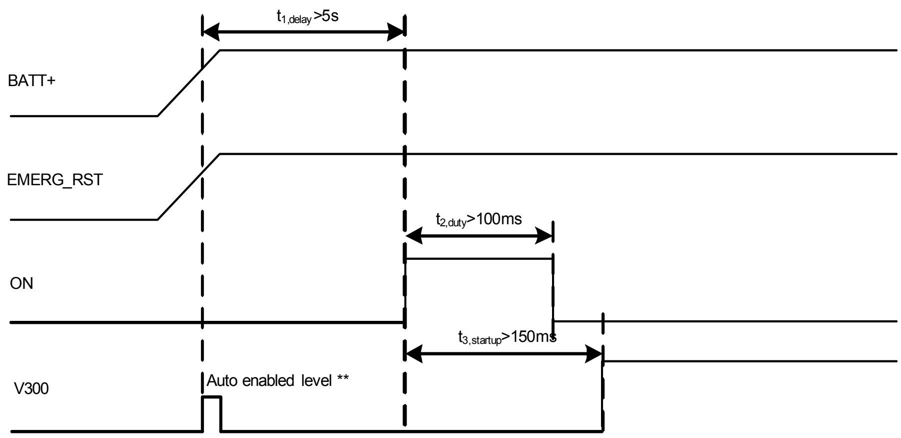


Figure 24: ON timing

Auto enabled level**: V300 rail is automatically enabled at the lowest voltage (1.5V) when module is powered on. This lowest voltage will be disabled immediately after the module's firmware boots up. V300 turns to normally voltage (3V) after the ON signal is triggered.

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]).

3.2.2 Restart Cinterion® ENS22-E

After startup Cinterion® ENS22-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 Cinterion® ENS22-E via AT+CFUN Command

To reset and restart the Cinterion® ENS22-E module use the command AT+CFUN. See [1] for details.

3.2.2.2 Restart Cinterion® ENS22-E Using EMERG_RST

The EMERG_RST signal is internally connected to the baseband chipset. A low level for more than 100ns sets the processor into a reset state. After releasing the EMERG_RST line (i.e., with a change of the signal level from low to high), the module restarts.

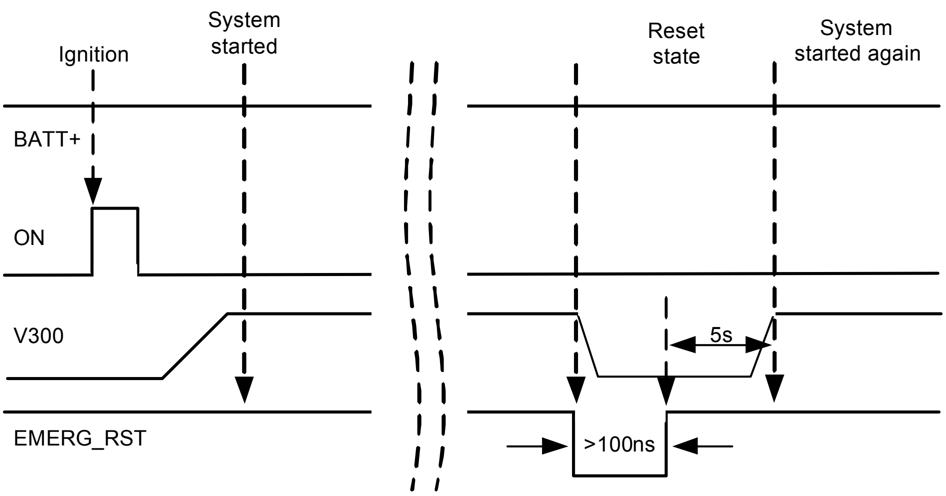


Figure 25: Emergency reset timing

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

Caution: Use the EMERG_RST line only when, due to serious problems, the software is not responding for more than 10 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 Cinterion® ENS22-E does not respond, if reset or shutdown via AT command fails.

3.2.3 Turn off Cinterion® ENS22-E

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

- *Software controlled shutdown procedure*: Software controlled by sending an AT command over the serial application interface. See Section 3.2.3.1.
- *Automatic shutdown (software controlled)*: Takes effect if module's board temperature or voltage levels exceed a critical limit. See Section 3.2.4.

3.2.3.1 Switch off Cinterion® ENS22-E Using AT Command

The best and safest approach to powering down Cinterion® ENS22-E is to issue the appropriate AT command. This procedure lets Cinterion® ENS22-E log off from the network and allows the software to enter into a secure state and safe 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.

While Cinterion® ENS22-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.**

3.2.4 Automatic Shutdown

Automatic shutdown takes effect if the following event occurs:
- Cinterion® ENS22-E board is exceeding the critical limits of overtemperature or undertemperature (see Section 3.2.4.1)
- Undervoltage or overvoltage is detected (see Section 3.2.4.2 and Section 3.2.4.3)

The automatic shutdown procedure is equivalent to the power-down initiated with an AT command, i.e. Cinterion® ENS22-E logs off from the network and the software enters a secure state avoiding loss of data.

3.2.4.1 Thermal Shutdown

The board temperature is constantly monitored by an internal temperature sensor located on the PCB. The values detected by the temperature sensor 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, Cinterion® ENS22-E instantly displays an alert (if enabled).
- URCs indicating the level "-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): The presentation of URCs is disabled, i.e. no URCs with alert levels "-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 3.5. Refer to Table 11 for the associated URCs.

Table 11: Temperature dependent behavior

Sending temperature alert (only if URC presentation enabled)	
^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. Cinterion® ENS22-E switches off.
^SCTM_B: -2	Alert: Board equal or below undertemperature limit. Cinterion® ENS22-E switches off.

3.2.4.2 Undervoltage Shutdown

The undervoltage shutdown threshold is the specified minimum supply voltage V_{BATT+} given in Table 15. When the average supply voltage measured by Cinterion® ENS22-E approaches the undervoltage warning threshold, 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.

Note: For external applications operating at the limit of the allowed tolerance, the default undervoltage warning threshold may be adapted by subtracting an offset. For details see [1]: AT^SCFG= "MEShutdown/sVsup/threshold".

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

^SBC: Undervoltage shutdown

This undervoltage shutdown 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.

3.2.4.3 Overvoltage Shutdown

The overvoltage shutdown threshold is the specified maximum supply voltage V_{BATT+} given in Table 15. When the average supply voltage measured by Cinterion® ENS22-E approaches the overvoltage warning threshold (i.e. 0.1V 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 Cinterion® ENS22-E components are directly linked to BATT+ and, therefore, the supply voltage remains applied at major parts of Cinterion® ENS22-E. Especially the power amplifier linked to $BATT+_{RF}$ is very sensitive to high voltage and might even be destroyed.

3.3 Power Saving while Attached to NB-IoT

Cinterion® ENS22-E can be configured to control power consumption by DRX, eDRX, and PSM while attached to an NB-IoT network. PSM is the recommended and efficient way of power saving.

Generally, power saving depends on the module's application scenario and may differ from the following normal operation.

3.3.1 Power Saving in DRX

Cinterion® ENS22-E can be configured to use DRX (Discontinuous Reception) in idle mode to reduce power consumption. The power saving possibilities while attached to an NB-IoT network depend on the paging timing cycle of the base station.

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

t = DRX Cycle Value * 10 ms

DRX cycle value in NB-IoT networks is any of the four values: 128, 256, 512 and 1024, thus resulting power saving intervals between 1.28 and 10.24 seconds. The DRX cycle value of the base station is assigned by the NB-IoT network operator.

In the pauses between listening to paging messages, the module resumes power saving, as shown in Figure 26.

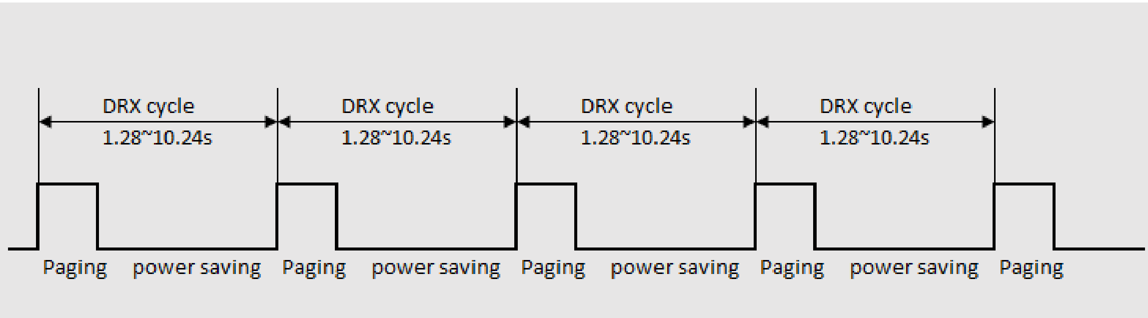


Figure 26: DRX based paging and power saving in NB-IoT networks

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

3.3.2 Power Saving in eDRX

Cinterion® ENS22-E and the network may negotiate the use of eDRX (extended DRX) to reduce power consumption, while being available for mobile terminating data and/or network originated procedures within a certain delay dependent on the DRX cycle value. If the network is configured to use eDRX, the module only monitors the Paging messages, during a periodic Paging Time Window (PTW) configured for Cinterion® ENS22-E.

The possible eDRX paging cycle length (PCL) ranges from 20.48s up to a maximum of 10485.76s (almost 3 hours). The eDRX PCL is mapped according to Table 12.

Table 12: eDRX cycle length mapping table

eDRX value (binary code)	E-UTRAN eDRX PCL duration (seconds)
0010	20.48
0011	40.96
0101	81.92
1001	163.84
1010	327.68
1011	655.36
1100	1310.72
1101	2621.44
1110	5242.88
1111	10485.76

The PTW length can be calculated using the following formula:

t_ptw = (PTW value +1)* 2560 ms

Figure 27 shows the eDRX procedure, with the module listening to paging messages in paging time window (PTW).

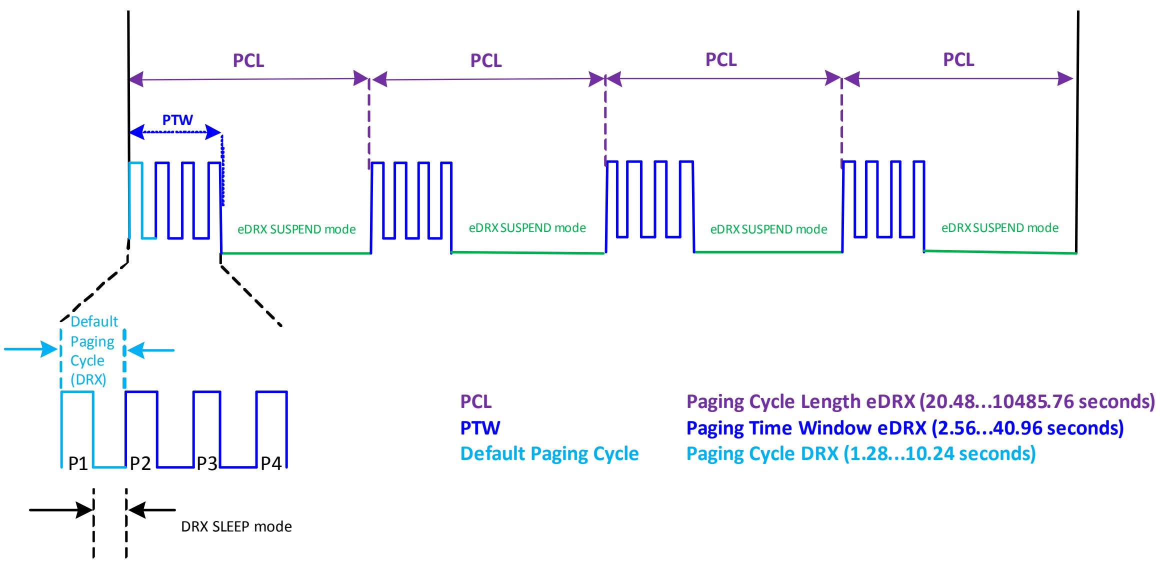


Figure 27: eDRX based paging and power saving (SLEEP) in NB-IoT networks

The eDRX timer can be configured by AT+CEDRXS command, which negotiates the eDRX setting with the network. The dynamic parameters are readable by AT+CEDRXRDP command. For more information on these AT commands, see [1].

Note: eDRX should be configured together with 3GPP PSM (AT+CPSMS) as it will not only affect SLEEP mode, but also the SUSPEND mode - see Section 3.3.4.2.

3.3.3 Power Saving in PSM

Cinterion® ENS22-E can be configured to use 3GPP PSM to reduce power consumption. PSM is similar to power off, while Cinterion® ENS22-E remains registered with the network. There is no need to re-attach or re-establish PDN connections. Cinterion® ENS22-E in PSM is not immediately reachable for mobile terminating services (see also SUSPEND mode in Section 3.3.4.2).

The network accepts and negotiates the use of PSM by providing a specific value for active timer (T3324). Upon expiry of the active timer, or if the value provided by the network is zero, Cinterion® ENS22-E may activate PSM.

NOTE: If Cinterion® ENS22-E requests to enable both PSM (requesting an active time and possibly a periodic TAU timer) and eDRX (with a specific extended idle mode DRX cycle value), it is up to the network to decide whether to:
1. Enable only PSM, i.e. not accept the request for extended idle mode DRX.
2. Enable only extended idle mode DRX, i.e. not accept the request for an active time.
3. Enable both PSM (i.e. provide active time) and extended idle mode DRX (i.e. provide extended idle mode DRX parameters).

Figure 28 shows the module's eDRX and PSM timings for the third case where module and network negotiate PSM and eDRX simultaneously (for eDRX see also Section 3.3.2). For the second case the module will continue with the eDRX paging cycles (see Figure 27). For the first case the module will not extend the DRX paging cycles, but will continue with the DRX paging cycles until the active timer (T3324) expires (see Figure 26).

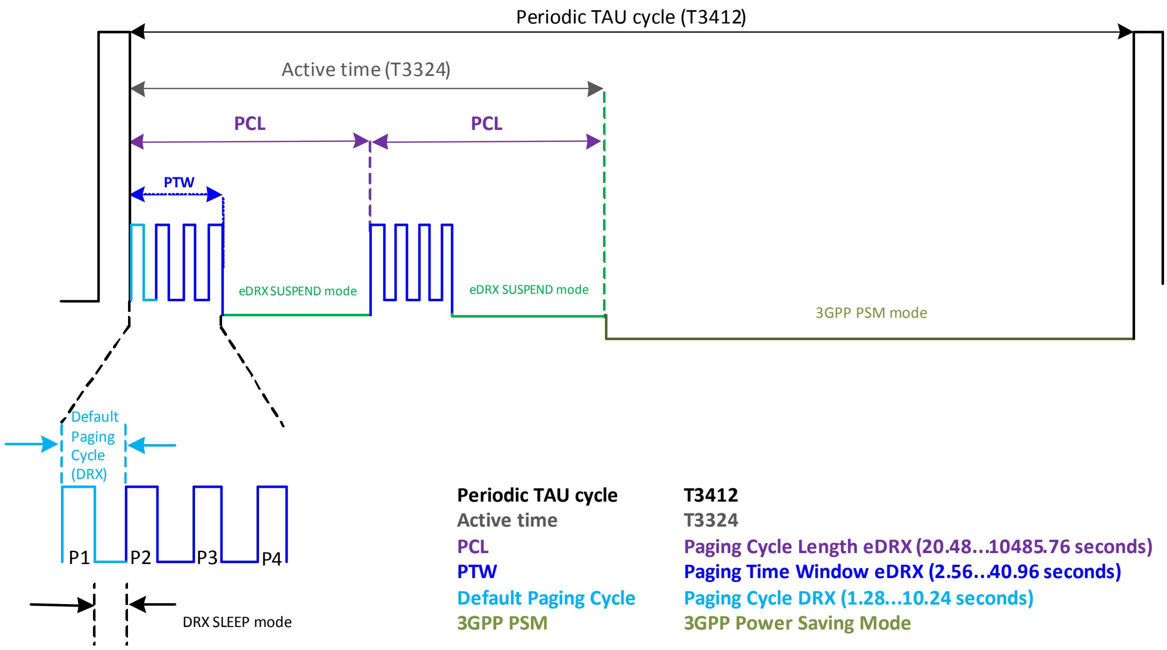


Figure 28: Enable eDRX and PSM in NB-IoT networks

Cinterion® ENS22-E monitors paging message only while the active timer (T3324) has not expired. If the module has uplink data or signal, it will not change to PSM.

The active timer (T3324) and periodic Tracking Area Update (TAU) timer can be configured by AT+CPSMS command. The timer value is only one byte: bit5~1 indicate the value, bit8~6 indicate the timer unit.

The timer unit is mapped according to Table 13 and Table 14.

Table 13: Active timer unit mapping table

Active timer value (bit 8~6)	Active timer unit
000	2 seconds
001	1 minute
010	Decihour (6 minutes)
111	The timer is deactivated

Table 14: Periodic TAU timer unit mapping table

Periodic TAU timer value (bit 8~6)	Periodic TAU timer unit
000	10 minutes
001	1 hour
010	10 hours
011	2 seconds
100	30 seconds
101	1 minute
110	320 hours
111	The timer is deactivated

3.3.4 Power Saving in SLEEP and SUSPEND Modes

Cinterion® ENS22-E supports the following low consumption modes:

- SLEEP mode: A low energy consumption mode. There is no activity inside the module but module preserves the state in which it was before entering the SLEEP mode, including the electrical states of the GPIOs. See Section 3.3.4.1.
- SUSPEND mode: The lowest energy consumption mode of Cinterion® ENS22-E, in which the module is still registered to the network. There is no activity inside the module unless the internal counter and circuit for wake-up mechanism. See Section 3.3.4.2.

Figure 29 shows how Cinterion® ENS22-E transits between different states and modes.

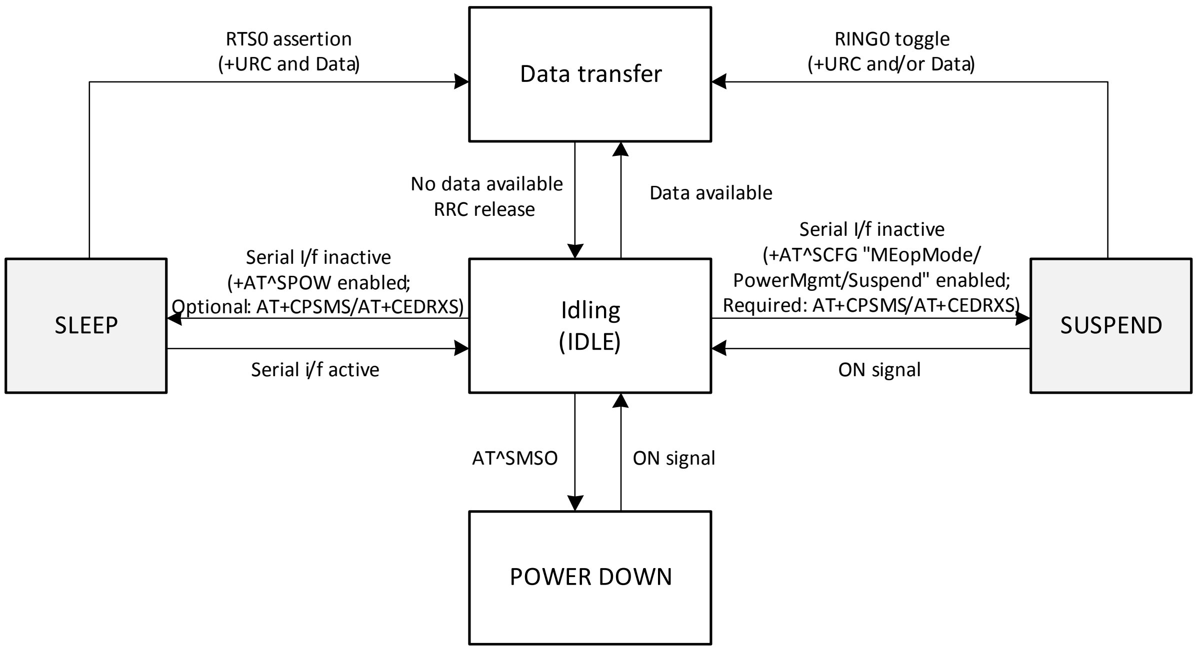


Figure 29: State Transition of Cinterion® ENS22-E

Notes:
- When all UART interfaces (i.e. ASC0 and ASC1) are idle, the module enters SLEEP or SUSPEND mode by keeping RTS0 high for 5 seconds.
- The UART interfaces are not idle if there is any response message not read out from ASC0 or ASC1.

3.3.4.1 SLEEP Mode

By default, the module enters SLEEP mode if RTS0 is inactive (i.e. UART inactive) for a time interval of 5 seconds. The time interval is configurable by AT^SPOW. See [1] for details.

RTS0 can be used to wake up Cinterion® ENS22-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.

Note: After the assertion of RTS0, there is a minor time interval (<5ms) before the UART is ready (CTS0 is low). In this interval, data on the UART will be truncated.

When RTS0 is de-asserted, after UART is inactive for a configured time interval, the module will return to SLEEP mode again and de-assert the CTS0.

It is therefore recommended to enable RTS/CTS flow control (default setting).

Figure 30 shows the described RTS0 wake up mechanism.

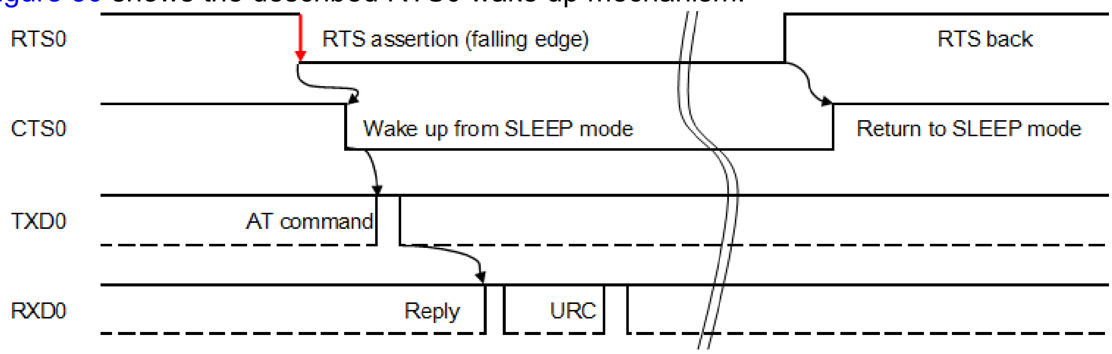


Figure 30: Wake-up via RTS0

3.3.4.2 SUSPEND Mode

The command AT^SCFG="MeOpMode/PowerMgmt/Suspend", <Suspend> enables the SUSPEND mode in Cinterion® ENS22-E. See [1] for details.

Cinterion® ENS22-E shall enter SUSPEND mode if PSM or eDRX is enabled (i.e. configuration negotiated with the network allows it).

Once the SUSPEND mode is enabled via AT command, and network negotiated parameters allow energy gaining from the SUSPEND mode, the following URC shows:

"^SUSPEND AVAILABLE"

In addition, if no more communication with network is needed, the module is ready to enter SUSPEND mode, the following URC shows:

"^SUSPEND READY"

If RTS0 is set to inactive (i.e. UART inactive) for a configured time interval, the module enters SUSPEND mode. The length of time interval is configurable using AT^SPOW. See [1] for details.

In SUSPEND mode, Power Indication Circuit (refer to Section 2.1.8.1) can report the module's power state (i.e. whether in SUSPEND mode).

Figure 31 shows the handshake between the host, module and network for entering SUSPEND mode.

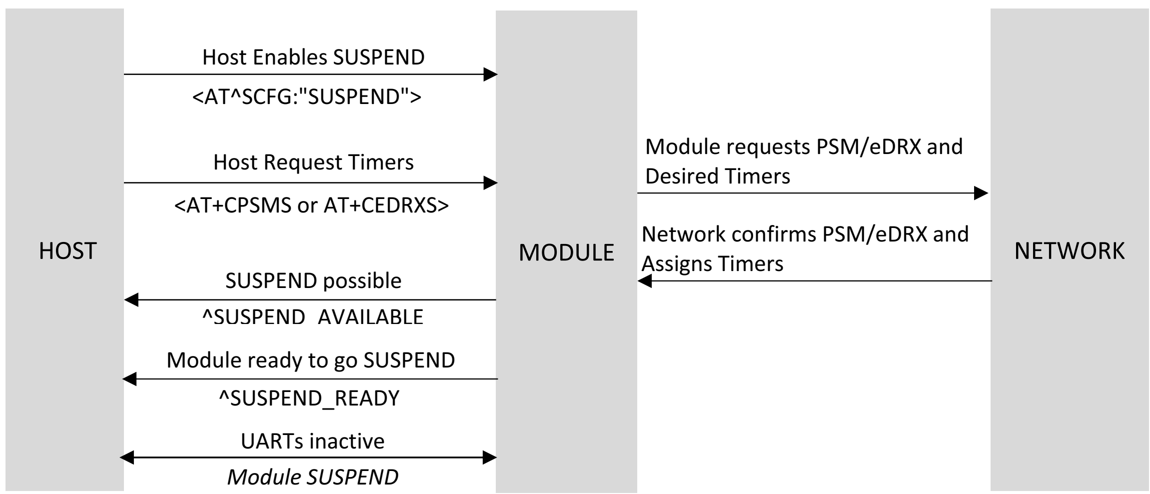


Figure 31: Handshake for entering SUSPEND mode

ON signal can be used to wake up the module from SUSPEND mode.

Figure 32 shows the handshake among the host, module and network for waking up the module via ON signal.

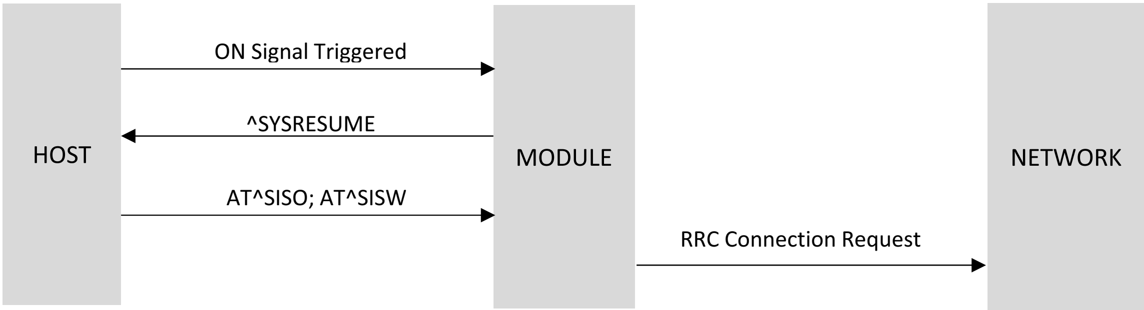


Figure 32: Handshake for waking up module via ON signal

Cinterion® ENS22-E automatically switches to a higher operation mode to properly handle the radio interface procedures (e.g. PTW in eDRX mode, or TAU in PSM mode). In such cases, the host will be woken up via RING0 if there is one of the following configured events for the host:

- URC on incoming data, or
- URC on incoming SMS

In one of the above events, and if the host sets RTS0 active within 5 seconds, then the module is woken up from SUSPEND mode.

Figure 33 shows the handshake among the host, module and network for waking up the module via URCs:

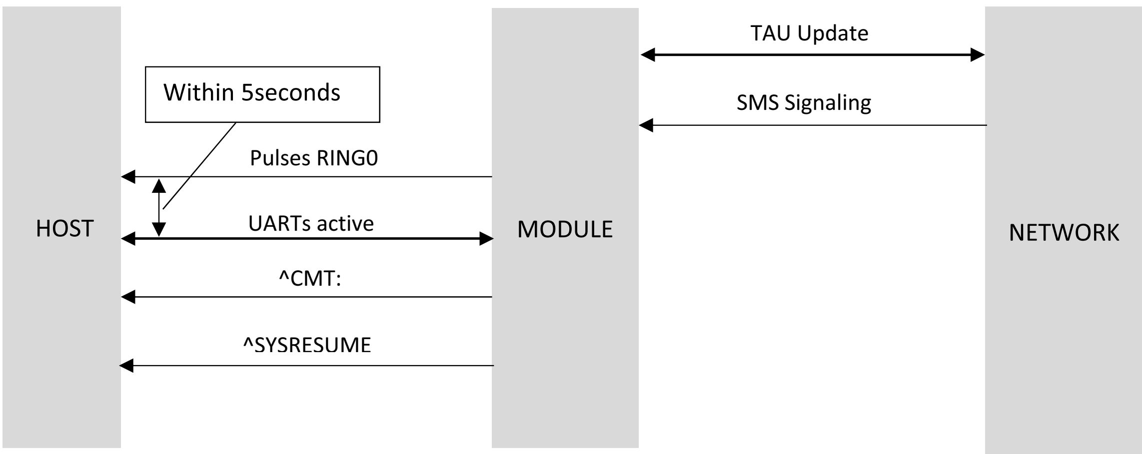


Figure 33: Handshake for waking up module via URCs within 5 seconds

In case the host does not set RTS0 active within 5 seconds, the state will return to SUSPEND mode.

Figure 34 shows the handshake among the host, module and network for waking up the module via URCs, after 5 seconds (timeout; the module returns to SUSPEND mode):

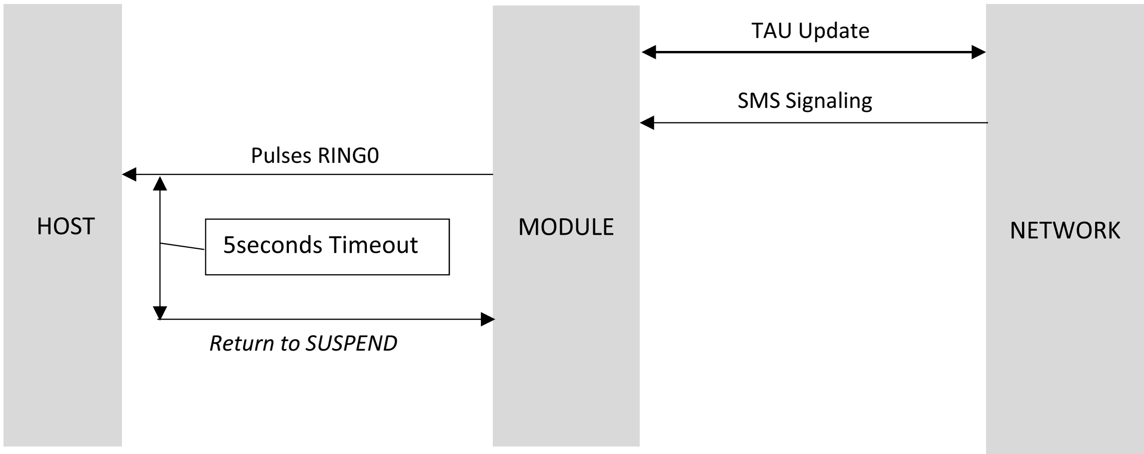


Figure 34: Handshake for waking up module via URCs, after 5 seconds

See [1] for more details about SUSPEND mode.

3.4 Power Supply

Cinterion® ENS22-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 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 Cinterion® ENS22-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.
- Switches the module's power voltages for the power-up and -down procedures.
- SIM switch to provide SIM power supply.

3.4.1 Power Supply Ratings

Table 15 and Table 16 assemble various voltage supply and current consumption ratings of the module.

Table 15: 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.	3.1[1]		4.2[2]	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}

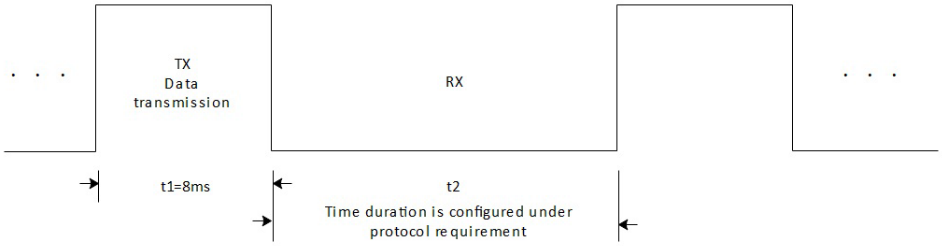
1. Extended supply voltage range 2.8V to 4.2V with restrictions in RF output power and deviations in the voltage levels of V300 and digital interfaces.
2. The module should not be supplied with voltage over 4.2V even temporarily. It is recommended to add ESD device with voltage stabilization function.

Table 16: Current consumption ratings[1]

	Description	Mode		Conditions		Typical rating	Unit
I_{BATT+}	OFF State supply current	Power Down mode		Power Down mode		3.8	µA
I_{BATT+}	Average supply current	SUSPEND mode		PSM		3.8	µA
				eDRX	Cycle=20.48s, PTW=2.56s	0.3	mA
					Cycle=81.92s, PTW=2.56s	0.2	mA
		SLEEP mode		PSM		2.4	mA
				eDRX	Cycle=20.48s, PTW=2.56s	2.7	mA
					Cycle=81.92s, PTW=2.56s	2.6	mA
				DRX	2.56s	3.5	mA
		Normal operation mode	Idle	PSM		3.9	mA
				eDRX	cycle=20.48s PTW=2.56s	4.2	mA
					cycle=81.92s PTW=2.56s	4.1	mA
				DRX	2.56s	4.6	mA
			Active	No active Tx		19.5	mA
				Active Tx @ 0dBm[2]	Band 3	41.6	mA
					Band 5	39.7	mA
					Band 8	40.5	mA
					Band 20	39.8	mA
					Band 28	41.9	mA
				Active Tx @ 23dBm[2]	Band 3	192.0	mA
					Band 5	179.0	mA
					Band 8	182.1	mA
					Band 20	182.3	mA
					Band 28	273.5	mA
I_{BATT+}	Peak supply current[3]	Normal operation mode @ 85°C		Active Tx @ 23dBm	Band 3	260[4]	mA
					Band 5	295[4]	mA
					Band 8	314[4]	mA
					Band 20	295[4]	mA
					Band 28	404[4]	mA

1. $V_{BATT+BB}$=3.6V, $V_{BATT+RF}$=3.6V, $T_{Ambient}$=25°C, and 50 Ohm load, unless otherwise noted.

2. The test conditions are: subcarrier spacing: 15 kHz; number of subcarriers: single tone; start position of subcarrier:0 ; modulation: QPSK. The test diagram is as follow..



3. The test conditions are: $V_{BATT+BB}$ =2.8V, $V_{BATT+RF}$ =2.8V, $T_{Ambient}$ =85°C, QPSK, Multi-tone 12 subcarriers, and 50 Ohm load.
4. This is the typical value of the peak supply current. For power supply dimensioning, it is suggested to add 20% margin to the peak supply current.

3.4.2 Minimizing Power Losses

When designing the power supply for your application please pay specific attention to power losses. Ensure that the input voltage V_{BATT+} never drops below 2.8V on the Cinterion® ENS22-E board, not even in a transmit burst where current consumption can rise (for peak values see the power supply ratings listed in Section 3.4.1)

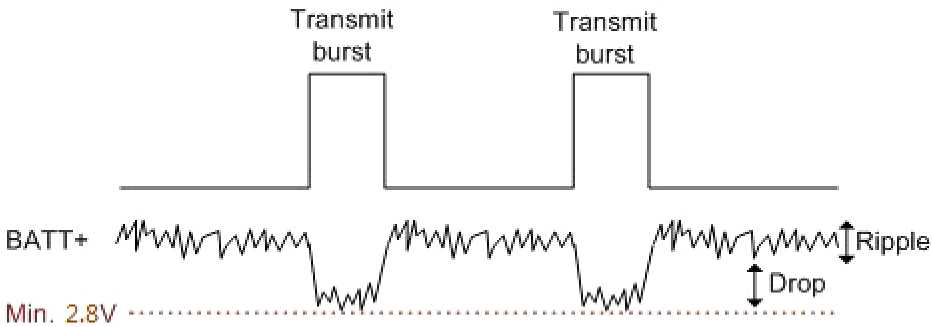


Figure 35: Power supply limits during transmit burst

3.4.3 Measuring the Supply Voltage (V_{BATT+})

To measure the supply voltage V_{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 5 (BATT+$_{BB}$) as shown in Figure 36.

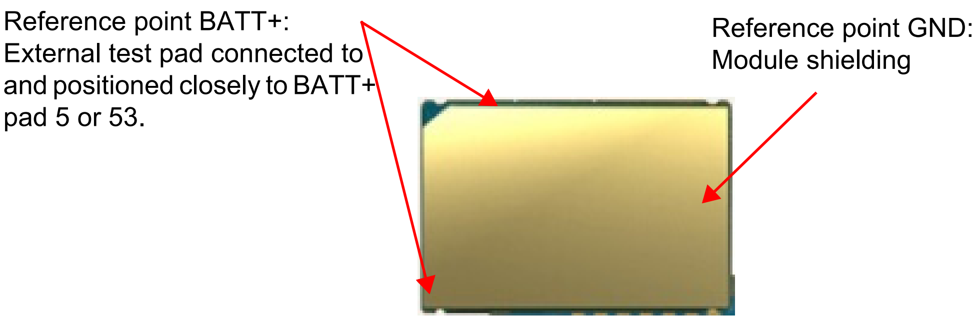


Figure 36: Position of reference points BATT+ and GND

3.4.4 Monitoring Power Supply by AT Command

To monitor the supply voltage you can also use the AT^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 Cinterion® ENS22-E is in idle mode or Limited Service (deregistered). The displayed voltage (in mV) is averaged over the last measuring period before the AT^SBV command was executed.

If the measured voltage drops below or rises above the voltage shutdown thresholds, the module will send an "^SBC" URC and shut down (for details see Section 3.2.4).

3.5 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 17: Board temperature

Parameter	Min	Typ	Max	Unit
Normal operation	-30	+25	+85	°C
Extended operation[1]	-40		+85	°C
Automatic shutdown[2] Temperature measured on ENS22 board	<-40		>+85	°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 ±5°C on the thresholds may occur.

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.

3.6 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 Cinterion® ENS22-E module.

Special ESD protection provided on Cinterion® ENS22-E:
- Antenna interface: A parallel 33nH ESD protection inductor (see Section 3.4.4)

Cinterion® ENS22-E has been tested according to group standard ETSI EN 301 489-1 and test standard EN 61000-4-2. Electrostatic values can be gathered from the following table.

Table 18: Electrostatic values

Specification/Requirements	Contact discharge	Air discharge
EN 61000-4-2		
Antenna interfaces	±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.

3.6.1 ESD Protection for Antenna Interface

Cinterion® ENS22-E has a parallel 33nH ESD protection inductor near the side of antenna in-erface. This inductor is a DC current path to GND. External DC voltage is not allowed, which would damage the ESD inductor.

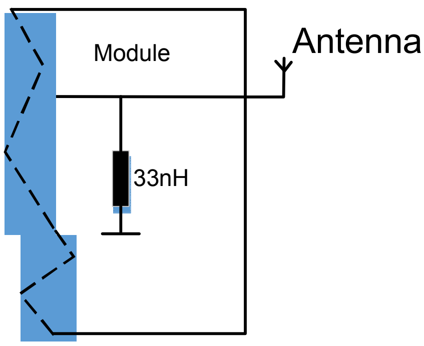


Figure 37: Antenna interface with ESD

3.7 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. 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 38 and Table 19). 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 1kΩ 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.

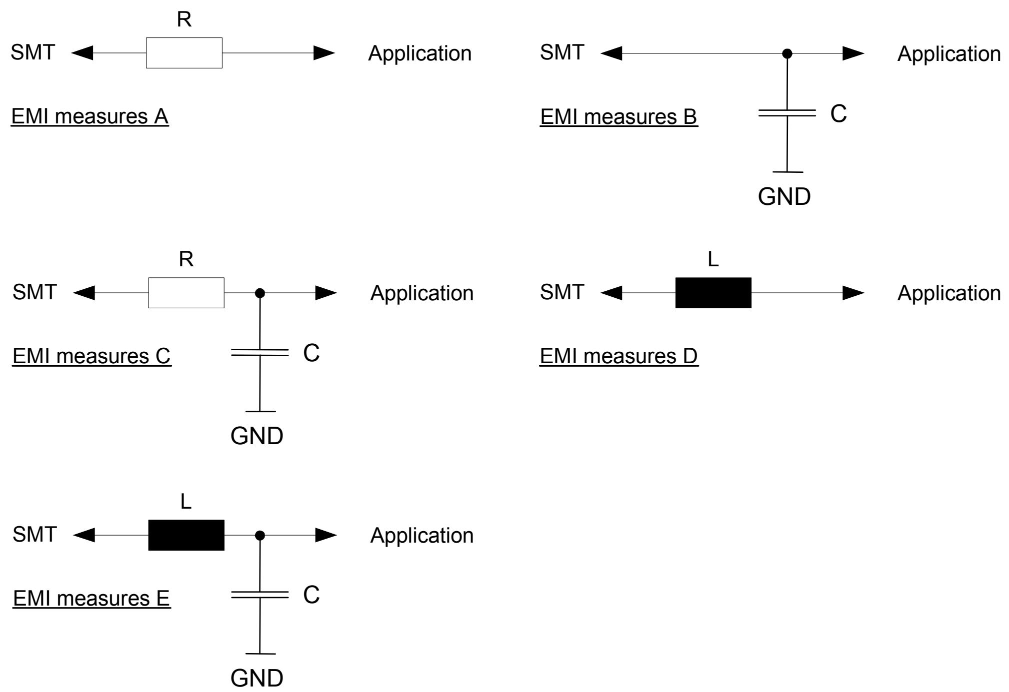


Figure 38: EMI circuits

Note: In case the application uses an internal RF antenna that is implemented close to the Cinterion® ENS22-E module, Gemalto strongly recommends sufficient EMI measures, e.g. of type B or C, for each digital input or output.

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

Table 19: EMI measures on the application interface

Signal name	EMI measures					Remark
	A	B	C	D	E	
CCCLK[1]	x	x	x			The external capacitor is recommended not to exceed 1nF. The value of the capacitor depends on the external application.
CCIO[1]	x	x	x			
CCRST[1]	x	x	x			
RXD0	x	x	x			
TXD0	x	x	x			
CTS0	x	x	x			
RTS0	x	x	x			
GPIO24/RING0	x	x	x			
GPIO1/DTR0	x	x	x			
GPIO2/DCD0	x	x	x			
GPIO3/DSR0	x	x	x			
GPIO4	x	x	x			
GPIO5	x	x	x			
GPIO8	x	x	x			
GPIO9	x	x	x			The rising signal edge is reduced with an additional capacitor.
GPIO10	x	x	x			
GPIO16/RXD1	x	x	x			
GPIO17/TXD1	x	x	x			
GPIO18/RTS1	x	x	x			
GPIO19/CTS1	x	x	x			
CCVCC[1]		x		x	x	
V300		x		x	x	
$BATT+_{BB}$ (pad 5)		x		x	x	
$BATT+_{RF}$ (pad 53)		x		x	x	

1. Not applicable for eSIM option.

3.8 Reliability Characteristics

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

Note: The reliability testing is still in progress.

Table 20: 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 (± x, y and z)	DIN IEC 60068-2-27
Dry heat	Temperature: +70 ±2°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°C ±2°C High temperature: +85°C ±2°C Changeover time: < 30s (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°C ±2°C Low temperature: +25°C ±2°C Humidity: 93% ±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 ±2°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 Cinterion® ENS22-E

Figure 39 shows the top and bottom view of Cinterion® ENS22-E and provides an overview of the board's mechanical dimensions. For further details see Figure 40.

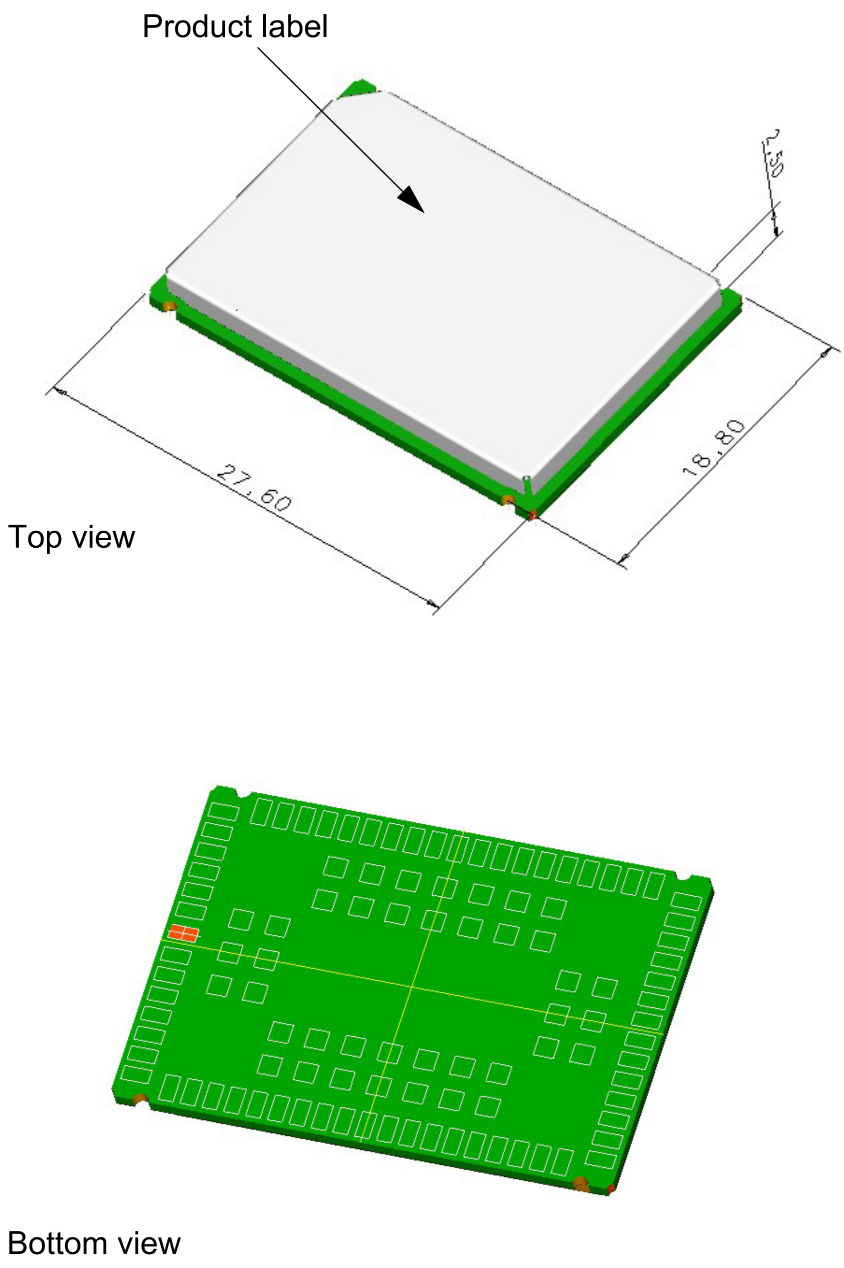


Figure 39: Cinterion® ENS22-E – top and bottom view

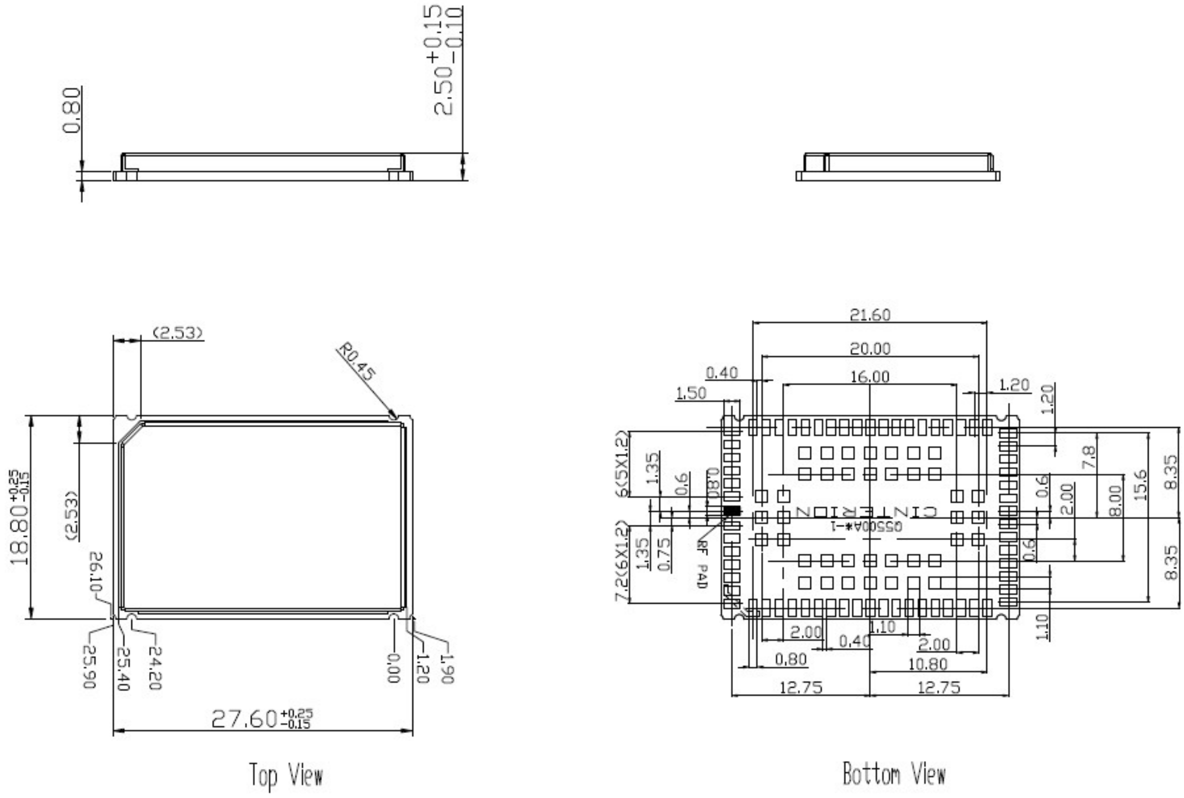


Figure 40: Dimensions of Cinterion® ENS22-E (all dimensions in mm)

4.2 Mounting Cinterion® ENS22-E onto the Application Platform

This section describes how to mount Cinterion® ENS22-E onto the PCBs, including land pattern and stencil design, board-level characterization, soldering conditions, durability and mechanical handling.

Note: To avoid short circuits between signal tracks on an external application's PCB and various markings at the bottom side of the module, it is recommended not to route the signal tracks on the top layer of an external PCB directly under the module, or at least to ensure that signal track routes are sufficiently covered with solder resist.

4.2.1 SMT PCB Assembly

4.2.1.1 Land Pattern

The land pattern design as shown below is based on Gemalto characterizations for lead-free solder paste on a four-layer test PCB.

The land pattern given in Figure 41 reflects the module's pad layout, including signal pads and ground pads (for pad assignment see Section 2.1.1).

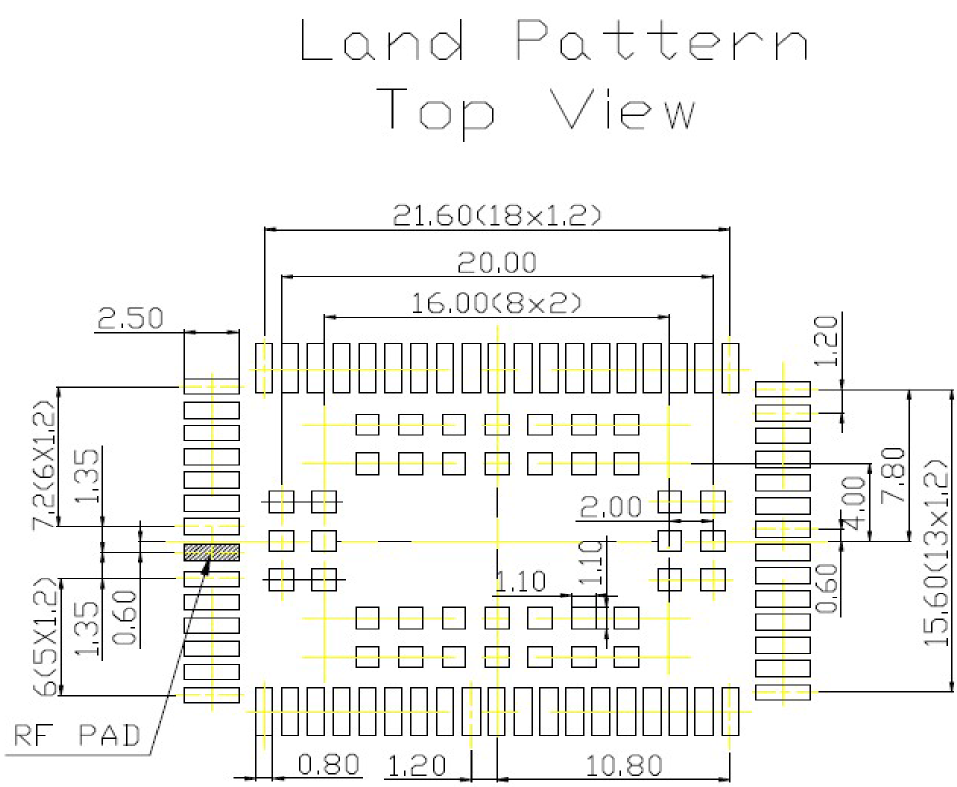


Figure 41: Land pattern (top view)

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.

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.

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

Cinterion® ENS22-E comprises components that are susceptible to damage induced by absorbed moisture.

Gemalto M2M's Cinterion® ENS22-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

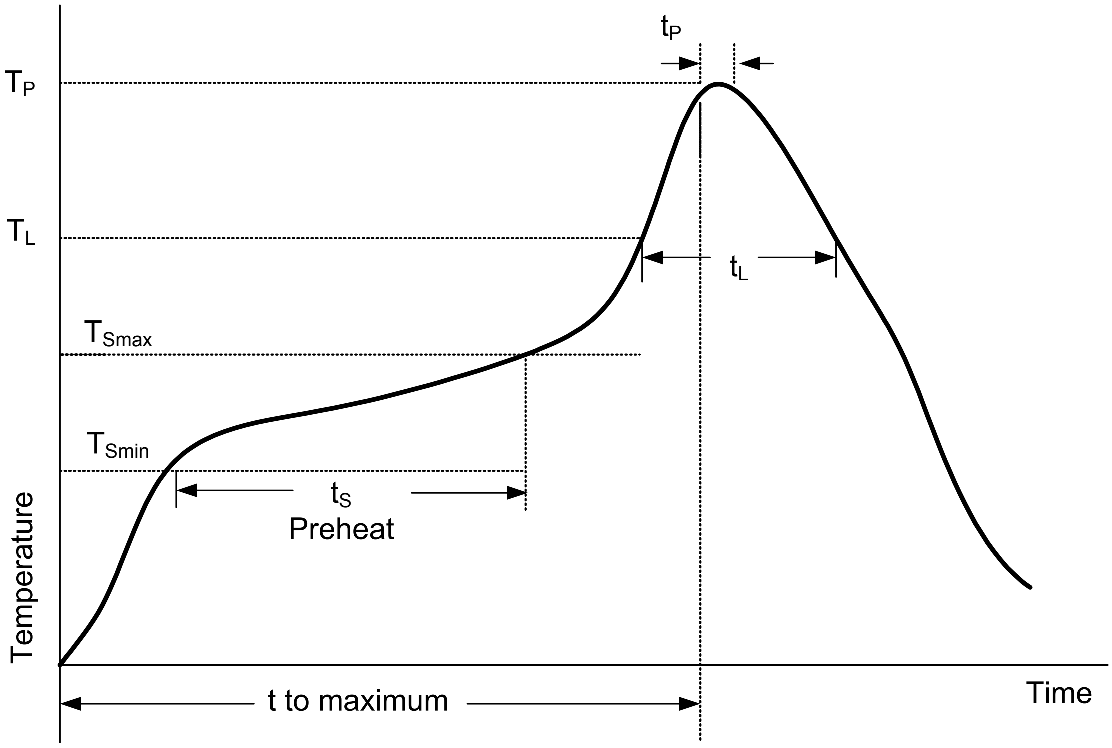


Figure 42: Reflow Profile

Table 21: Reflow temperature ratings[1]

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 50-90 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	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.

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 245°C. This specifies the temperature as measured at the module’s top side.
- A maximum duration of 30 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.

Cinterion® ENS22-E is specified for one soldering cycle only. Once Cinterion® ENS22-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

Cinterion® ENS22-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 22: 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

Cinterion® ENS22-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 47 for details):
- It is *not necessary* to bake Cinterion® ENS22-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 Cinterion® ENS22-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.

4.3 Packaging

4.3.1 Tape and Reel

The single-feed tape carrier for Cinterion® ENS22-E is illustrated in Figure 43. The figure also shows the proper part orientation. The tape width is 44mm and the Cinterion® ENS22-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

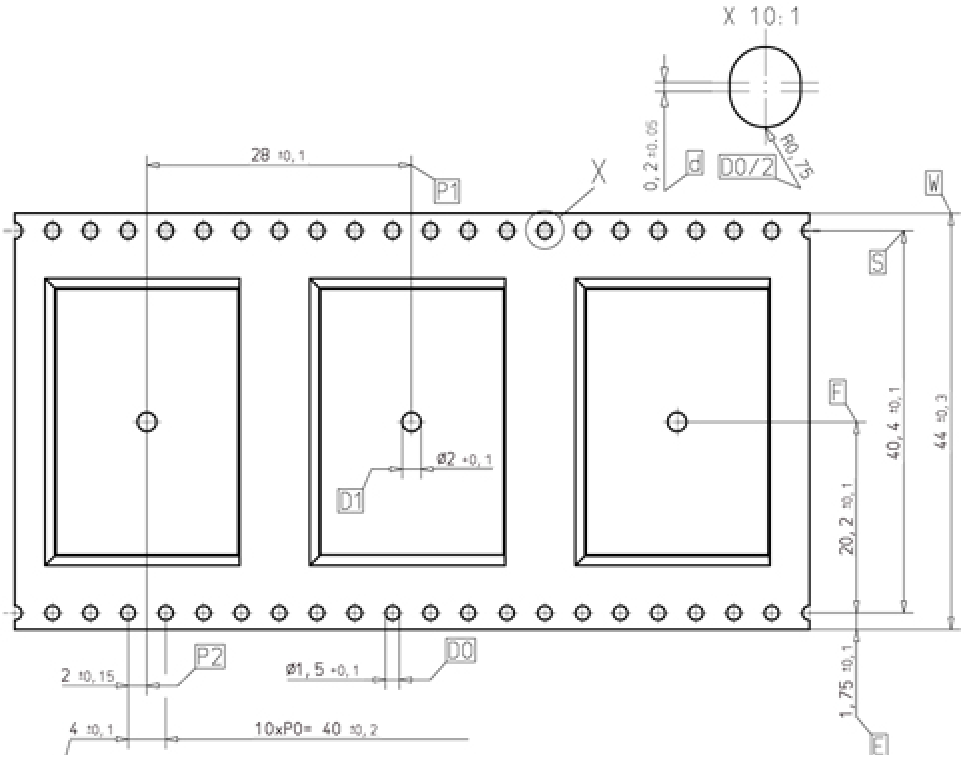


Figure 43: Carrier tape

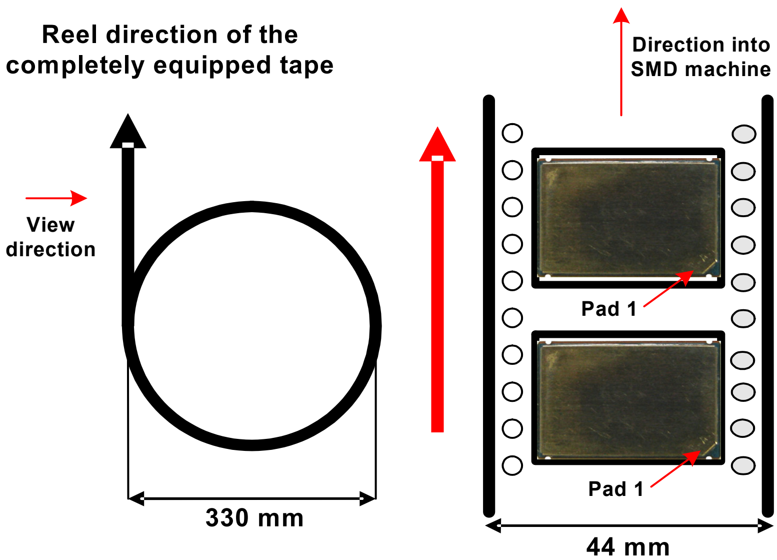


Figure 44: Reel direction

4.3.1.2 Barcode Label

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

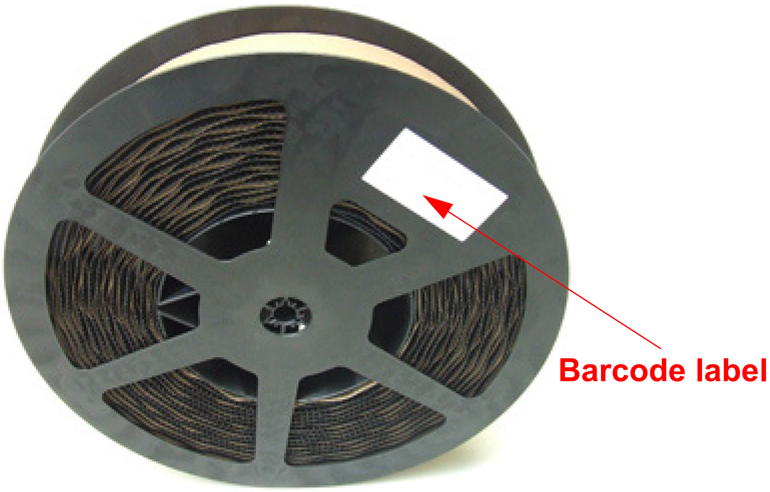


Figure 45: Barcode label on tape reel

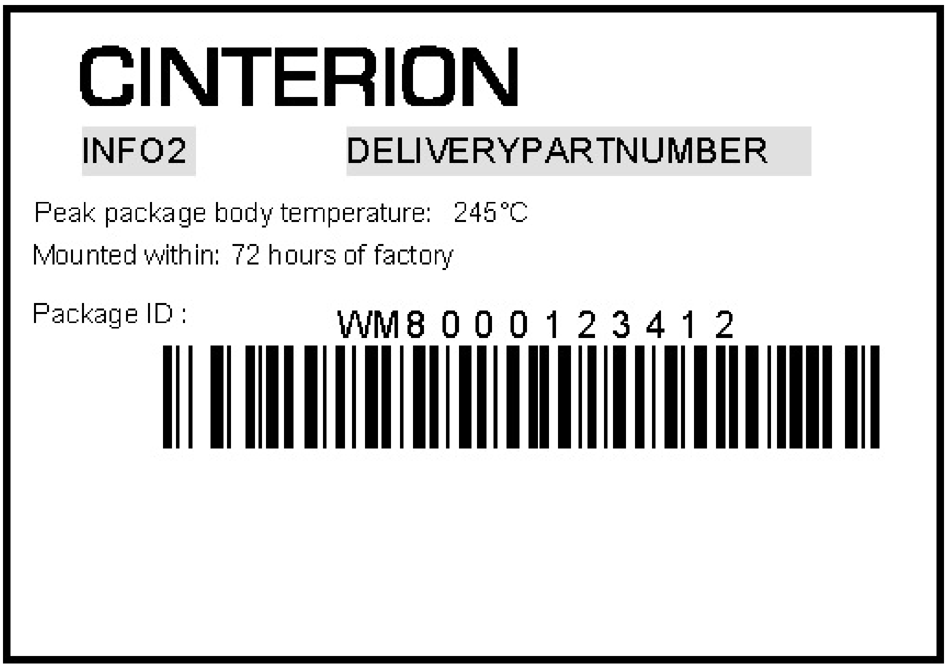


Figure 46: Barcode label on tape reel - layout

Variables on the label are explained in Table 23.

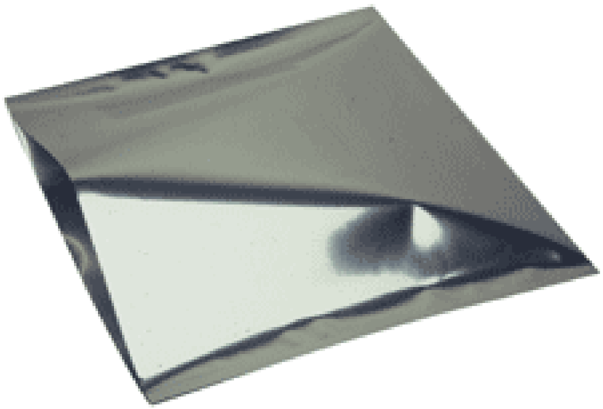
4.3.2 Shipping Materials

Cinterion® ENS22-E is distributed in tape and reel carriers. The tape and reel carriers used to distribute Cinterion® ENS22-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 47. 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 Cinterion® ENS22-E modules from moisture exposure. It should not be opened until the devices are ready to be soldered onto the application.



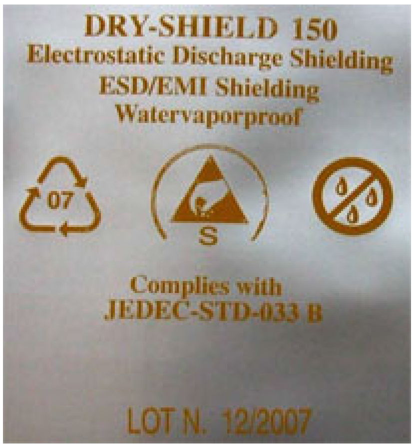


Figure 47: Moisture barrier bag (MBB) with imprint

The label shown in Figure 48 summarizes requirements regarding moisture sensitivity, including shelf life and baking requirements. It is attached to the outside of the moisture barrier bag.

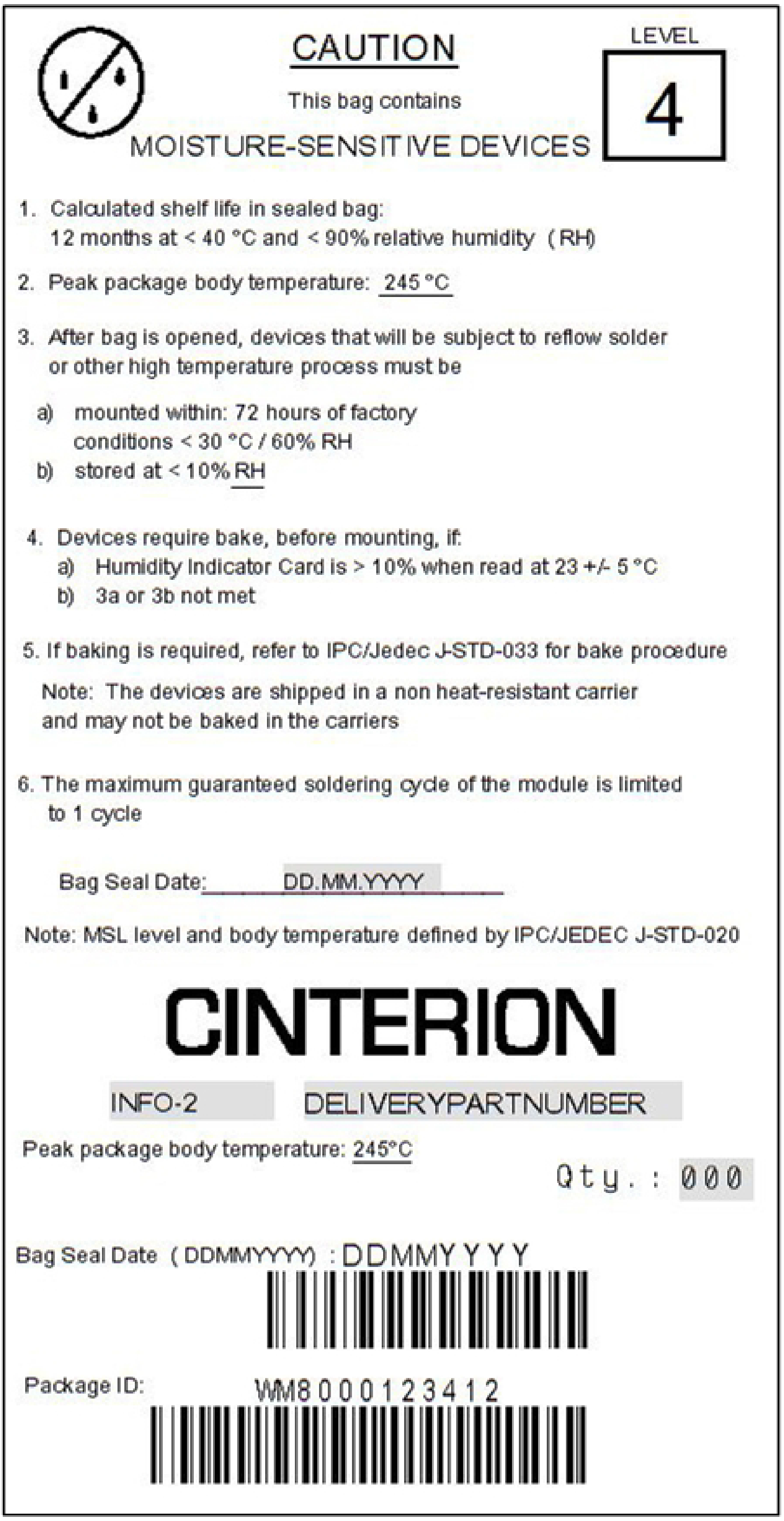


Figure 48: Moisture Sensitivity Label

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 49. If the components have been exposed to moisture above the recommended limits, the units will have to be rebaked.

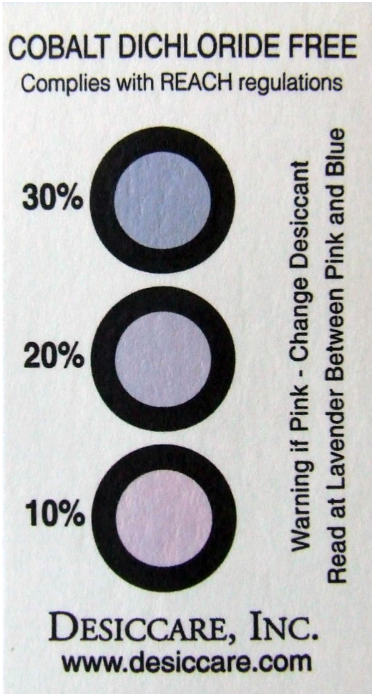


Figure 49: Humidity Indicator Card - HIC

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.

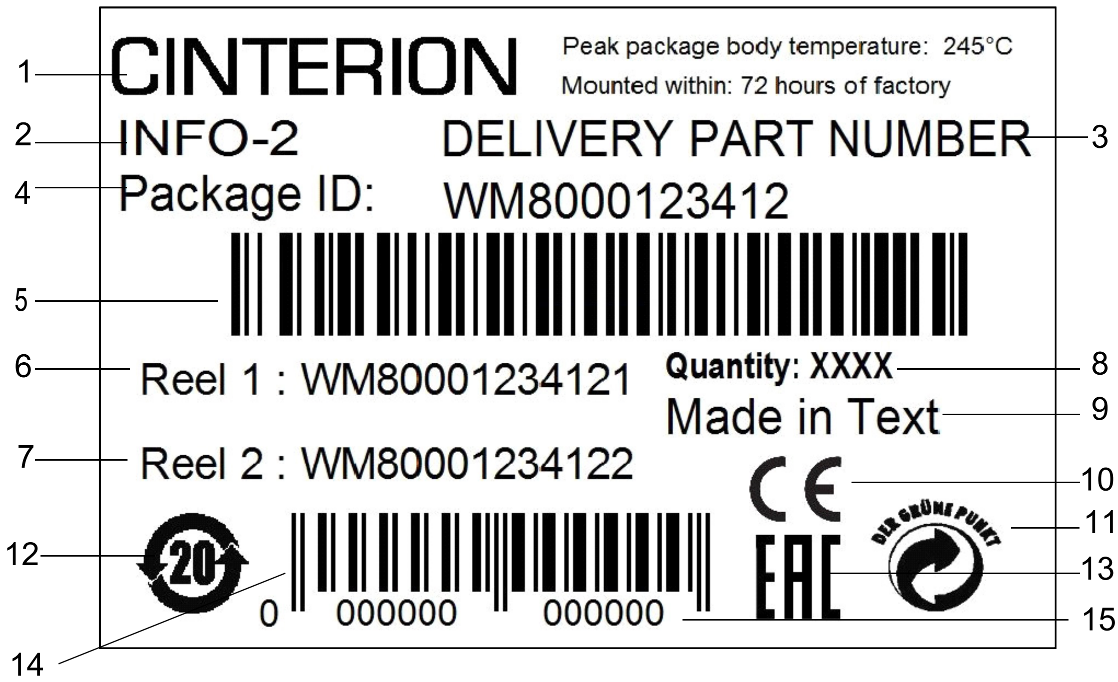


Figure 50: Sample of VP box label

Table 23: VP Box label information

No.	Information
1	Cinterion Logo
2	Product name
3	Product ordering number
4	Package ID number of VP box (format may vary depending on the product)
5	Package ID barcode (Code 128)
6	Package ID Reel 1 (format may vary depending on the product)
7	Package ID Reel 2 (format may vary depending on the product)
8	Quantity of the module inside the VP box (max. 1000 pcs)
9	Country of Production
10	CE logo (CE mark on VP box label is present only for modules with CE imprinted on the shielding)
11	Der Grüne Punkt (Green Dot) symbol
12	Chinese RoHS symbol (see Table 27)
13	EAC logo
14	European Article Number (EAN-13) barcode
15	European Article Number, consists of 13 digits (EAN-13)

4.3.3 Trays

If small module quantities are required, e.g., for test and evaluation purposes, Cinterion® ENS22-E may be distributed in trays (for dimensions see Figure 51). 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.

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).

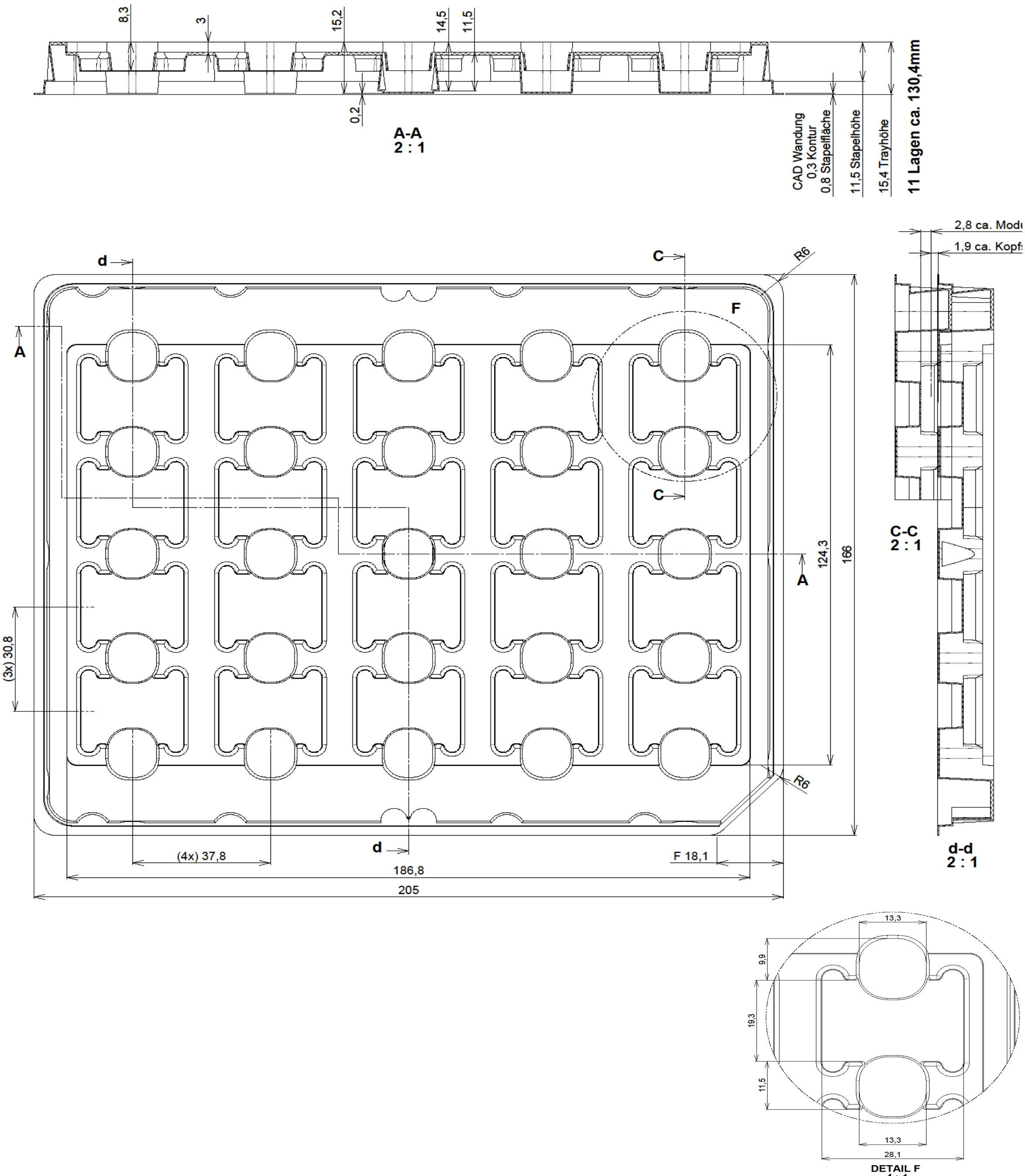


Figure 51: Tray dimensions

5 Regulatory and Type Approval Information

5.1 Directives and Standards

Cinterion® ENS22-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 "Cinterion® ENS22-E Hardware Interface Description".[1]

Table 24: Directives

2014/53/EU	Directive of the European Parliament and of the Council of 16 April 2014/ on the harmonization of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/05/EC. The product is labeled with the CE conformity mark
2002/95/EC (RoHS 1) 2011/65/EC (RoHS 2) 2015/863/EC (RoHS 3)	Directive of the European Parliament and of the Council of 27 January 2003 (revised on 8 June 2011, and amended in 4 June 2015) on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)

Table 25: Standards of Type Approval

GCF-CC v.3.71	Global Certification Forum - Certification Criteria
ETSI EN 301 908-13 V11.1.2	IMT cellular networks; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 13: Evolved Universal Terrestrial Radio Access (E-UTRA) User Equipment (UE)
ETSI EN 301 908-1 V11.1.1	IMT cellular networks; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 1: Introduction and common requirements
Draft ETSI EN 301 489-52 V1.1.0	Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 52: Specific conditions for Cellular Communication Mobile and portable (UE) radio and ancillary equipment; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU
Draft ETSI EN 301 489-01 V2.2.0	ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU and the essential requirements of article 6 of Directive 2014/30/EU
EN 60950-1: 2006 +A11:2009+A1:2010+A12:2011+A2:2013	Safety of information technology equipment
EN 62311: 2008	Assessment of electronic and electrical equipment related to human expo-sure restrictions for electromagnetic fields (0 Hz - 300 GHz)

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.

Table 26: Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes
EN 62311:2008	Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)

Table 27: Standards of the Ministry of Information Industry of the People's Republic of China

SJ/T 11363-2006	"Requirements for Concentration Limits for Certain Hazardous Substances in Electronic Information Products" (2006-06).
SJ/T 11364-2006	"Marking for Control of Pollution Caused by Electronic Information Products" (2006-06). According to the "Chinese Administration on the Control of Pollution caused by Electronic Information Products" (ACPEIP) the EPUP, i.e., Environmental Protection Use Period, of this product is 20 years as per the symbol shown here, unless otherwise marked. The EPUP is valid only as long as the product is operated within the operating limits described in the Gemalto M2M Hardware Interface Description. Please see Table 28 for an overview of toxic or hazardous substances or elements that might be contained in product parts in concentrations above the limits defined by SJ/T 11363-2006.

Table 28: Toxic or hazardous substances or elements with defined concentration limits

部件名称 Name of the part	有毒有害物质或元素 Hazardous substances					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr(VI))	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
金属部件 (Metal Parts)	O	O	O	O	O	O
电路模块 (Circuit Modules)	X	O	O	O	O	O
电缆及电缆组件 (Cables and Cable Assemblies)	O	O	O	O	O	O
塑料和聚合物部件 (Plastic and Polymeric parts)	O	O	O	O	O	O
O: 表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T11363-2006 标准规定的限量要求以下。 Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in SJ/T11363-2006. X: 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T11363-2006标准规定的限量要求。 Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part *might exceed* the limit requirement in SJ/T11363-2006.						

5.2 Reference Equipment for Type Approval

The Gemalto M2M reference setup submitted to type approve Cinterion® ENS22-E (including a special approval adapter for the DSB75) is shown in the following figure[1]:

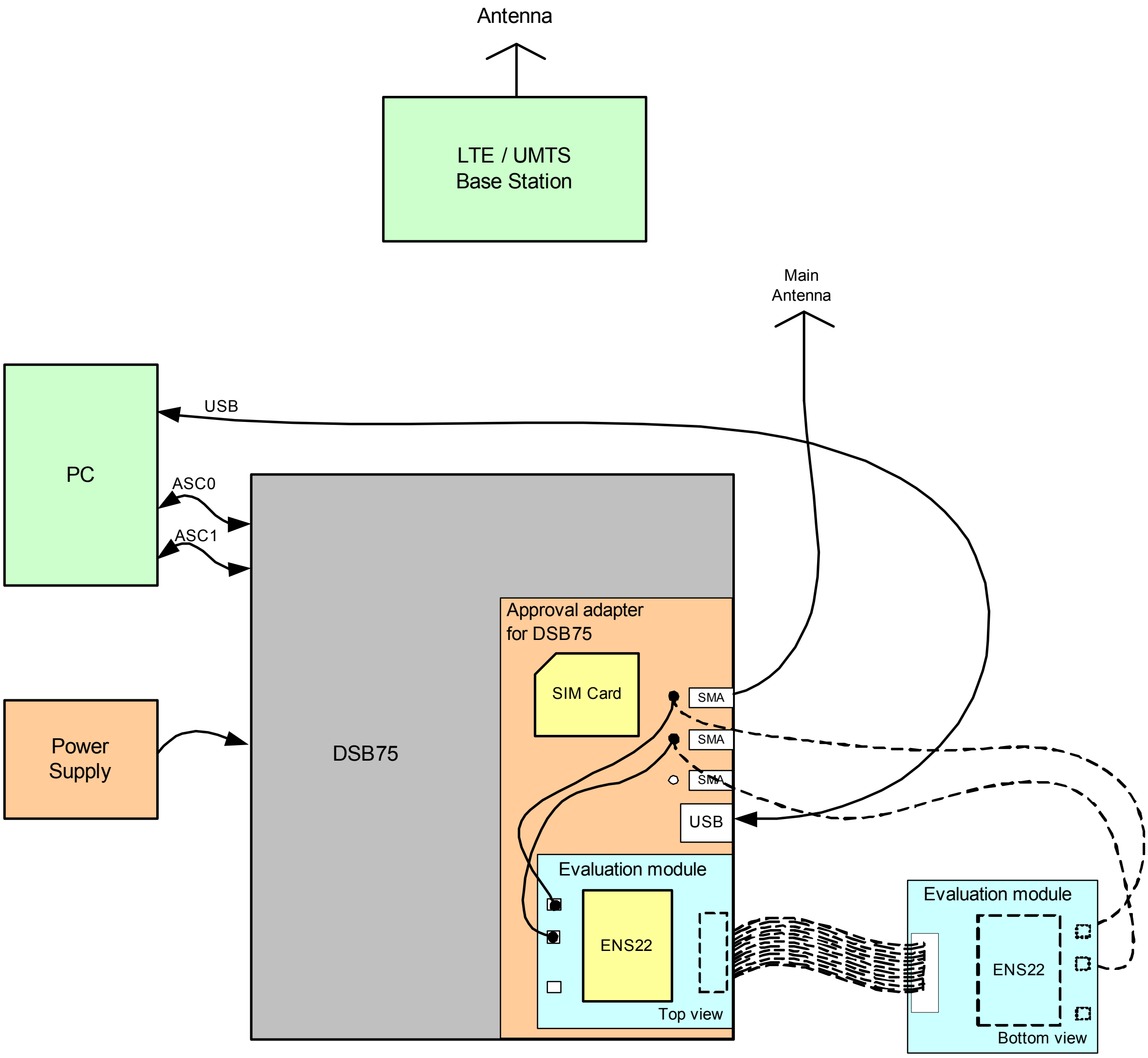


Figure 52: Reference equipment for Type Approval

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 UMTS test equipment instead of employing the SMA antenna connectors on the Cinterion® ENS22-E DSB75 adapter as shown in Figure 52. 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/pdfiles/wmod3&4T.pdf)

6 Document Information

6.1 Revision History

Preceding document: "Cinterion® ENS22-E Hardware Interface Description" v01.120
New document: "Cinterion® ENS22-E Hardware Interface Description" v**02.000**

Chapters	What is new
--	Updated Figure 1, Figure 2, and Figure 18 for eSIM option.
1.1	Added Internal SIM Interface (eSIM option) and LGA DevKit description; updated band category to LTE Cat. NB1/NB2; updated description of ASC0/ASC1.
2.1.1	Updated SIM related signals; added a note for eSIM option in Table 1.
2.1.2	Updated comment of ASC0 in Table 2.
2.1.4	Removed an item in the Features description.
2.1.6	Added Internal SIM Interface (eSIM option) section.
2.3	Removed a note.
3.1	Updated description of modes in Table 10.
3.2.1	Added description of URC ^SYSSTART upon startup or restart.
3.3.2	Updated description and Figure 27 for eDRX mode.
3.3.3	Updated description and Figure 28 for PSM mode.
3.3.4	Updated Figure 29.
3.4	Updated current consumption ratings in Table 16.
3.7	Added a note for eSIM option in Table 19.
4.2.1.1	Updated Figure 41 for land pattern.
4.3.1.2	Added Figure 46 for the layout of barcode label on tape reel.
4.3.2.2	Added Figure 50 and Table 23 for the information of VP box label.
5.1	Updated GCF-CC v.3.71 and EN 62311: 2008 in Table 25.
7.1	Updated part ordering numbers.
7.2	Added new section Module Label Information.

Preceding document: "Cinterion® ENS22-E Hardware Interface Description" v01.000
New document: "Cinterion® ENS22-E Hardware Interface Description" v01.120

Chapters	What is new
1.1	Updated properties of serial interfaces and GPIO interfaces.
--	Removed I^2C and SPI interfaces related description throughout the document.
--	Updated Figure 1.2, Figure 2, Figure 4, Figure 18, and Figure 39.
3.7	Updated remark in Table 19.
5.1	Updated Table 24.

7.1	Updated part ordering numbers.

Preceding document: "Cinterion® ENS22-E Hardware Interface Description" v00.990
New document: "Cinterion® ENS22-E Hardware Interface Description" v01.000

Chapters	What is new
2.2.3	Moved the routing example to section 2.2.3.2.
2.3	Updated Figure 18.
3.2.1	Updated Figure 24 for auto enabled level.
3.3.4	Updated Figure 29.
3.3.4.1	Updated description for AT^SPOW; added a note.
3.3.4.2	Updated description for AT^SPOW.
3.4.1	Updated Table 15 for footnotes, and Table 16 for peak supply current and footnotes.
4.3.3	Updated Figure 51.
5.1	Updated directives and standards.

Preceding document: "Cinterion® ENS22-E Hardware Interface Description" v00.940
New document: "Cinterion® ENS22-E Hardware Interface Description" v00.990

Chapters	What is new
--	Updated Figure 1.2.
1.3	Updated Figure 2.
2.1.3	Added a note for adjusting overshoot and undershoot.
2.1.4	Added a note for adjusting overshoot and undershoot, and another note for module wake-up setting.
2.3	Updated Figure 18.
2.3.1	Removed description about circuit with level shifters.
3.2.1	Updated Figure 23.
3.4.1	Updated Table 16.
5.1	Updated directives and standards.
6.3	Updated terms and abbreviations.
7.1	Corrected ordering numbers.

Preceding document: "Cinterion® ENS22-E Hardware Interface Description" v00.010
New document: "Cinterion® ENS22-E Hardware Interface Description" v00.940

Chapters	What is new
1.1	Updated description for feature implementation.
--	Updated Figure 1.2.
2.1	Updated Table 1.

2.1.2	Updated Table 2.
2.1.3	Updated description for ASC0 support.
2.1.4	Updated description for ASC1 support.
2.1.7	Updated description for GPIO Interface, and Table 5.
--	Updated description for I^2C.
--	Updated description for SPI.
2.2.1	Updated Table 7.

New document: "Cinterion® ENS22-E Hardware Interface Description" Version 00.010

Chapter	What is new
--	Initial document setup.

6.2 Related Documents

[1] Cinterion® ENS22-E AT Command Set
[2] Cinterion® ENS22-E Release Note
[3] Cinterion® ENS22-E Startup Guide
[4] Application Note 48: SMT Module Integration
[5] Hardware Migration Guide: Differences between BGSx, EHSx, ELSx, EMS31, ENS22, EXS82, v11

6.3 Terms and Abbreviations

Abbreviation	Description
ASC0/ASC1	Asynchronous Controller. Abbreviations used for first and second serial interface of the module
CE	Conformité Européene (European Conformity)
CTS	Clear to Send
DCD	Data Carrier Detect
DCE	Data Communication Equipment (typically modems, e.g. Gemalto M2M module)
DRX	Discontinuous Reception
eDRX	Enhanced Discontinuous Reception
DSB	Development Support Box
DSR	Data Set Ready
DTE	Data Terminal Equipment (typically computer, terminal, printer)
DTR	Data Terminal Ready
EMC	Electromagnetic Compatibility
EMI	Electro-Magnetic Interference
ESD	Electrostatic Discharge
ETSI	European Telecommunications Sdandards Institute
FR	Full Rate
GND	Ground
GPIO	General Purpose Input/Output
HIC	Humidity Indicator Card
I/O	Input/Output
IC	Integrated Circuit
I^2C	Inter Integrated Circuit
IMEI	International Mobile Equipment Identity
ITU	International Telecommunications Union
kbps	kbits per second
LGA	Land Grid Array
LTE	Long Term Evolution
MBB	Moisture Barrier Bag
MNO	Mobile Network Operator
MSL	Moisture Sensitivity Level
NB-IoT	Narrow Band Internet of Things
NC	Not Connected
PCB	Printed Circuit Board

Abbreviation	Description
PSM	Power Saving Mode
PTCRB	PCS Type Certification Review Board
RF	Radio Frequency
RoHS	Restriction of the use of certain hazardous substances in electrical and electronic equipment.
RTS	Request to Send
Rx	Receive Direction
RXD	Received Data
SE	Security Element
SIM	Subscriber Identification Module
SMA	Small A Type
SMD	Surface Mount Device
SMS	Short Message Service
SMT	Surface Mount Technology
SPI	Serial Peripheral Interface
TAU	Tracking Area Update
TE	Terminal Equipment, also referred to as DTE
Tx	Transmit Direction
TXD	Transmitted Data
UART	Universal asynchronous receiver-transmitter
UICC	Universal Integrated Circuit Card
UMTS	Universal Mobile Telecommunications System
URC	Unsolicited Result Code
USIM	Universal Subscriber Identity Module

7 Appendix

7.1 List of Parts and Accessories

Table 29: List of parts and accessories

Description	Supplier	Ordering information
Cinterion® ENS22-E	Gemalto M2M	Standard module Gemalto M2M IMEI: Packaging unit (ordering) number: L30960-N5800-A110 Module label number: S30960-S5800-A110-1[1] Packaging unit (ordering) number (eSIM option): L30901-N5807-A110 Module label number (eSIM option): S30901-S5807-A110-1[1]
Cinterion® ENS22-E Evaluation Module	Gemalto M2M	Ordering number: L30960-N5801-A110 Ordering number (eSIM option): L30901-N5808-A110
DSB75	Gemalto M2M	Ordering number: L36880-N8811-A100
LGA DevKit	Gemalto M2M	LGA DevKit consists of Cinterion®LGA DevKit SM Base PCB: Ordering number: L30960-N0111-A100 Cinterion® LGA DevKit Socket SML: Ordering number: L30960-N0110-A100
EVAL DSB Adapter for mounting Cinterion® ENS22-E evaluation modules onto DSB75	Gemalto M2M	Ordering number: L30960-N0100-A100

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

7.2 Module Label Information

The label engraved on the top of Cinterion® ENS22-E compromises the following information.

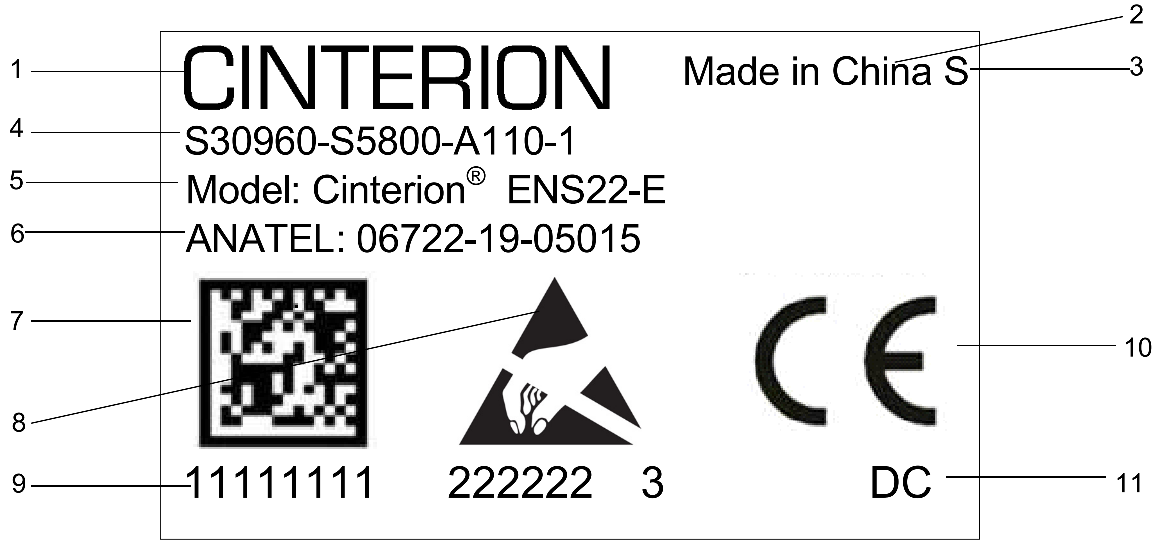


Figure 53: Cinterion® ENS22-E label

Table 30: Cinterion® ENS22-E label information

No.	Information
1	Cinterion logo
2	Marking “Made in China”
3	Factory code
4	Product ordering number
5	Product variant
6	ANATEL approval
7	Manufacturer 2D barcode
8	Electrostatic discharge (ESD) warning symbol
9	Product IMEI
10	CE logo (CE mark on VP box label is present only for modules with CE imprinted on the shielding)
11	2-digit date code of product production (for decoding see Table 31 below)

Table 31: Date code table

Date Code												
Code	L	M	N	P	R	S	T	U	V	W	X	A
Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Code	1	2	3	4	5	6	7	8	9	O	N	D
Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.

About Gemalto

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

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

Cinterion products integrate seamlessly with Gemalto identity modules, security solutions and licensing and monetization solutions, to streamline development timelines and provide cost efficiencies that improve the bottom line.

As an experienced software provider, we help customers manage connectivity, security and quality of service for the long lifecycle of IoT solutions.

For more information please visit
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Gemalto M2M GmbH
Werinherstrasse 81
81541 Munich
Germany

gemalto
a Thales company