Cinterion® TN23-W

Hardware Interface Description

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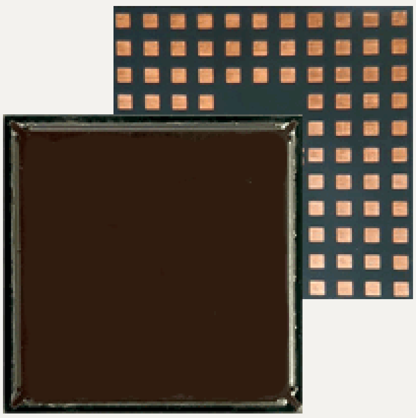

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1 Introduction

This document[1] describes the hardware of the Cinterion® TN23-W module optimized for global coverage as they support a comprehensive set of bands required for global deployment. It helps you quickly retrieve interface specifications, electrical and mechanical details and information on the requirements to be considered for integrating further components.

Note: This Hardware Interface Description is an early draft version and as such subject to change depending on further implementation and measurements.

1.1 Product Variants

This document applies to the following Thales module variant:
- Cinterion® TN23-W

1.2 Key Features at a Glance

Feature	Implementation
General	
Frequency bands (see Section 2.2.1)	LTE Cat NB1/2: 700 (Bd12, Bd13, Bd17, Bd28, Bd85), 800 (Bd18, Bd19, Bd20, Bd26), 850 (Bd5), 900 (Bd8), AWS-3 (Bd66), AWS-1 (Bd4), 1800 (Bd3), 1900 (Bd2, Bd25), 2100 (Bd1) **Note:** For each frequency band TN23-W's firmware locks the channel closest to the edge of the frequency band in order to meet the standard requirements of different countries and regions. The provided modules will thus not support the channel closest to the edge of each band. The available frequency ranges have been tested and verified to meet the standard requirements of the corresponding countries and regions.
Output power (according to 3GPP Release 13)	LTE Cat NB1/2: Class 3 (+23dBm ±2dB) for all supported LTE Cat NB1/2 bands
Power supply (see Section 2.1.2 and Section 3.4)	Normal range: 3.0V to 4.5V Extended range: 2.8V to 4.5V
Operating temperature (board temperature) (see Section 3.5)	Normal range: -30°C to +85°C Extended range: -40°C to +85°C
Physical (see Section 4.1)	Dimensions: 15.3 mm x 15.3 mm x 2.9 mm Weight: 1.0g
RoHS (see Section 5.1)	All hardware components fully compliant with EU RoHS Directive

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

Feature	**Implementation**
LTE features	
3GPP Release 14	LTE Cat NB1 (HD-FDD) DL: max. 27.2kbps, UL: max. 62.5kbps LTE Cat NB2 (HD-FDD) DL: max. 127kbps, UL: max. 158kbps
SMS	SMS over NAS
Software	
AT commands	Hayes 3GPP TS 27.007, TS 27.005, Thales AT commands
Embedded processing platform **(optional)**	Embedded processing option with API. Memory space available for embedded applications is TBD.KB for application code, TBD.KB min for File System and TBD.KB min for RAM. Please take into account that the application code is copied into RAM. For more details, please consult software documentation.
Firmware update	SWUP and IoT Suite based FOTA. Incremental FW upgrade and full FW update. Updatable bootloader. Optimized FOTA package size.
Interfaces	
Module interface	Surface mount device with solderable connection pads (SMT application interface). Land grid array (LGA) technology ensures high solder joint reliability and allows the use of an optional module mounting socket. For more information on how to integrate SMT modules see also [4]. This application note comprises chapters on mounting and application layout issues as well as on additional SMT application development equipment.
2 serial interfaces (see Section 2.1.3 and Section 2.1.4)	ASC0: • 8-wire modem interface with status and control lines, unbalanced, asynchronous • Adjustable baud rates: 300bps to 921,600bps • Supports RTS0/CTS0 hardware flow control (as configuration option). ASC1: • 4-wire, unbalanced asynchronous modem interface • Adjustable baud rates: 300bps to 921,600bps • Supports RTS1/CTS1 hardware flow control (as configuration option).
UICC interface (see Section 2.1.5)	Supported SIM/USIM cards: 1.8V
eUICC interface (see Section 2.1.6	Supports embedded MFF-XS UICC interface (as an option).
Status (see Section 2.1.10.1)	Supports status indication LED.
Fast shutdown (see Section 2.1.10.3)	Supports fast shutdown interrupt signal.
ADC Input	Analog-to-Digital Converter with one unbalanced analog inputs

Feature	**Implementation**
SIM switch (see Section 2.1.10.4)	Supports signal to switch between two externally connected SIMs.
GPIO interface (see Section 2.1.7)	With the embedded processing option 3 pads are programmable as GPIOs.
I^2C interface (see Section 2.1.8)	I^2C interface only available with embedded processing option.
SPI interface (see Section 2.1.9)	SPI interface only available with embedded processing option.
Antenna interface pads (see Section 2.2)	50Ω. LTE main antenna
Power on/off, Reset	
Power on/off	Switch-on / Wakeup by hardware signal ON Automatic power on after connecting module to the power supply. Switch-off by AT command and hardware signal FST_SHDN Automatic switch-off in case of critical voltage conditions
Reset	Orderly shutdown and reset by AT command Emergency reset by hardware signal EMERG_RST
Special features	
Phonebook	SIM and phone
Evaluation kit (For ordering information see Section 7.1)	
LGA DevKit	LGA DevKit designed to test Thales LGA modules. For more information see also LGA DevKit.
Evaluation module	TN23-W module soldered onto a dedicated PCB that can be connected to the an approval adapter in order to be mounted onto the DSB75 or DSB-Mini.
DSB75	DSB75 Development Support Board designed to test and type approve Thales modules and provide a sample configuration for application engineering. A special adapter is required to connect the TN23-W evaluation module to the DSB75.

1.3 TN23-W System Overview

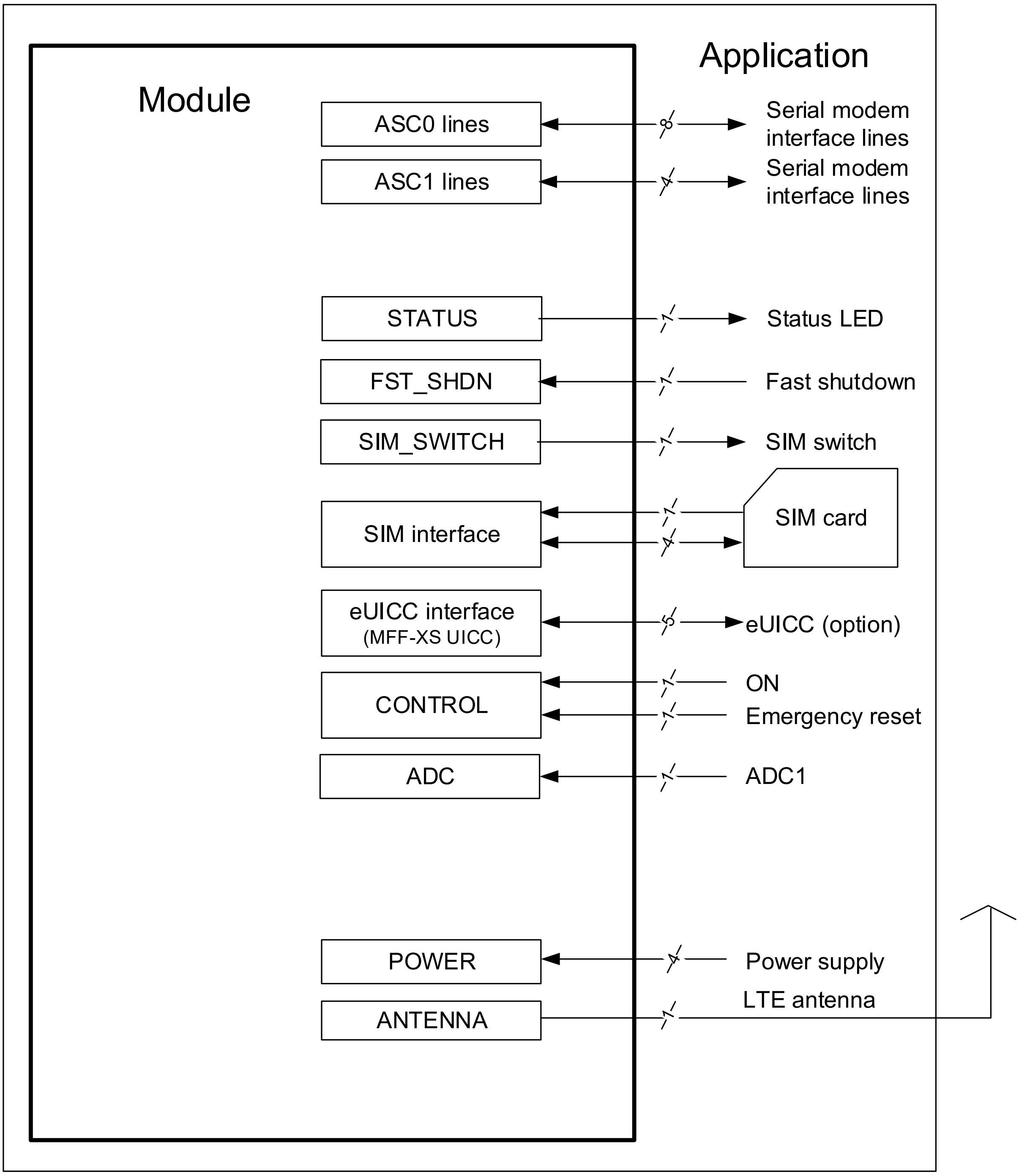

Figure 1: TN23-W system overview

Please **note** that with the embedded processing option some ASC0/ASC1 lines as well as the STATUS, FST_SHDN, and SIM_SWITCH lines are programmable as GPIOs, I^2C or SPI interface lines. For details see Section 2.1, and Section 2.1.7.

1.4 Circuit Concept

The figure below shows block diagrams for the TN23-W module variants, and illustrate the major functional components:

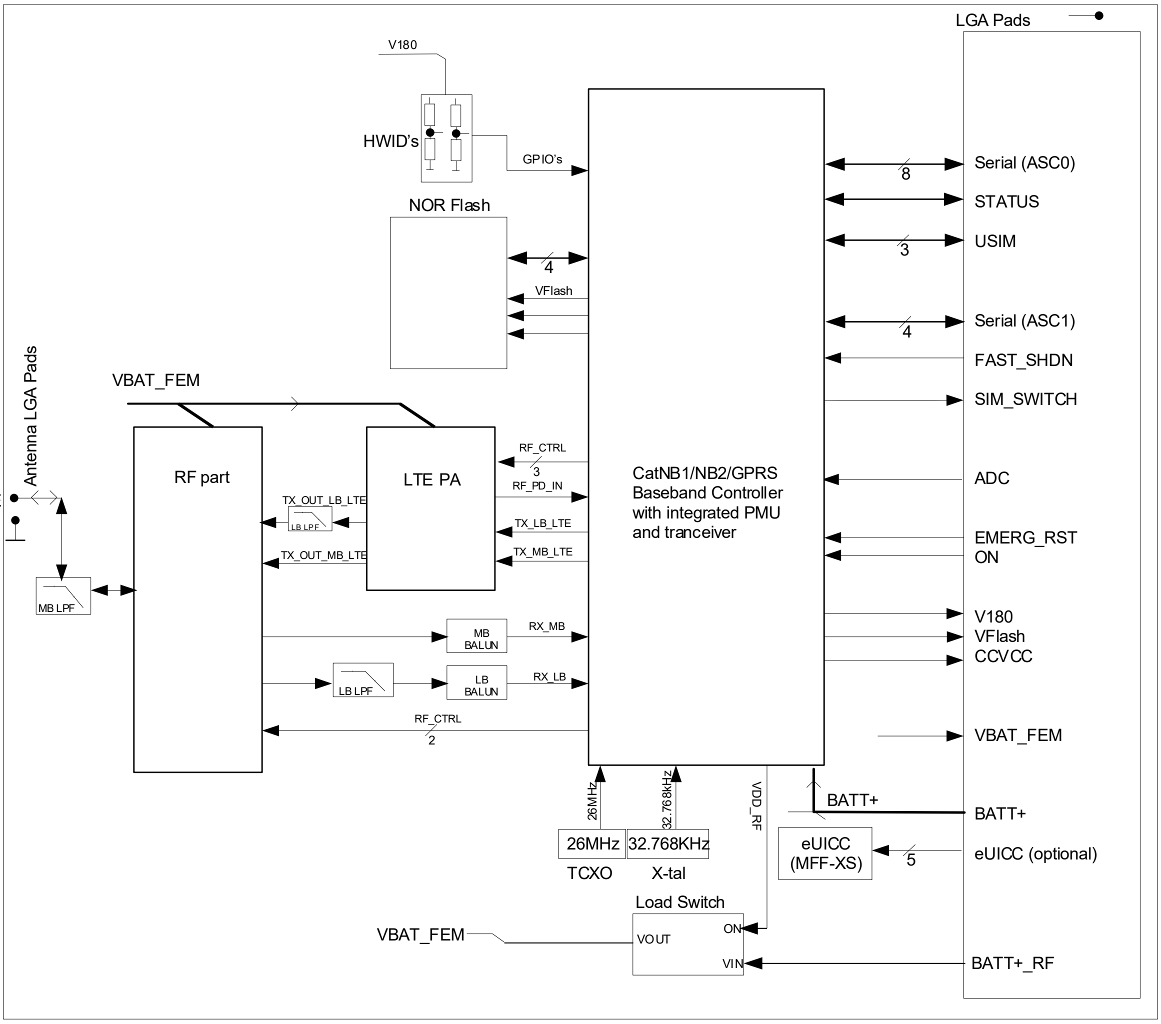

Figure 2: TN23-W block diagram

Please **note** that with the embedded processing option some ASC0/ASC1 lines as well as the STATUS, FST_SHDN, and SIM_SWITCH lines are programmable as GPIOs, I^2C or SPI interface lines. For details see Section 2.1, and Section 2.1.7.

2 Interface Characteristics

TN23-W 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 TN23-W provides connecting pads to integrate the module into external applications.

As a rule all pads should be soldered for mechanical stability and heat dissipation.

Signal pads that are not used, i.e., marked as “rfu”, need to be soldered, but should not have an electrical connection to the external application or GND. Also, pads mentioned in squared brackets (I2CDAT and I2CCLK pads, SPI pads as well as shared GPIO pads) are available with the embedded processing option only.

Please note that the reference voltages listed in Table 2 are the values measured directly on the TN23-W module. They do not apply to the accessories connected.

Note: Thales strongly recommends to provide test points for certain signal lines to and from the module while developing SMT applications – for debug, test and/or trace purposes during the manufacturing process. In this way it is possible to detect soldering (and other) problems. Please refer to [4] and [5] for more information on test points and how to implement them. The signal lines for which test points should be provided for are marked as “Test point recommended“ in Table 2.

Table 1: Overview: Pad assignments common to TN23-W[1] [2]

Pad no.	Signal name	Pad no.	Signal name	Pad no.	Signal name
B7	GND	E12	rfu	J15	V180
B8	GND	E13	rfu	J16	GND
B9	rfu	E14	GND	J17	CC2_VPP
B10	GND	E15	EMERG_RST	K7	rfu
B11	GND	E16	VFLASH	K8	rfu
B12	RF_OUT	E17	VBAT_FEM	K9	STATUS [GPIO5]
B13	GND	F7	GND	K10	FST_SHDN [GPIO4]
B14	GND	F8	rfu	K11	rfu
B15	rfu	F9	rfu	K12	RING0 [SPI_CS]
B16	GND	F10	GND	K13	DTR0 [MISO]
B17	GND	F11	rfu	K14	DCD0 [SPI_CLK]
C7	rfu	F12	rfu	K15	CCCLK
C8	SIM_SWITCH [GPIO8]	F13	rfu	K16	rfu
C9	GND	F14	GND	K17	CC2_CLK
C10	GND	F15	ADC1	L7	rfu
C11	GND	F16	rfu	L8	TXD1
C12	GND	F17	GND	L9	rfu
C13	GND	G7	rfu	L10	rfu
C14	GND	G8	rfu	L11	DSR0 [MOSI]
C15	GND	G9	rfu	L12	RTS0
C16	GND	G10	GND	L13	CTS0
C17	rfu	G14	GND	L14	CCVCC
D7	rfu	G15	$BATT+_{RF}$	L15	CCRST
D8	rfu	G16	$BATT+_{RF}$	L16	CC2_VCC
D9	rfu	G17	rfu	L17	CC2_RST
D10	GND	H7	rfu	M7	GND
D11	GND	H8	rfu	M8	GND
D12	GND	H9	RTS1[3] [I2CDAT]	M9	rfu
D13	GND	H10	CTS1[4] [I2CCLK]	M10	rfu
D14	GND	H14	GND	M11	GND
D15	ON	H15	$BATT+_{BB}$	M12	RXD0
D16	rfu	H16	$BATT+_{BB}$	M13	TXD0
D17	rfu	H17	rfu	M14	CCIO
E7	rfu	J7	rfu	M15	rfu
E8	rfu	J8	rfu	M16	CC2_IO
E9	rfu	J9	RXD1	M17	GND
E10	GND	J10	GND		
E11	rfu	J14	rfu		

1. rfu = reserved for future use, i.e., currently not supported.
2. Pads mentioned in squared brackets (I2CDAT and I2CCLK pads, SPI pads as well as shared GPIO pads) are available with the embedded processing option only.
3. For engineering samples (A1.1) only: H9 is rfu, and K8: RTS1 [I2CDAT].
4. For engineering samples (A1.1) only: H10 is rfu, and J8 is CTS1 [I2CCLK].

	17	16	15	14	13	12	11	10	9	8	7
M	GND	CC2_IO	rfu	CCIO	TXD0	RXD0	GND	rfu	rfu	GND	GND
L	CC2_RST	CC2_VCC	CCRST	CCVCC	CTS0	RST0	DSR0	rfu	rfu	TXD1	rfu
K	CC2_CLK	rfu	CCCLK	DCD0	DTR0	RING0	rfu	FST_SHDN	STATUS/	rfu	rfu
J	CC2_VPP	GND	V180	rfu	Reserved for future use			GND	RXD1	rfu	rfu
H	rfu	$BATT+_{BB}$	$BATT+_{BB}$	GND				CTS1	RTS1	rfu	rfu
G	rfu	$BATT+_{RF}$	$BATT+_{RF}$	GND	Marking			GND	rfu	rfu	rfu
F	GND	rfu	ADC1	GND	rfu	rfu	rfu	GND	rfu	rfu	GND
E	VBAT_FEM	VFLASH	EMERG_RST	GND	rfu	rfu	rfu	GND	rfu	rfu	rfu
D	rfu	rfu	ON	GND	GND	GND	GND	GND	rfu	rfu	rfu
C	rfu	GND	GND	GND	GND	GND	GND	GND	GND	SIM_SWITCH	rfu
B	GND	GND	rfu	GND	GND	RF_OUT	GND	GND	rfu	GND	GND

Figure 3: TN23-W top view: Pad assignments

	7	8	9	10	11	12	13	14	15	16	17
M	GND	GND	rfu	rfu	GND	RXD0	TXD0	CCIO	rfu	CC2_IO	GND
L	rfu	TXD1	rfu	rfu	DSR0	RST0	CTS0	CCVCC	CCRST	CC2_VCC	CC2_RST
K	rfu	rfu	STATUS/	FST_SHDN	rfu	RING0	DTR0	DCD0	CCCLK	rfu	CC2_CLK
J	rfu	rfu	RXD1	GND	Reserved for future use			rfu	V180	GND	CC2_VPP
H	rfu	rfu	RTS1	CTS1				GND	$BATT+_{BB}$	$BATT+_{BB}$	rfu
G	rfu	rfu	rfu	GND	Marking			GND	$BATT+_{RF}$	$BATT+_{RF}$	rfu
F	GND	rfu	rfu	GND	rfu	rfu	rfu	GND	ADC1	rfu	GND
E	rfu	rfu	rfu	GND	rfu	rfu	rfu	GND	EMERG_RST	VFLASH	VBAT_FEM
D	rfu	rfu	rfu	GND	GND	GND	GND	GND	ON	rfu	rfu
C	rfu	SIM_SWITCH	GND	GND	GND	GND	GND	GND	GND	GND	rfu
B	GND	GND	rfu	GND	GND	RF_OUT	GND	GND	rfu	GND	GND

Figure 4: TN23-W bottom view: Pad assignments

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	Voltage ranges: $V_{I}max = 4.5V$ $V_{I}nom = 3.8V$ $V_{I}min = 3.0V$ Slew rate < 25mV/µs	Lines of BATT+ and GND must be connected in parallel for supply purposes because higher peak currents may occur. For TN23-W minimum voltage must not fall below 3.0V (LTE) including drop, ripple, spikes. $BATT+_{BB}$ and $BATT+_{RF}$ require an ultra-low ESR capacitor: $BATT+_{BB}$ --> 47µF $BATT+_{RF}$ --> 150µF If using Multilayer Ceramic Chip Capacitors (MLCC) please take DCbias into account. Note that minimum ESR value is advised at <70mΩ. $BATT+_{BB}$ must be discharged below 0.3V to assure a safe power up. Please note that the TN23-W lower voltage range can be extended to 2.8V, remaining fully functional and safe while no longer being fully compliant with 3GPP or other wireless standards. Please note that if both voltage domains and power supply lines are referred to - i.e., BATT+BB and BATT+RF - BATT+ is used throughout the document.
Power supply	GND		Ground	Application Ground

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
External supply voltage	V180	O	Normal Operation: $V_O$norm = 1.80V ±3% $I_O$max = 10mA Sleep Mode Operation: $V_O$sleep = 1.80V ±3% $I_O$max = 1mA Suspend Mode Operation: $V_O$suspend = 0V Clmax = 1µF	V180 can be used to supply level shifter at the interfaces. V180 can be used for the power indication circuit.
	VFLASH	O	Normal Operation: $V_O$nom = 1.80V ±3% $I_O$max = 10mA Sleep Mode Operation: $V_O$sleep = TBD. $I_O$max = 1mA Suspend Mode Operation: $V_O$suspend = 0V Clmax = 100nF	Test point recommended.
Ignition	ON	I	V_{IH}max=VBATT V_{IH}min = 2.8V V_{IL}max = 0.6V High level pulse width > 100µs ON ___|~~~~~~~~~~~~|___	This signal switches the module on. The ON signal is high level sensitive triggered **Note:** For engineering samples (A1.1), the maximum allowed input voltage level is 1.8V. The module might get damaged if VBATT is used.
Status signaling	STATUS	O	V_{OL}max = 0.2*V180 V_{OH}min = 0.8*V180 V_{OH}max = 1.9V	If unused keep pin open. With the embedded processing option this line is also available as GPIO: STATUS --> GPIO5
Fast shutdown	FST_SHDN	I	V_{IL}max = 0.3*V180 V_{IH}min = 0.7*V180 V_{IH}max = 1.9V	If unused keep pin open. With the embedded processing option this line is also available as GPIO: STATUS --> GPIO4

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
Emergency reset	EMERG_RST	I	Internal pull up resistor is 620K $V_{OH}max$ = 1.8V $V_{IH}min$ = 1.3V $V_{IL}max$ = 0.3V ~~~~|___|~~~~ low impulse width > 100µs	This line must be driven low by an open drain or open collector driver connected to GND. If unused keep pin open.
Serial Modem Interface ASC0	RXD0	O	$V_{OL}max$ = 0.2*V180 $V_{OH}min$ = 0.8*V180 $V_{OH}max$ = 1.9V	If unused keep pin open. With the embedded processing option ASC0 lines are also available as SPI lines. See also Section 2.1.9.
	CTS0	O		
	DSR0	O		
	DCD0	O		
	RING0	O		
	TXD0	I	$V_{IL}max$ = 0.3*V180 $V_{IH}min$ = 0.7*V180 $V_{IH}max$ = 1.9V	
	RTS0	I		
	DTR0	I		
Serial Modem Interface ASC1	RXD1	O	$V_{OL}max$ = 0.2*V180 $V_{OH}min$ = 0.8*V180 $V_{OH}max$ = 1.9V	If unused keep pin open. With the embedded processing option ASC1 lines are also available as I^2C lines. See also Section 2.1.8.
	CTS1	O		
	TXD1	I	$V_{IL}max$ = 0.3*V180 $V_{IH}min$ = 0.7*V180 $V_{IH}max$ = 1.9V	
	RTS1	I		
1.8V SIM Card Interface	CCVCC	O	$V_{O}min$ = 1.5V $V_{O}typ$ = 1.8V $V_{O}max$ = 2V $I_{O}max$ = -60mA	Maximum cable length or copper track to SIM card holder should not exceed 100mm. The signals CCRST, CCIO, CCCLK and CCVCC are protected against ESD with a special diode array.
	CCRST CCCLK	O O	$V_{OL}max$ = 0.2*V180 $V_{OH}min$ = 0.8*V180 $V_{OH}max$ = 1.9V	
	CCIO	I/O	$V_{OL}max$ = 0.2*V180 $V_{OH}min$ = 0.8*V180 $V_{OH}max$ = 1.9V $V_{IL}max$ = 0.3*V180 $V_{IH}min$ = 0.7*V180 $V_{IH}max$ = 1.9V	

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
1.8V MIM interface	CC2_VPP	--	Used for single wire protocol (SWP NFC) in MFF-XS eUICC.	SWP NFC is currently not supported and deactivated for the eUICC. Thus, there are two options: If an external SWP master is connected nevertheless (or for future use) the CC2_VPP line should be pulled up by an external 10k resistor to VCC. If there is no plan to use SWP the CC2_VPP line can be grounded.
	CC2_VCC	I	$V_I$min = 1.62V $V_I$typ = 1.8V $V_I$max = 1.98V	Maximum cable length or copper track should be no longer as 100mm to eUICC interface. The signals CC2_RST, CC2_IO, CC2_CLK and CC2_VCC are protected against ESD with a special diode array. If unused keep pin open.
	CC2_CLK	I	VILmax = 0.2*CC2_VCC at IOLmax = -20µA VILmin = -0.3V at IOLmax = -20µA VIHmax=CC2_VCC+0.3V at IOHmax =+20µA VIHmin = 0.7*CC2_VCC at IOH max=+20µA	
	CC2_RST	I	VILmax = 0.2*CC2_VCC at IOL max = -200µA VILmin = -0.3V at IOL max = -200µA VIHmax=CC2_VCC+0.3V at IOHmax =+20µA VIHmin = 0.8*CC2_VCC at IOH max=+20µA	
	CC2_IO	I/O	VILmax = 0.2*CC2_VCC at IIH = +1mA/+20 µA VILmin = -0.3V at IIH = +1mA/+20 µA VIHmin = 0.7*CC2_VCC at IIH = -20/+20 µA VIHmax = CC2_VCC+0.3V at IIH = -20/+20 µA VOLmax =0.15*CC2_VCC at IOL=-1mA VOHmin = 0.7*CC2_VCC at IIH = -20/+20 µA VOHmax = CC2_VCC+0.3V at IIH = -20/+20 µA	

Table 2: Signal properties

Function	Signal name	IO	Signal form and level	Comment
SIM switch	SIM_SWITCH	O	$V_{OL}max = 0.2*V180$ $V_{OH}min = 0.8*V180$ $V_{OH}max = 1.9V$	If unused keep lines open. With the embedded processing option this line is also available as GPIO: STATUS --> GPIO8
I^2C	I2CCLK	O	TBD.	Only available with the embedded processing option. See also Section 2.1.8. If unused keep lines open.
	I2CDAT	IO		
SPI	SPI_CLK	O	TBD.	Only available with the embedded processing option. See also Section 2.1.9. If unused keep lines open.
	SPI_MOSI	O		
	SPI_MISO	I		
	SPI_CS	O		
GPIO interface	GPIO4	IO	TBD.	Only available with the embedded processing option. See also Section 2.1.7. If unused keep lines open.
	GPIO5	IO		
	GPIO8	IO		
ADC (Analog-to-Digital Converter)	ADC1	I	RI = 0.5Kohm,C I=2.6pF VI = 0.1V … 1.8V (valid range) Resolution: 12bit max	If unused keep pin open.

2.1.2.1 Absolute Maximum Ratings

The absolute maximum ratings stated in Table 3 are stress ratings under any conditions. Stresses beyond any of these limits will cause permanent damage to TN23-W.

Table 3: Absolute maximum ratings

Parameter	Min	Max	Unit
Supply voltage $BATT+_{BB}$ (no service)	-0.2	+4.5	V
Voltage at all digital pins in POWER DOWN mode	0	0	V
Voltage at digital pins 1.8V domain in normal operation	-0.2	V180+0.2	V
Current at digital pins in normal operation (totally for all IOs)	-	-50	mA
Voltage at SIM interface, CCVCC 1.8V in normal Operation	1.5	2.12	V
Current at SIM interface in 1.8V operation	-	-50	mA
Voltage at ADC pin in normal operation	0	1.8	V
V180 in normal operation	1.5	2.12	V
Current at V180 in normal operation	-	-50	mA
VFLASH in normal operation	1.5	2.12	V
Current at VFLASH in normal operation	-	-50	mA

2.1.3 Serial Interface ASC0

TN23-W offers 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 1.8V (for high data bit or inactive state). For electrical characteristics please refer to Table 2. For an illustration of the interface line's startup behavior see Figure 6.

TN23-W 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

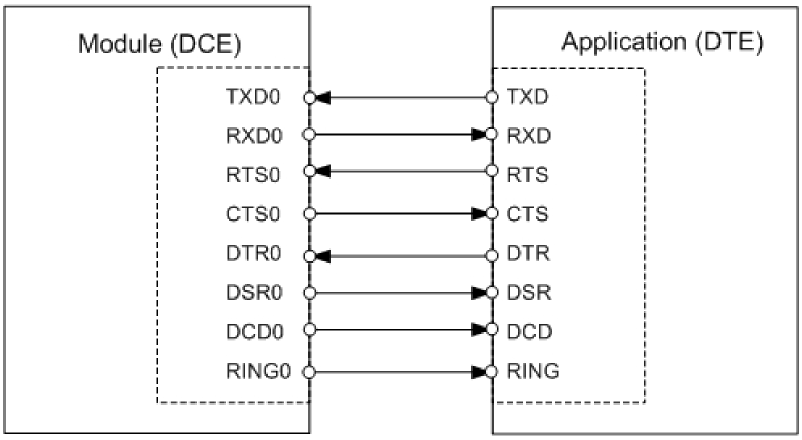

Figure 5: Serial interface ASC0

Features:
- Includes the data lines TXD0 and RXD0, the status lines RTS0 and CTS0 and, in addition, the modem control lines DTR0, DSR0, DCD0 and RING0.
- The RING0 signal serves to indicate incoming calls and other types of URCs (Unsolicited Result Code). It can also be used to send pulses to the host application, for example to wake up the application from power saving state.
- By default configured to 8 data bits, no parity and 1 stop bit.
- ASC0 can be operated at fixed bit rates from 300bps up to 921,600bps.
- Supports RTS0/CTS0 hardware flow control as a configuration option (see [1]). Although hardware flow control is recommended, this allows communication by using only RXD and TXD lines.

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

TBD.

Dotted lines indicate possible alternative signal states - depending on externally provided signal states.
For pull-up and pull-down values see Table 10.

Figure 6: ASC0 startup behavior

2.1.4 Serial Interface ASC1

TN23-W provides a 4-wire unbalanced, asynchronous modem interface ASC1 conforming to ITU-T V.24 protocol DCE signaling. The electrical characteristics do not comply with ITU-T V.28. The significant levels are 0V (for low data bit or active state) and 1.8V (for high data bit or inactive state). For electrical characteristics please refer to Table 2. For an illustration of the interface line's startup behavior see Figure 8.

TN23-W 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

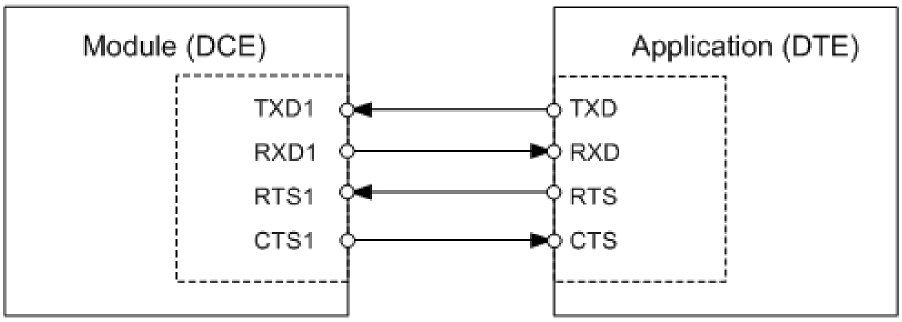

Figure 7: Serial interface ASC1

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 or 2 stop bits.
- ASC1 can be operated at fixed bit rates from 300bps to 921,600bps.
- Supports RTS1/CTS1 hardware flow as a configuration option (see [1]). Although hardware flow control is recommended, this allows communication by using only RXD and TXD lines.

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

TBD.

Figure 8: ASC1 startup behavior

2.1.5 UICC/SIM/USIM Interface

TN23-W has an integrated UICC/SIM/USIM interface compatible with the 3GPP 31.102 and ETSI 102 221. This is wired to the host interface in order to be connected to an external SIM card holder. Four pads on the SMT application interface are reserved for the SIM interface.

The UICC/SIM/USIM interface supports 1.8V SIM cards. Please refer to Table 2 for electrical specifications of the UICC/SIM/USIM interface lines.

Table 4: Signals of the SIM interface (SMT application interface)

Signal	Description
GND	Separate ground connection for SIM card to improve EMC. Thales recommends to use pad J16 or pad M17 as ground connection.
CCCLK	UICC clock
CCVCC	SIM supply voltage.
CCIO	Serial data line, input and output.
CCRST	UICC reset

Note: No guarantee can be given, nor any liability accepted, if loss of data is encountered after removing the SIM card during operation. Also, no guarantee can be given for properly initializing any SIM card that the user inserts after having removed the SIM card during operation. In this case, the application must restart TN23-W.

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

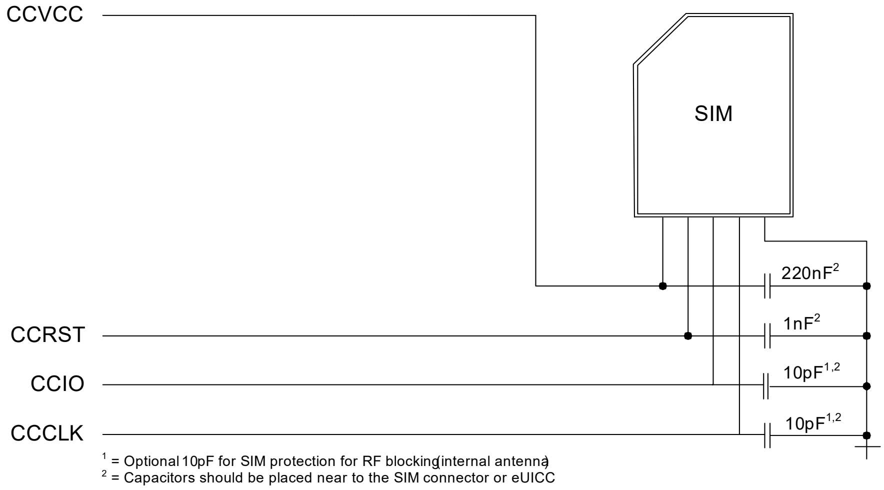

Figure 9: External UICC/SIM/USIM card holder circuit

The total cable length between the SMT application interface pads on TN23-W and the pads of the external SIM card holder must not exceed 100mm in order to meet the specifications of 3GPP TS 51.010-1 and to satisfy the requirements of EMC compliance.

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

An example for an optimized ESD protection for the SIM interface is shown in Section 2.1.5.1.

It is possible to connect the UICC/USIM/SIM interface lines to an external SIM card multiplexer controlled by the module's SIM_SWITCH signal. Thus, it becomes possible to switch between two networks/subscriptions each with its own UICC, and maybe different connection speeds. See also Section 2.1.10.4.

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 (e.g., NUP4114) to the SIM interface lines as shown in the example given in Figure 10.

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

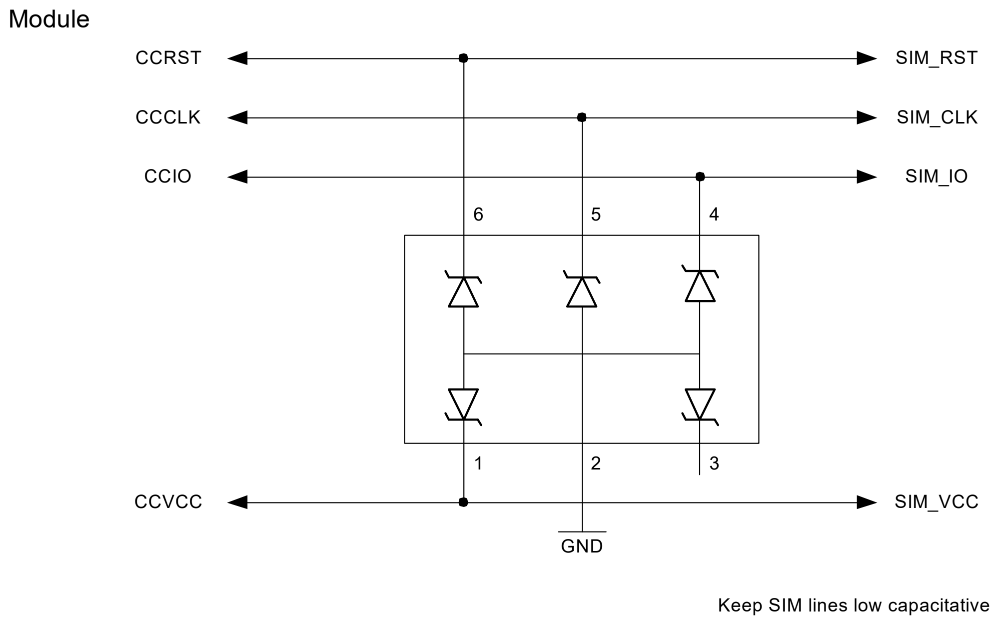

Figure 10: SIM interface - enhanced ESD protection

The capacitors shown in Figure 9 must be placed close to the SIM Connector.

2.1.6 eUICC Interface

As an option TN23-W supports an eUICC in MFF-XS format. This MFF-XS eUICC is located under the shielding, is only connected to specific module pads, and has no physical connections with other circuits inside the module. Figure 11 shows an example of how to connect the eUICC to the module's SIM interface lines as well as a switch to select whether to use the internal MFF-XS eUICC or an external plug-in SIM card. Figure 12 shows an example for a direct connection to the module's SIM interface lines.

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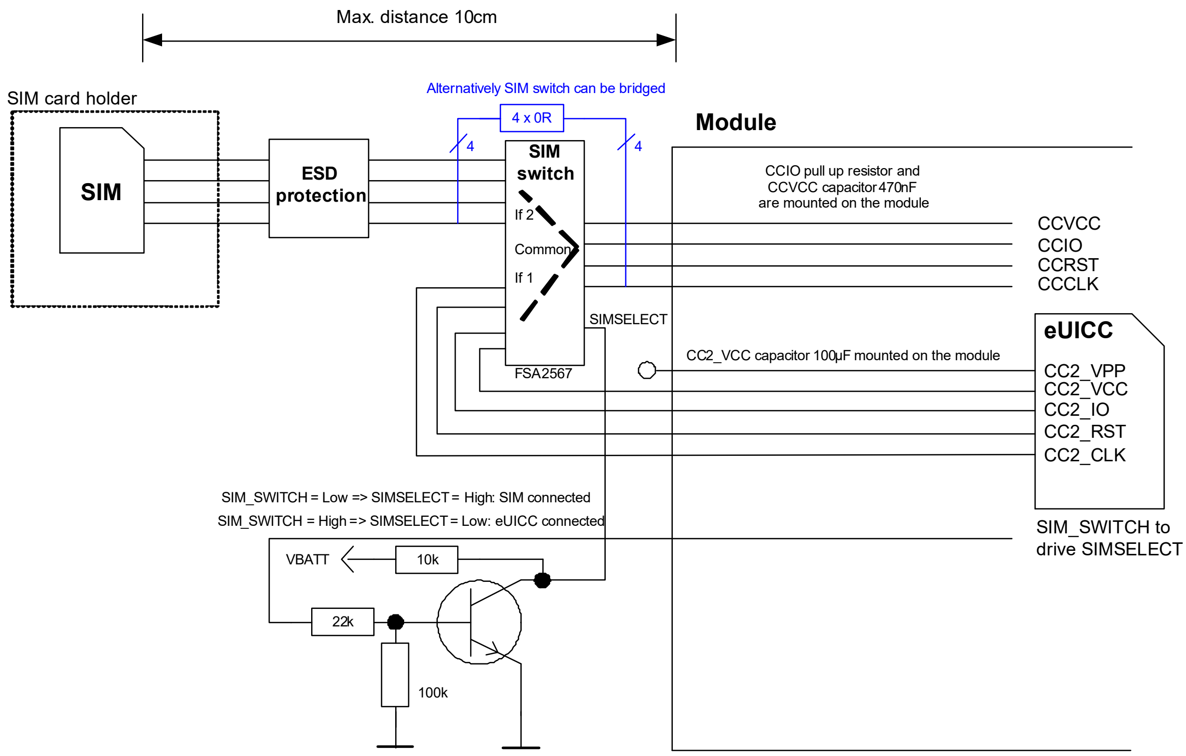


Figure 11: eUICC interface with switch for external SIM

The eUICC interface comprises five lines (plus ground) as listed below in Table 5.

Table 5: Signals of the eUICC interface option (SMT application interface)

Signal	Description
CC2_RST	Chip Card Reset
CC2_CLK	Chip Card Clock
CC2_IO	Chip Card I/O (data line)
CC2_VPP	-
CC2_VCC	Operation voltage for SIM Card (=1.8V)
GND	eUICC Ground

The below Figure 12 shows a direct connection of the internal eUICC to the module's SIM interface lines.

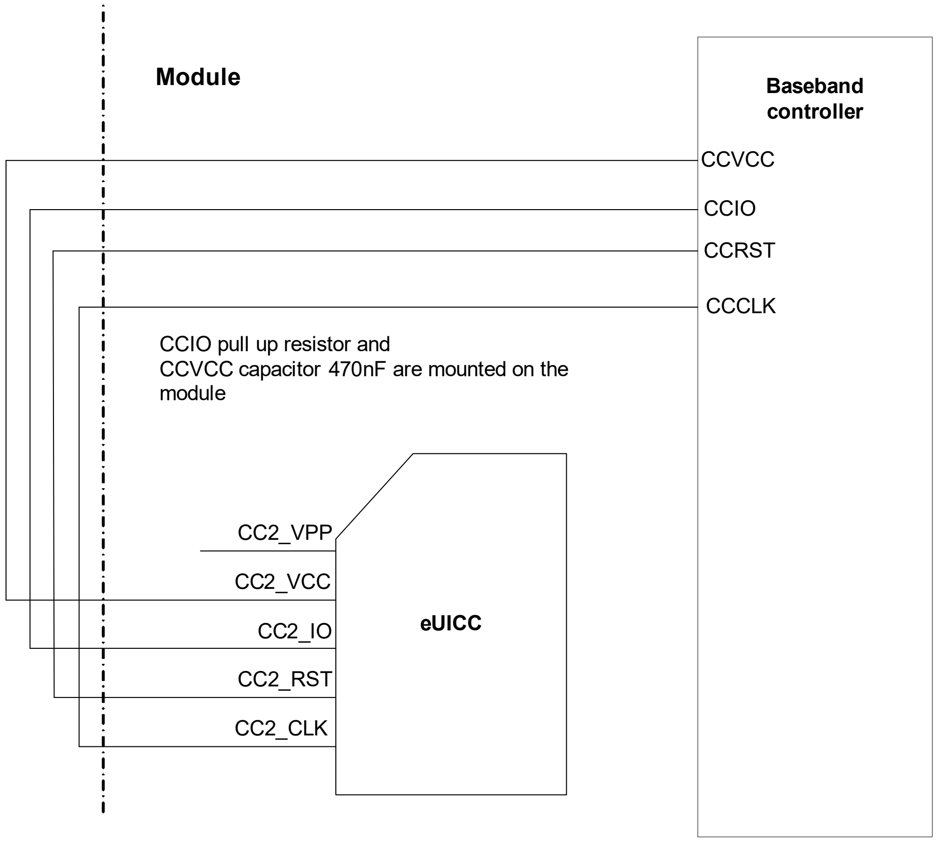


Figure 12: eUICC interface without SIM switch

2.1.7 GPIO Interface

The embedded processing option of TN23-W provides a GPIO interface with 3 GPIO lines. The GPIO lines are shared with other interfaces or functions: Status LED (see Section 2.1.10.1), fast shutdown (see Section 2.1.10.3), and SIM switch (see Section 2.1.10.4).

The following table lists the GPIOs with their default assignments being marked green.

Table 6: GPIO lines and alternative assignments

GPIO	Status LED	Fast Shutdown	SIM switch
GPIO4		FST_SHDN	
GPIO5	STATUS		
GPIO8			SIM_SWITCH

After startup, the above mentioned alternative GPIO line assignments can be configured through embedded applications.

The alternative assignments are mutually exclusive, i.e. a pad used for instance as GPIO5 by an embedded application is locked for alternative usage.

2.1.8 I²C Interface

The embedded processing option of TN23-W provides an inter-integrated circuit interface. I²C is a serial, 8-bit oriented data transfer bus for bit rates up to 400kbps in Fast mode. It consists of two lines, the serial data line I2CDAT and the serial clock line I2CCLK. The module acts as a single master device, e.g. the clock I2CCLK is driven by the module. I2CDAT is a bi-directional line. Each device connected to the bus is software addressable by a unique 7-bit address, and simple master/slave relationships exist at all times. The module operates as master-transmitter or as master-receiver. The customer application transmits or receives data only on request of the module.

The I²C lines are shared with two ASC1 lines: CTS1 --> I2CCLK, and RTS1 --> I2CDAT. The I²C bus can be configured and activated via embedded application, and in this case the ASC1 lines are no longer available. For more information see [7].

The I²C interface can be powered via the V180 line of TN23-W. If connected to the V180 line, the I²C interface will properly shut down when the module enters the Power Down mode.

In the application I2CDAT and I2CCLK lines need to be connected to a positive supply voltage via a pull-up resistor. For electrical characteristics please refer to Table 2.

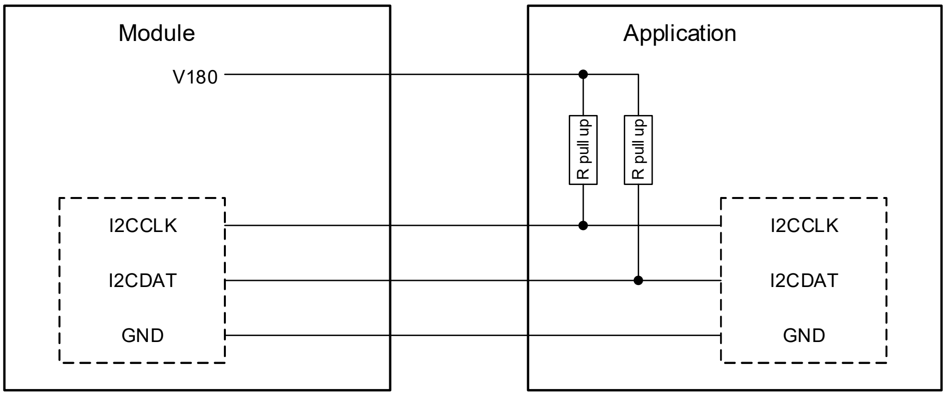


Figure 13: I²C interface connected to V180

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

2.1.9 SPI Interface

The embedded processing option of TN23-W provides an SPI interface where four TN23-W interface lines can be configured as Serial Peripheral Interface (SPI). The SPI is a synchronous serial interface for control and data transfer between TN23-W and the external application. Only one application can be connected to the SPI and the interface supports only master mode. The transmission rates are up to 6.5Mbit/s. The SPI interface comprises the two data lines MOSI and MISO, the clock line SPI_CLK a well as the chip select line SPI_CS.

The SPI lines are shared with four ASC0 lines: DTR0 --> MISO, DSR0 --> MOSI, DCD0 --> SPI_CLK, and RING0 --> SPI_CS. The SPI interface can be configured and activated via embedded application, and in this case the ASC0 lines are no longer available. For more information see [7].

In general, SPI supports four operation modes. The modes are different in clock phase and clock polarity. The module's SPI mode can be configured via embedded processing option. Make sure the module and the connected slave device works with the same SPI mode.

Figure 14 shows the characteristics of the four SPI modes. The SPI modes 0 and 3 are the most common used modes. For electrical characteristics please refer to Table 2.

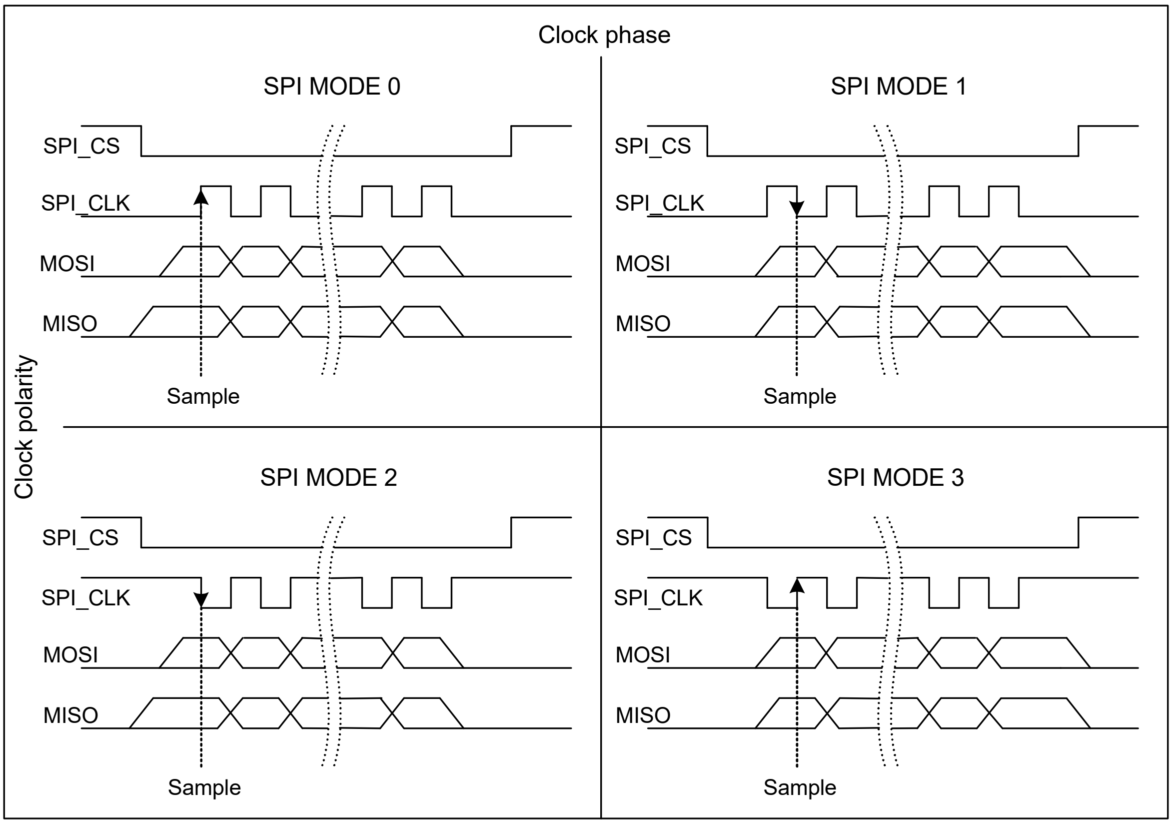


Figure 14: Characteristics of SPI modes

2.1.10 Control Signals

2.1.10.1 Status LED

The STATUS line can be configured to drive a status LED that indicates different operating modes of the module. For details on how to configure status signaling please refer to [1].

To take advantage of this function connect an LED to the STATUS line as shown in Figure 15.

With the embedded processing option the STATUS signal can also be programmed as GPIO5 (see Section 2.1.7).

The sample circuit is not optimized for low current consumption.

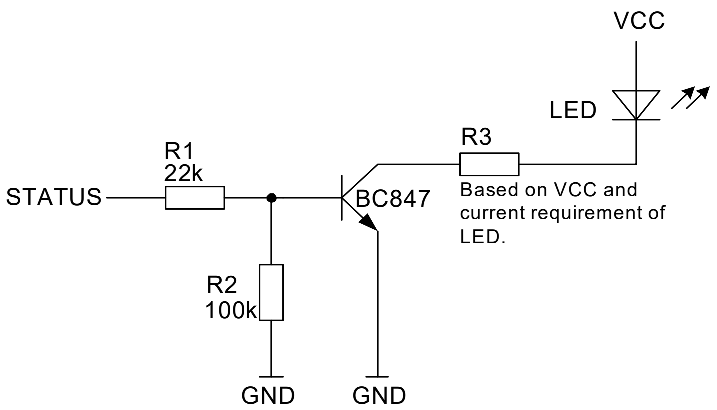


Figure 15: Status signaling with LED driver

2.1.10.2 Power Indication Circuit

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

It is therefore recommended to implement a power indication signal that reports the module's power state and shows whether it is active or in Power Down mode. While the module is in Power Down mode all signals with a high level from an external application need to be set to low state or high impedance state. The sample power indication circuit illustrated in Figure 16 denotes the module's active state with a low signal and the module's Power Down mode with a high signal or high impedance state. The sample circuit is not optimized for low current consumption.

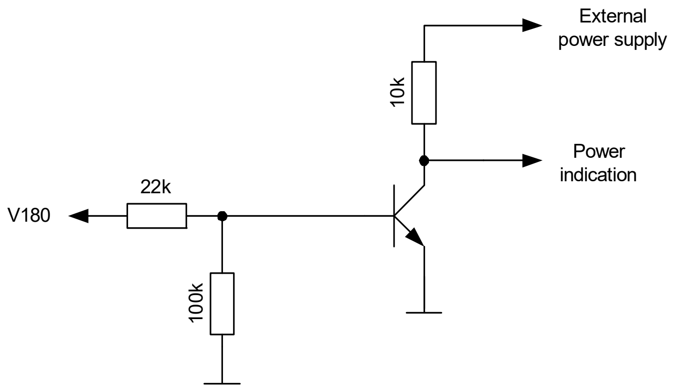


Figure 16: Power indication circuit

2.1.10.3 Fast Shutdown

The FST_SHDN line is an active low control signal and must be applied for at least TBD. milliseconds. It is recommended to keep the FST_SHDN line low until the module has shut down. If unused this line can be left open because of a configured internal pull-up resistor. Before setting the FST_SHDN line to low, the ON signal should be set to low (see Figure 17). Otherwise there might be back powering at the ON line in Power Down mode.

A low impulse on the FST_SHDN line starts the fast shutdown procedure (see Figure 17). The fast shutdown procedure still finishes any data activities on the module's flash file system, thus ensuring data integrity, but will no longer deregister gracefully from the network, thus saving the time required for network deregistration. The fast shutdown procedure takes less than 15 milliseconds. A low level of the V180 signal indicates that the module has entered the Power Down mode.No shutdown URCs will be issued with a fast shutdown.

With the embedded processing option the FST_SHDN signal can also be programmed as GPIO4 (see Section 2.1.7).

TBD.

Figure 17: Fast shutdown timing

2.1.10.4 SIM Switch

The UICC/USIM/SIM interface lines may be connected to an external SIM card multiplexer controlled by the SIM_SWITCH signal as shown in Figure 18. Thus, it becomes possible to switch between two networks/subscriptions each with their own UICC, and maybe different connection speeds. Please note that hot SIM insert/removal is only possible on the first SIM interface. Also note that the SIM_SWITCH can be used to switch between a SIM and the embedded optional eUICC interface as described in Section 2.1.6.

The SIM_SWITCH signal is controlled by AT command (see [1]).

With the embedded processing option the SIM_SWITCH signal can also be programmed as GPIO8 (see Section 2.1.7).

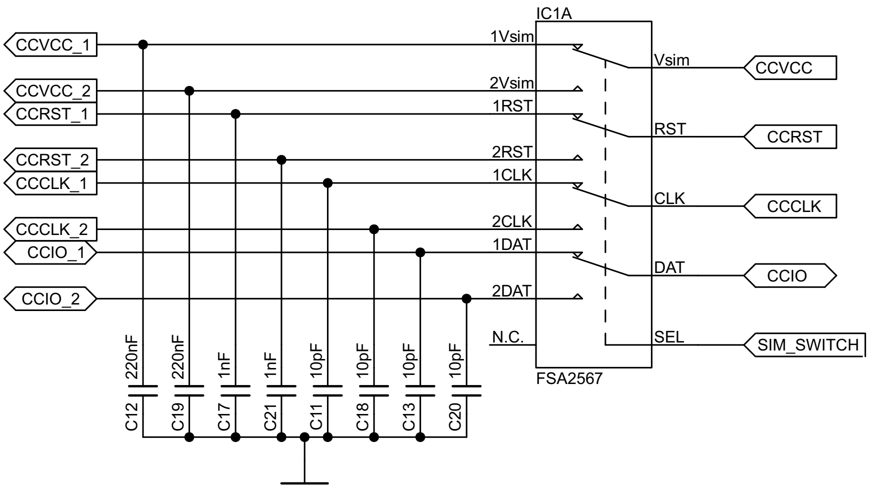


Figure 18: SIM switch circuit

2.2 RF Antenna Interface

The RF interface has an impedance of 50Ω. TN23-W is capable of sustaining a total mismatch at the antenna line without any damage, even when transmitting at maximum RF power.

The external antenna must be matched properly to achieve best performance regarding radiated power, modulation accuracy and harmonic suppression. Antenna matching networks are not included on the TN23-W module and should be placed in the host application if the antenna does not have an impedance of 50Ω.

Regarding the return loss TN23-W provides the following values in the active band:

Table 7: Return loss in the active band

State of module	Return loss of module	Recommended return loss of application
Receive	≥ 8dB	≥ 12dB
Transmit	not applicable	≥ 12dB
Idle	≤5dB	not applicable

2.2.1 Antenna Interface Specifications

Table 8: RF Antenna Interface LTE NB1/2

Parameter	Conditions	Min	Typical	Unit
LTE connectivity (Cat NB1/2	Band: 1, 2, 3, 4, 5, 8, 12, 13, 17, 18, 19, 20, 25, 26, 28, 66, 85			
Receiver Input Sensitivity @NTNV Configuration ID:1; **DL**: Modulation: QPSK; Sub-carriers: 12; **UL**: Modulation: BPSK; Sub-carrier spacing: 15KHz; Ntones: 1@0	LTE Band 1	-108.2	-114	dBm
	LTE Band 2	-108.2	-114	dBm
	LTE Band 3	-108.2	-114	dBm
	LTE Band 4	-108.2	-114	dBm
	LTE Band 5	-108.2	-114	dBm
	LTE Band 8	-108.2	-114	dBm
	LTE Band 12	-108.2	-113	dBm
	LTE Band 13	-108.2	-113	dBm
	LTE Band 17	-108.2	-114	dBm
	LTE Band 18	-108.2	-113.5	dBm
	LTE Band 19	-108.2	-113.5	dBm
	LTE Band 20	-108.2	-113.5	dBm
	LTE Band 25	-108.2	-114	dBm
	LTE Band 26	-108.2	-114	dBm
	LTE Band 28	-108.2	-113	dBm
	LTE Band 66	-108.2	-114	dBm
	LTE Band 85	-108.2	-114	dBm
Power @ ARP with 50Ohm Load, NTNV Configuration ID:1; **UL**: Modulation: BPSK; Sub-carrier: 1;Subcarrier space: 3.75 kHz; Ntones: 1@0	LTE Band 1	+21	+23.0	dBm
	LTE Band 2	+21	+23.0	dBm
	LTE Band 3	+21	+23.0	dBm
	LTE Band 4	+21	+23.0	dBm
	LTE Band 5	+21	+23.0	dBm
	LTE Band 8	+21	+23.0	dBm
	LTE Band 12	+21	+23.0	dBm
	LTE Band 13	+21	+23.0	dBm
	LTE Band 17	+21	+23.0	dBm
	LTE Band 18	+21	+23.0	dBm
	LTE Band 19	+21	+23.0	dBm
	LTE Band 20	+21	+23.0	dBm
	LTE Band 25	+21	+23.0	dBm
	LTE Band 26	+21	+23.0	dBm
	LTE Band 28	+21	+23.0	dBm
	LTE Band 66	+21	+23.0	dBm
	LTE Band 85	+21	+23.0	dBm

2.2.2 Antenna Installation

The antennas is connected by soldering the antenna pads (RF_OUT) and its neighboring ground pads directly to the application's PCB.

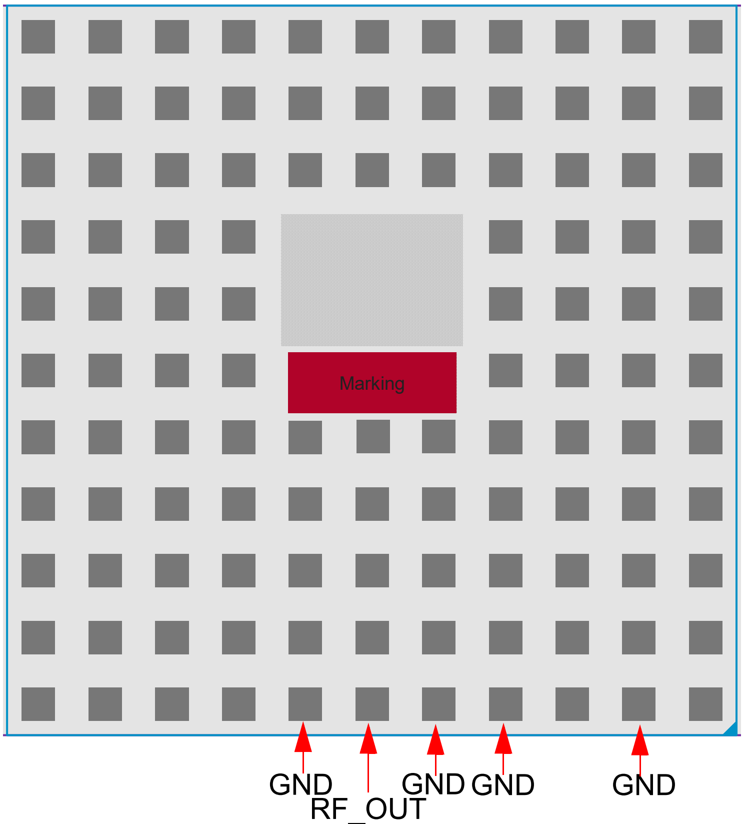


Figure 19: Antenna pads (top view)

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

The wiring of the antenna connection line, starting from the antenna pad to the application antenna should result in a 50Ω line impedance. Line width and distance to the GND plane needs to be optimized with regard to the PCB's layer stack. Some examples are given in Section 2.2.3.

To prevent receiver desensitization due to interferences generated by fast transients like high speed clocks on the application PCB, it is recommended to realize the antenna connection line using embedded Stripline rather than Micro-Stripline technology. Please see Section 2.2.3.1 for an example.[1]

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 TN23-W's antenna pad.

1. Please note that because of KDB 447498.GNSS, it is required to get a dedicated FCC ID, if using a PCB printed antenna.

2.2.3 RF Line Routing Design

2.2.3.1 Line Arrangement Examples

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

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

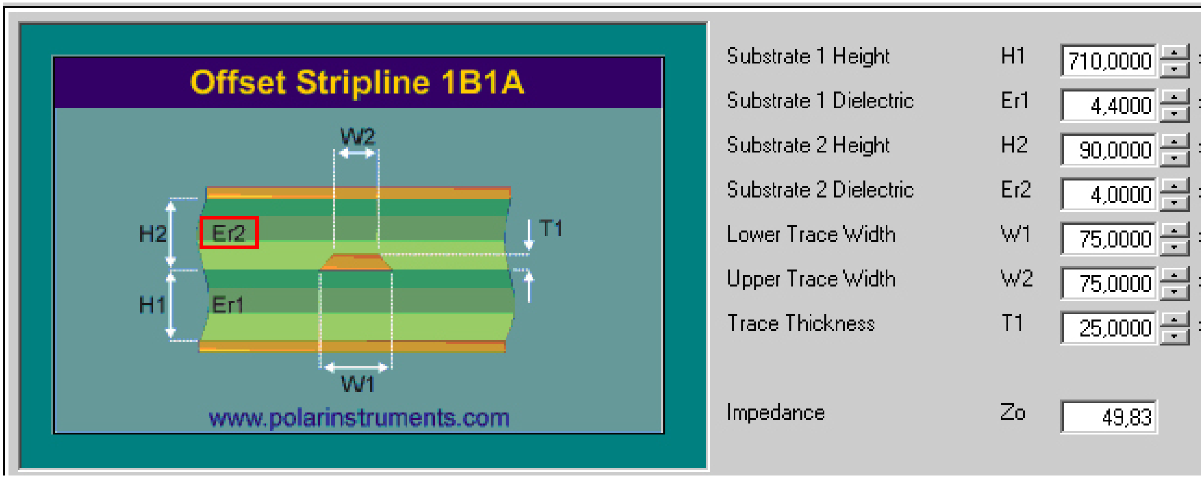


Figure 20: Embedded Stripline with 65µm prepreg (1080) and 710µm core

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).

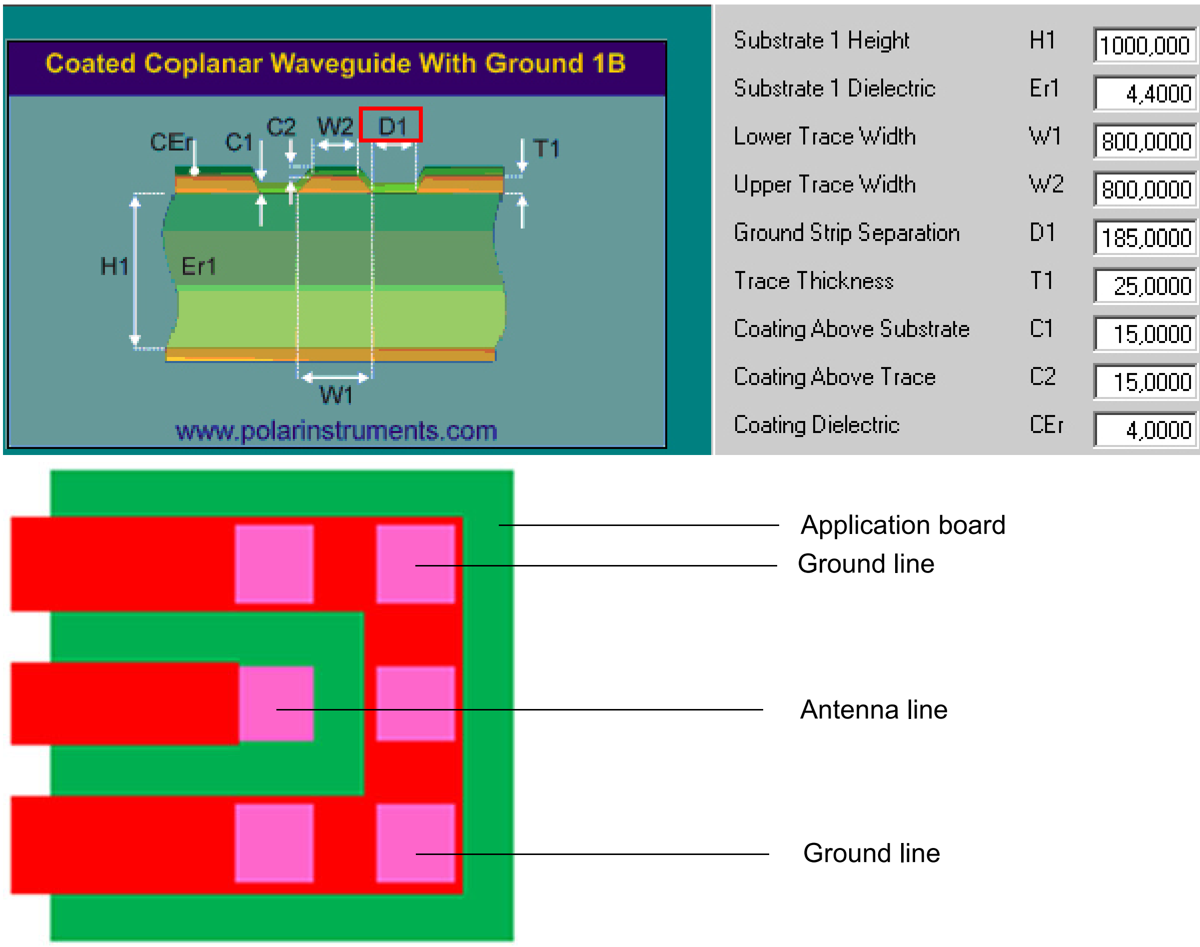


Figure 21: Micro-Stripline on 1.0mm Standard FR4 2-layer PCB - example 1

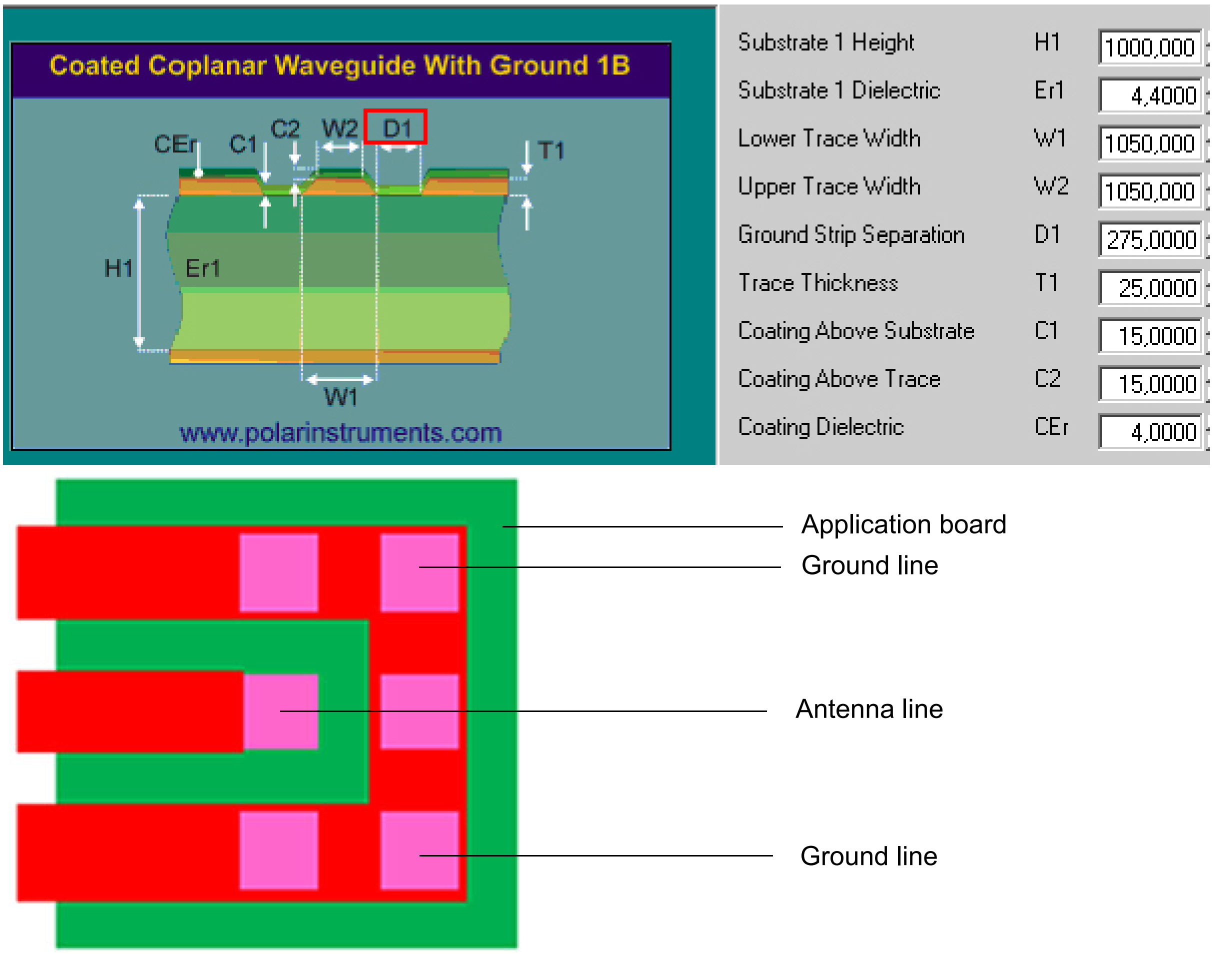


Figure 22: Micro-Stripline on 1.0mm Standard FR4 2-layer PCB - example 2

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

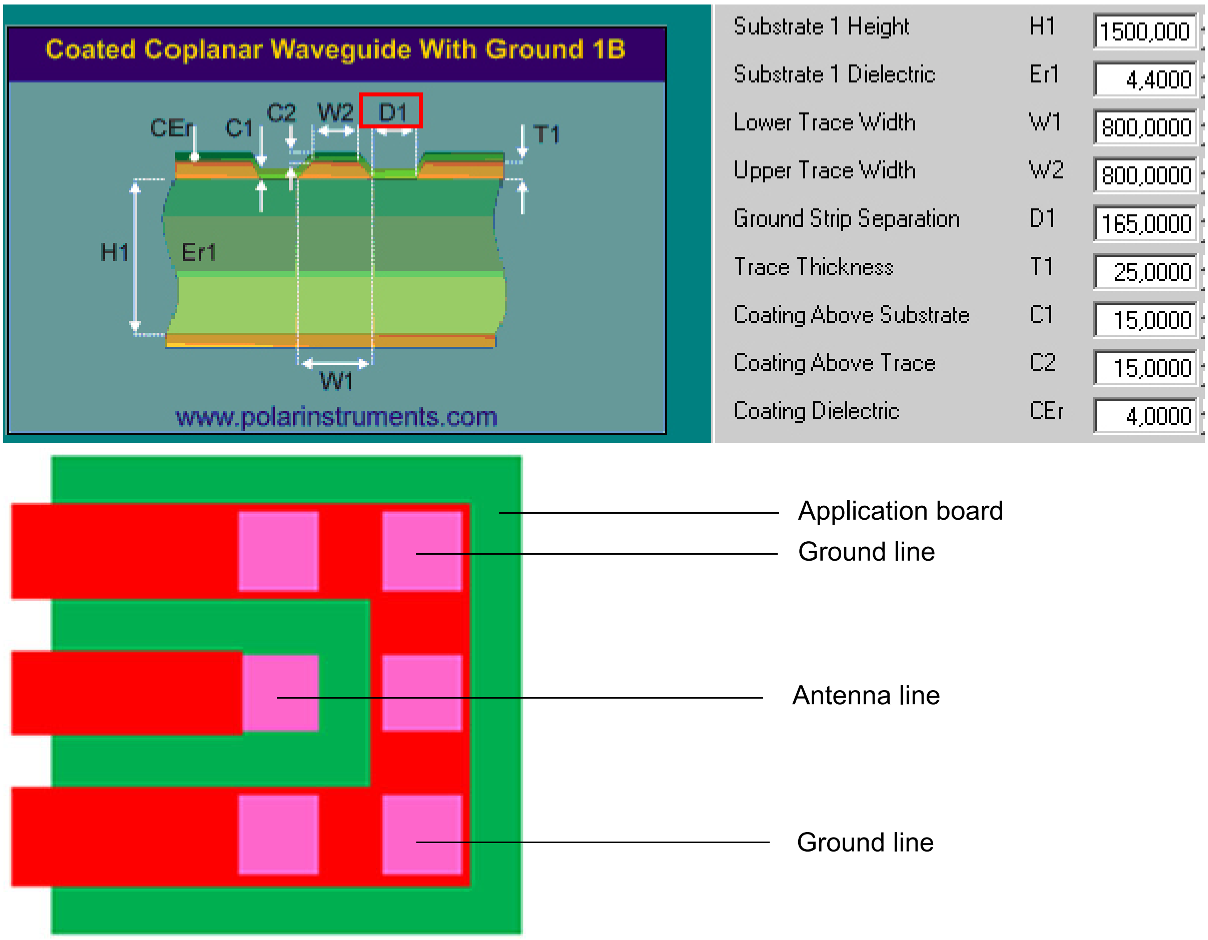


Figure 23: Micro-Stripline on 1.5mm Standard FR4 2-layer PCB - example 1

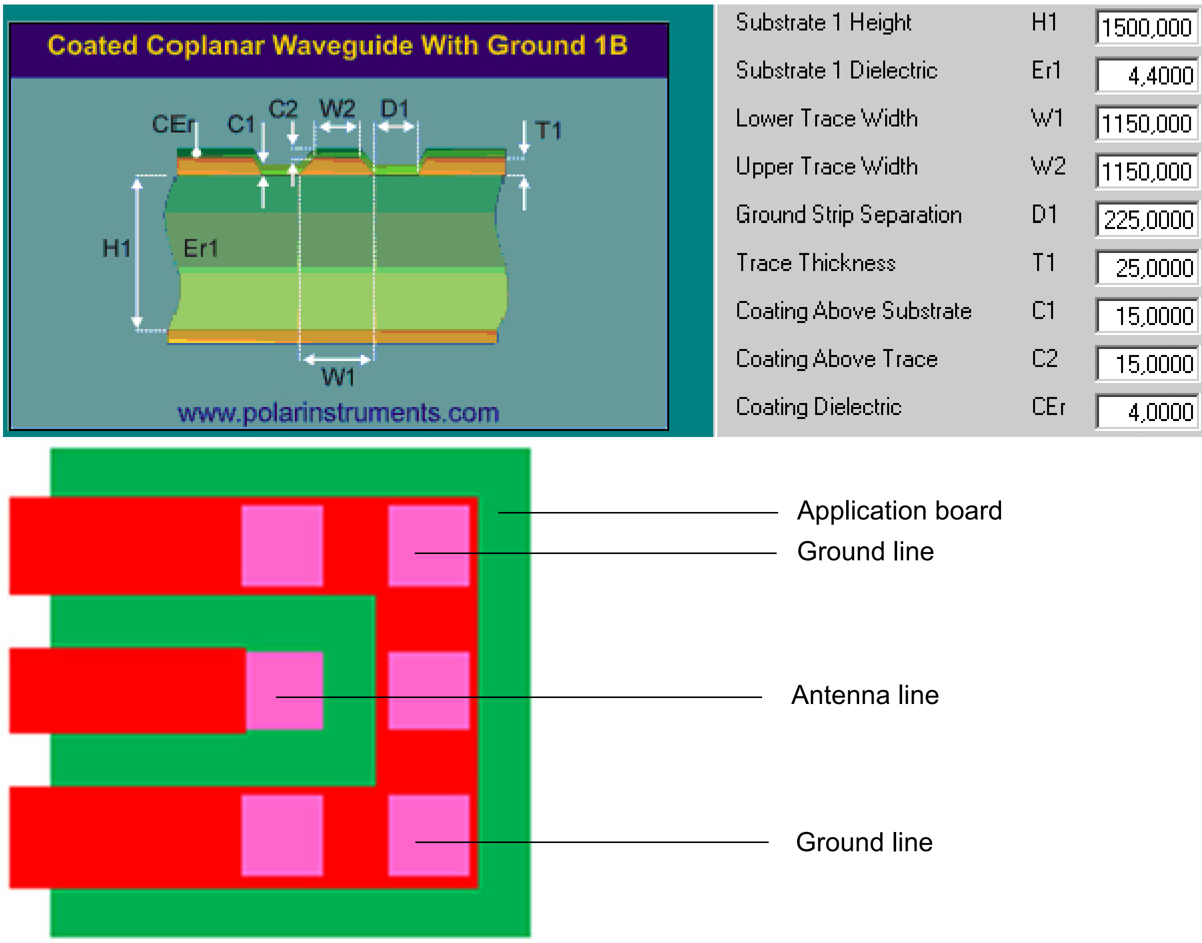


Figure 24: Micro-Stripline on 1.5mm Standard FR4 2-layer PCB - example 2

2.2.3.2 Routing Example

Interface to RF Connector
Figure 25 shows the connection of the module's antenna pad with an application PCB's coaxial antenna connector. Please note that the TN23-W bottom plane appears mirrored, since it is viewed from TN23-W top side. By definition the top of customer's board shall mate with the bottom of the TN23-W module.

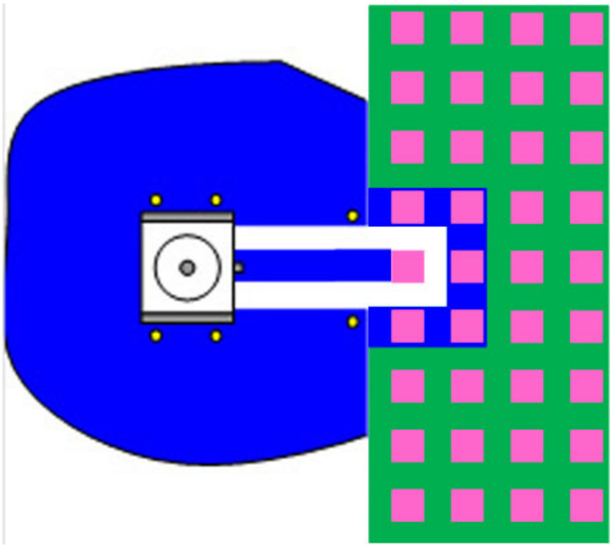


Figure 25: Routing to application's RF connector - top view

2.3 Sample Application

Figure 26 shows a typical example of how to integrate a TN23-W module with an application. Usage of the various host interfaces depends on the desired features of the application.

Note that the sample application is not optimized for low current consumption.

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

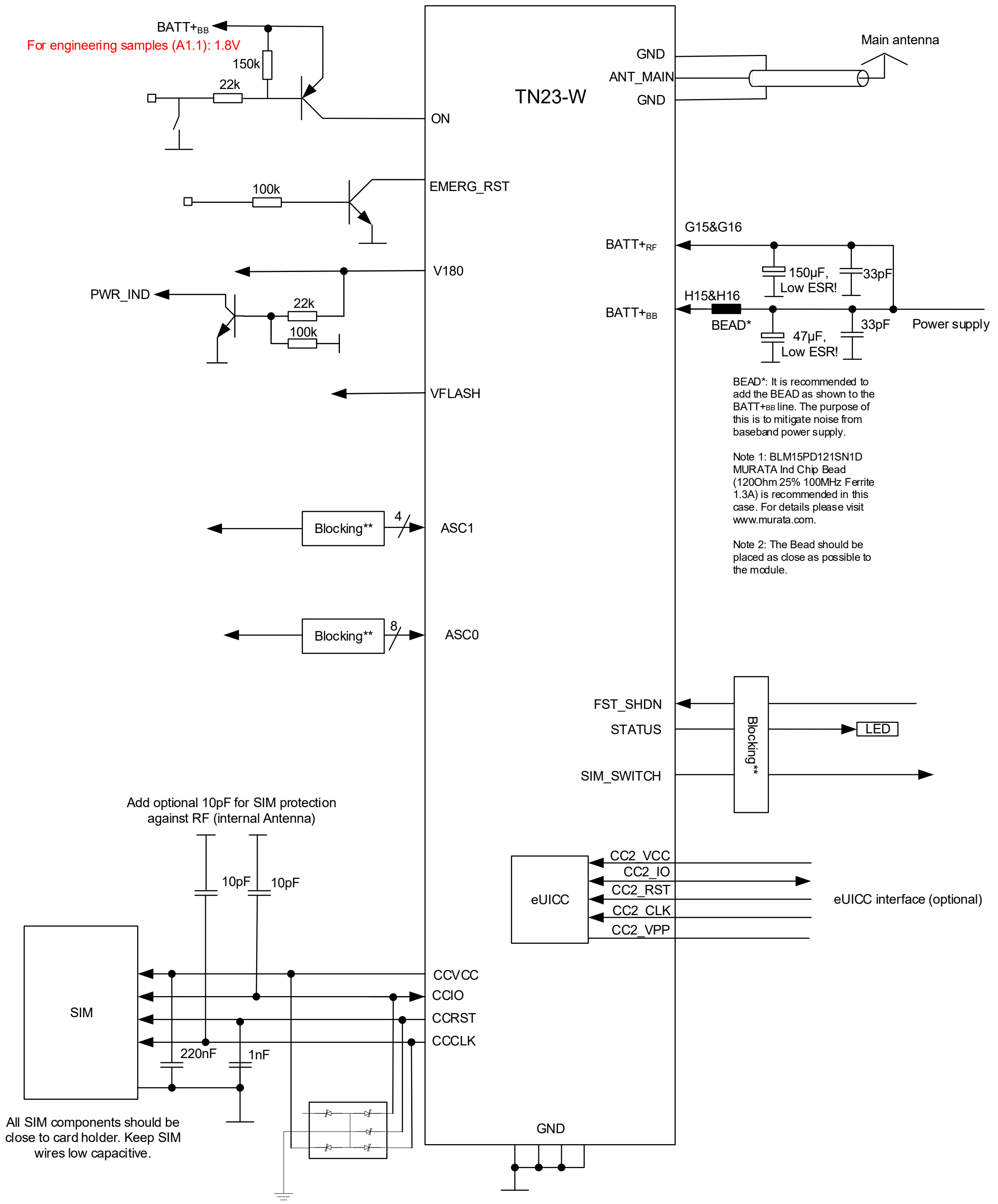
Because of the high RF field density inside the module, it cannot be guaranteed that no self interference might occur, depending on frequency and the applications grounding concept. The potential interferers may be minimized by placing small capacitors (47pF) at suspected lines (e.g. RXD0, TXD0, and ON).

While developing SMT applications it is strongly recommended to provide test points for certain signals, i.e., lines to and from the module - for debug and/or test purposes. The SMT application should allow for an easy access to these signals. For details on how to implement test points see [4]. Possible test points are mentioned in Section 2.1.2.

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

Depending on the micro controller used by an external application TN23-W‘s digital input and output lines may require level conversion. Section 2.3.1 shows a possible sample level conversion circuit.

Disclaimer
No warranty, either stated or implied, is provided on the sample schematic diagram shown in Figure 26 and the information detailed in this section. 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 TN23-W modules. Because of the number of frequencies used it is recommended to involve antenna vendors already quite early to maximize performance of the external application’s layout.



Blocking** = For more details see Section 3.7
eUICC*** = For more details see Section 2.1.6

Figure 26: Schematic diagram of TN23-W sample application

2.3.1 Sample Level Conversion Circuit

Depending on the micro controller used by an external application TN23-W's digital input and output lines (i.e., ASC0, ASC1) may require level conversion. The following Figure 27 shows a sample circuit with recommended level shifters for an external application's micro controller (with VLOGIC between 3.0V...3.6V). The level shifters can be used for digital input and output lines with V_{OH}max=1.85V or V_{IH}max =1.85V. The sample circuit is not optimized for low current consumption.

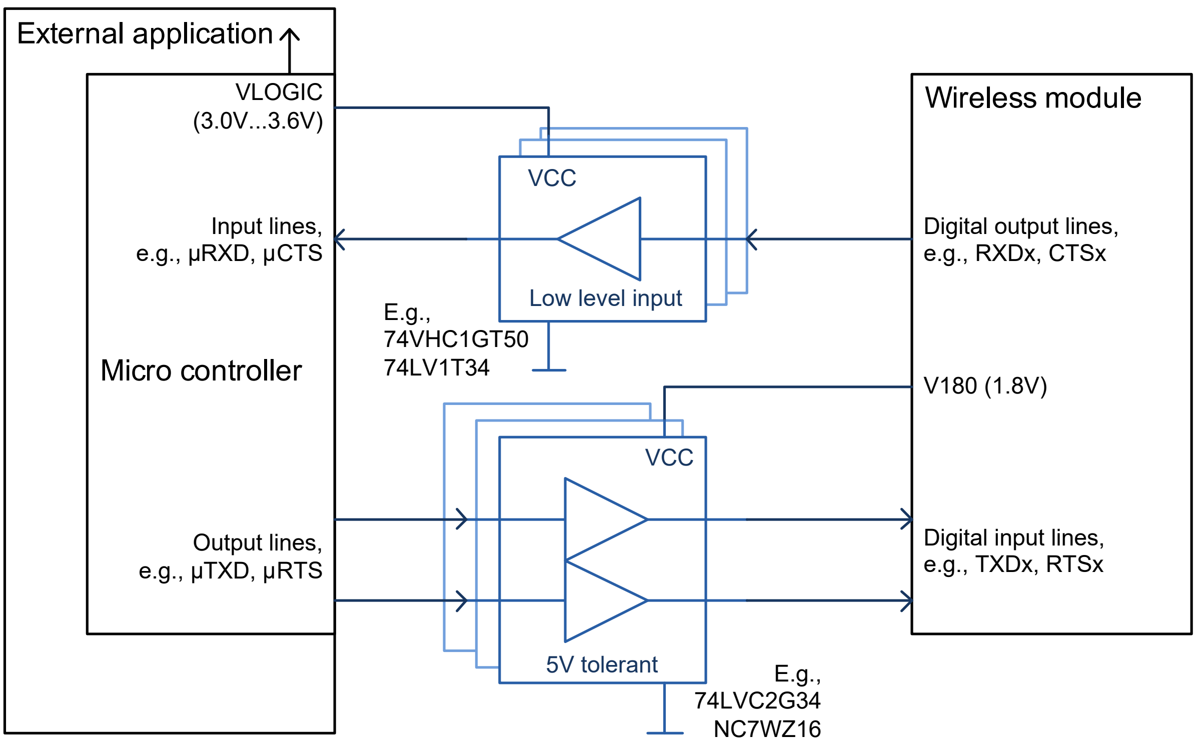


Figure 27: Sample level conversion circuit

3 Operating Characteristics

3.1 Operating Modes

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

Table 9: Overview of operating modes

Mode	Function	
Normal operation	Data transfer	LTE NB1/2 software is active to minimum extent.
	Idle	Software and interfaces are active and ready to send and receive, but no LTE NB1/2 data transfer is currently in progress.
SLEEP[1]	If the module was registered to the LTE NB1/2 network in IDLE mode, it is registered and paging in SLEEP mode, too. Power consumption in this state is extremely dependent on the current LTE NB1/2 network coverage.	
Airplane	Restricted operating mode where the module's radio part is shut down, causing the module to log off from the LTE NB1/2 network, and to disable all AT commands whose execution requires a radio connection. Airplane mode can be controlled by AT command (see AT+CFUN).	
POWER DOWN	State after normal shutdown by sending the switch off command. Software is not active. Interfaces are not accessible. Operating voltage remains applied.	

1. For details on the module's low power modes and their configuration, please refer to Section 3.3.

3.2 Power Up/Power Down Scenarios

Do not turn on TN23-W while it is beyond the safety limits of voltage stated in Section 2.1.2.1. TN23-W 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 TN23-W

TN23-W can be turned on as described in the following sections:

- Hardware driven switch on by ON signal: Starts Normal mode (see Section 3.2.1.1).
- Hardware driven automatic switch on via BATT+ signal: Starts Normal mode (see Section 3.2.1.2).

After startup or restart, a high level of the V180 line, as well as the URC(s) send by the module indicate that the module has started up (again). The URC notifies the host application that the first AT command can be sent to the module (see also [1]).

3.2.1.1 Switch on TN23-W Using ON Signal

The ON signal starts up/wakes up the module if the module is in low power state. This signal is an active high signal and allowed only the input voltage level of BATT power supply. The module starts in the operating mode, with a high-level signal at the ON signal.

Please note that for engineering samples (A1.1), the input voltage level must not exceed 1.8V. Otherwise, or if VBAT is used as input level, the module might get damaged.

The following figures shows the recommended power on circuits and the start-up timings if ON is valid.

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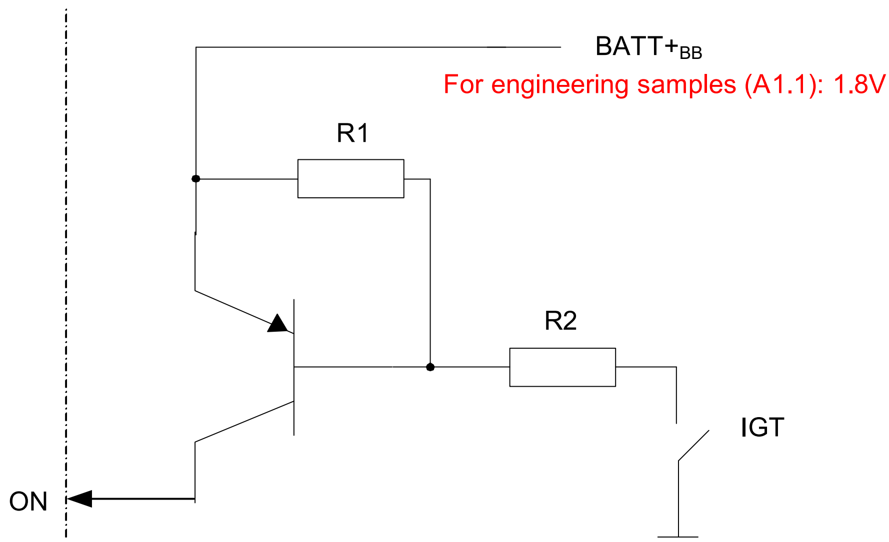


Figure 28: Sample ON circuit

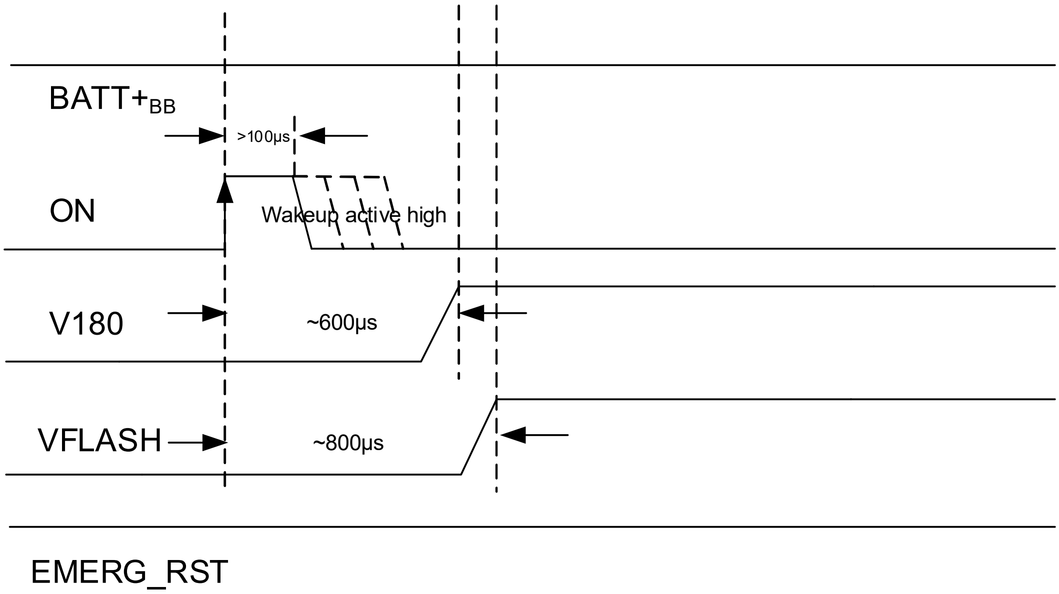


Figure 29: ON startup timing

3.2.1.2 Automatic On Timing

Module switch on is automatically initiated after connecting TN23-W to BATT+. The automatic startup timing is shown in Figure 30.

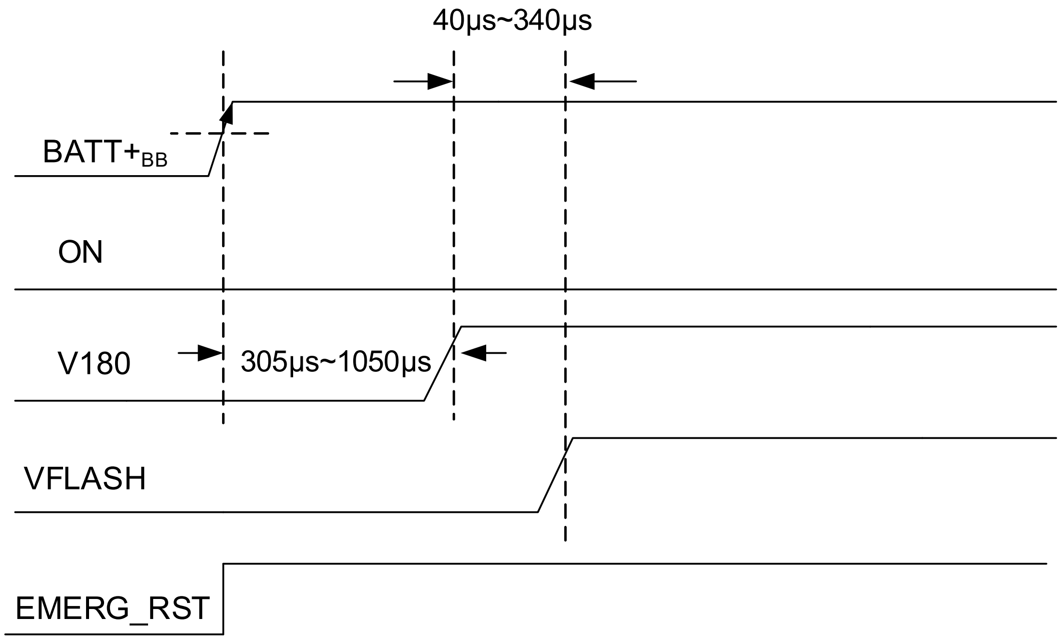


Figure 30: ON startup timing (automatic)

3.2.2 Restart TN23-W

After startup TN23-W 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 TN23-W via AT+CFUN Command

To reset and restart the TN23-W module use the command AT+CFUN. See [1] for details.

3.2.2.2 Restart TN23-W Using EMERG_RST

The EMERG_RST signal is internally connected to the central processor. A low level phase >100µs triggers the module restart process, and sets the processor and all signals to their respective reset states. The reset state is described in Section 3.2.3 as well as in the figures showing the startup behavior of an interface.

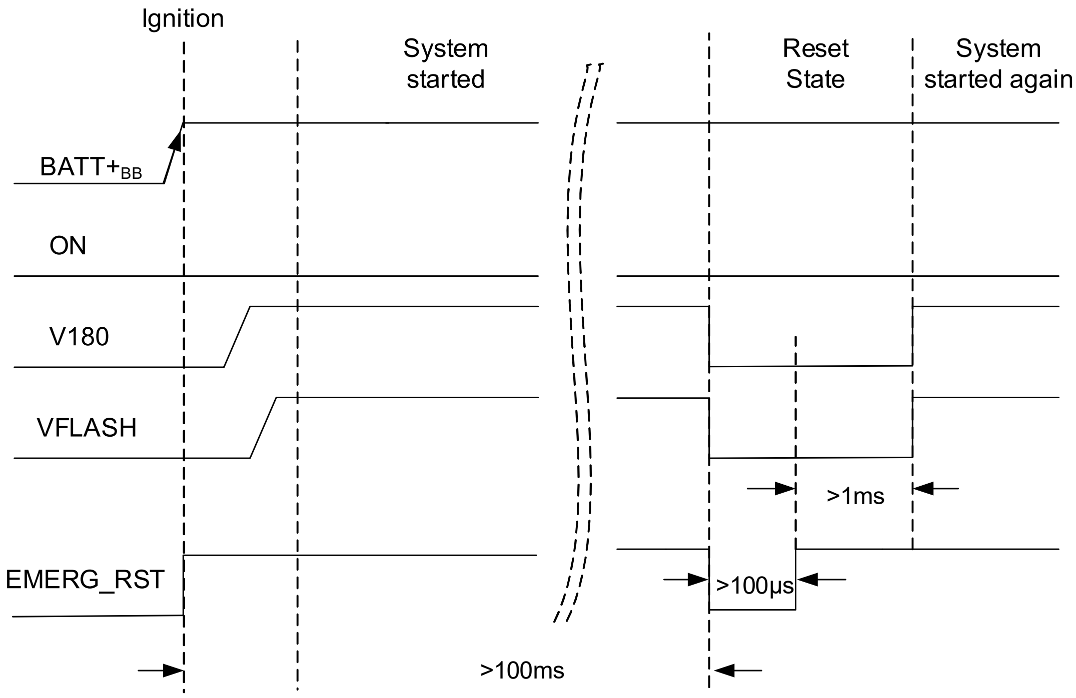


Figure 31: Emergency restart timing

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

Caution: Use the EMERG_RST line only when, due to serious problems, the software is not responding for more than 5 seconds. Pulling the EMERG_RST line causes the loss of all information stored in the volatile memory. Therefore, this procedure is intended only for use in case of emergency, e.g. if TN23-W does not respond, if reset or shutdown via AT command fails.

3.2.3 Signal States after Startup

Table 10 describes various states interface signals pass through after startup until the system is active.

Signals are in an initial state while the module is initializing. Once the startup initialization has completed, i.e. when the software is running, all signals are in a defined state, the module is ready to receive and transmit data. The state of some signals may change again once a respective interface is activated or configured by AT command. For details on certain other signal state changes during startup see also Section 3.2.1 (ON, V180), Section 3.2.2 (EMERG_RST), and Section 2.1.3 (ASC0 signals).

Table 10: Signal states

Signal name	Reset state	First start up configuration
CCIO	PD	TBD.
CCRST	PD	TBD.
CCCLK	PD	TBD.
RXD0	PU	TBD.
TXD0	PU	TBD.
CTS0	PU	TBD.
RTS0	PU	TBD.
DTR0 / MISO	PD	TBD.
DCD0 / SPI_CLK	PD	TBD.
DSR0 / MOSI	PD	TBD.
RING0 / SPI_CS	PD	TBD.
RXD1	PU	TBD.
TXD1	PU	TBD.
CTS1 / I2CCLK	PU	TBD.
RTS1 / I2CDAT	PU	TBD.
FST_SHDN / GPIO4	PD	TBD.
STATUS / GPIO5	PU	TBD.
SIM_SWITCH / GPIO8	PU	TBD.

Abbreviations used in above Table 10:

L = Low level H = High level L/H = Low or high level T = Tristate	I = Input O = Output OD = Open Drain PD = Pull down, 13.6kΩ ~45kΩ PU = Pull up, 13kΩ ~45kΩ

3.2.4 Turn off TN23-W

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

- *Software controlled shutdown procedure*: Software controlled by sending an AT command over the serial application interface. See Section 3.2.4.1.
- *Hardware controlled shutdown procedure*: Hardware controlled by setting the FST_SHDN line to low. See Section 2.1.10.3.
- *Automatic shutdown (software controlled)*: See Section 3.2.5
  - Takes effect if TN23-W board temperature exceeds a critical limit, or if
  - Undervoltage or overvoltage is detected.

3.2.4.1 Switch off TN23-W Using AT Command

The best and safest approach to powering down the module is to issue the AT^SMSO command. This procedure lets the module log off from the network and allows the software to enter into a secure state and to save data before disconnecting the power supply. The shutdown procedure will be an active process for about 2 seconds (depending on environmental conditions such as network states) until the module switches off. It cannot be specified how long the shutdown procedure may take at the worst.

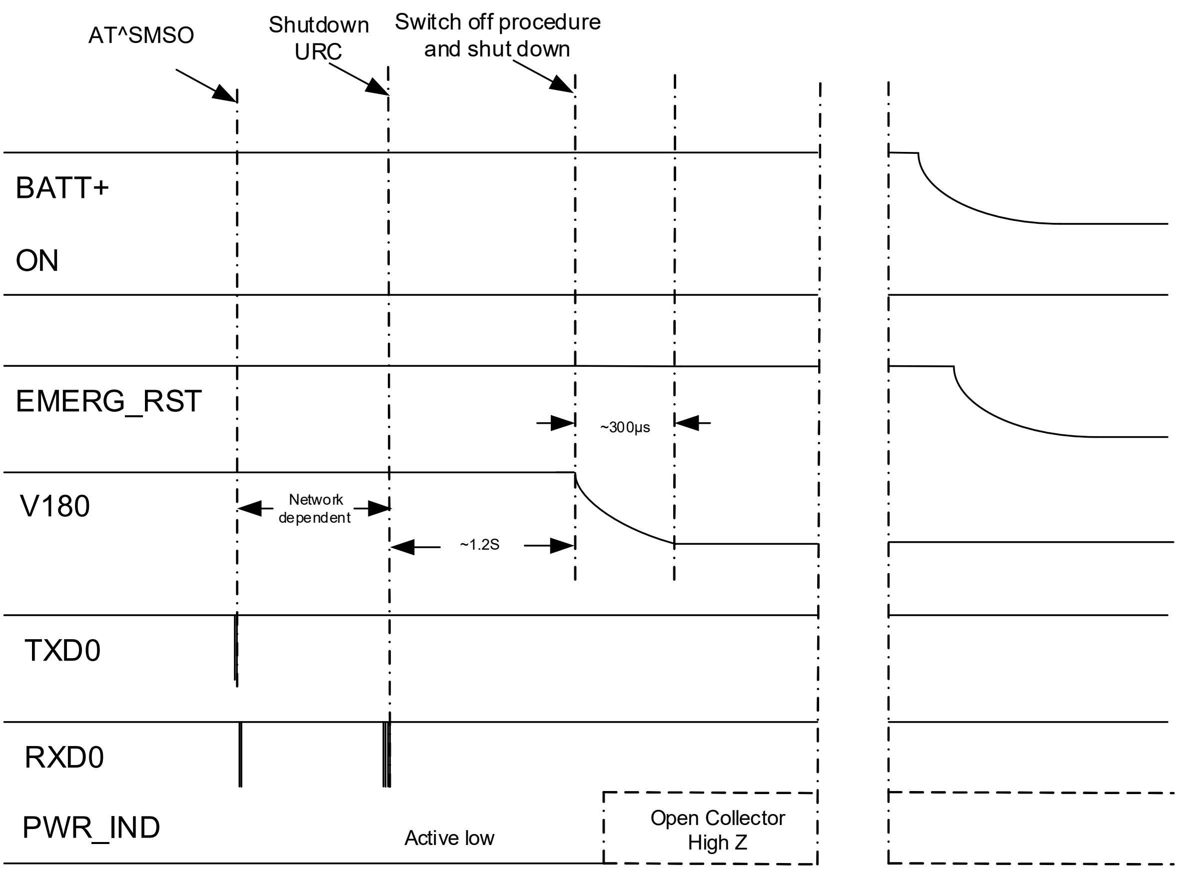


Figure 32: Switch off behavior

A low level of the V180 signal as well as the URC "^SHUTDOWN" indicate that the switch off procedure has completed and the module has entered the Power Down mode.

3.2.5 Automatic Shutdown

Automatic shutdown takes effect if the following event occurs:
- TN23-W board is exceeding the critical limits of overtemperature or undertemperature (see Section 3.2.5.1)
- Undervoltage or overvoltage is detected (see Section 3.2.5.2 and Section 3.2.5.3)

The automatic shutdown procedure is equivalent to the power-down initiated with an AT command, i.e. TN23-W logs off from the network and the software enters a secure state avoiding loss of data.

3.2.5.1 Thermal Shutdown

TBD.

3.2.5.2 Undervoltage Shutdown

The undervoltage shutdown threshold is the specified minimum supply voltage V_{BATT+} given in Table 2. When the average supply voltage measured by TN23-W approaches the undervoltage shutdown threshold (i.e., 0.05V offset) the module will send the following URC:

^SBC: Undervoltage

If the undervoltage persists the module will send the URC several times before switching off automatically.

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

Note: For battery powered applications it is strongly recommended to implement a BATT+ connecting circuit in order to not only be able save power, but also to restart the module after an undervoltage shutdown where the battery is deeply discharged. Also note that the undervoltage threshold is calculated for max. 400mV voltage drops during transmit burst. Power supply sources for external applications should be designed to tolerate 400mV voltage drops without crossing the lower limit of 3.3V. For external applications operating at the limit of the allowed tolerance the default undervoltage threshold may be adapted by subtracting an offset. For details see [1]: AT^SCFG= "MEShutdown/sVsup/threshold".

3.2.5.3 Overvoltage Shutdown

The overvoltage shutdown threshold is the specified maximum supply voltage V_{BATT+} given in Table 2. When the average supply voltage measured by TN23-W approaches the overvoltage shutdown threshold (i.e., 0.05V offset) the module will send the following URC:

^SBC: Overvoltage Warning

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

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

^SBC: Overvoltage Shutdown

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

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

Keep in mind that several TN23-W components are directly linked to BATT+ and, therefore, the supply voltage remains applied at major parts of TN23-W. Especially the power amplifier linked to $BATT+_{RF}$ is sensitive to high voltage and might even be destroyed.

3.3 Power Saving

TBD.

3.4 Power Supply

TN23-W 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 BATT+ in this document refers to both voltage domains and power supply lines - $BATT+_{BB}$ and $BATT+_{RF}$.

The power supply of TN23-W has to be a single voltage source at $BATT+_{BB}$ and $BATT+_{RF}$. It should be of type PS1, according to IEC 62368-1, and must be able to provide the peak current during the uplink transmission.

Suitable low ESR capacitors should be placed as close as possible to the BATT+ pads, e.g., X7R MLCC (see also Section 2.1.2).

All key functions for supplying power to the device are handled by the power management IC. It provides the following features:

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

3.4.1 Power Supply Ratings

Table 11 and Table 12 assemble various voltage supply and current consumption ratings (Cat NB1/2) of the module.

Table 11: Voltage supply ratings TN23-W

	Description	Conditions	Min	Typ	Max	Unit
BATT+	Supply voltage	Directly measured at Module. Voltage must stay within the min/ max values, including voltage drop, ripple, spikes	3.0	3.8	4.5	V

Table 12: Current consumption ratings TN23-W

Description		Conditions			Typical	Unit
I_{BATT+}[1] (i.e., sum of $BATT+_{BB}$ and $BATT+_{RF}$)	Average LTE NB1/2 supply current	Power Save Mode (PSM)	Base current		1.6	uA
			T3412 12 hours, T3324 2s, DRX 2.56s		8.0	
		RRC idle (Sleep) [2]	DRX =1024		0.354	mA
			DRX =512		0.523	mA
			DRX =256		0.876	mA
			DRX =128		1.565	mA
			20,48s eDRX	PTW = 2,56s DRX = 1,28s	0.207	mA
			40.96s eDRX	PTW = 2,56s DRX = 1,28s	0.120	mA
			81.92s eDRX	PTW = 2,56s DRX = 1,28s	0.078	mA
			163,84s eDRX	PTW = 10,24s DRX = 1,28s	0.066	mA
		RRC connected Active Transmission DL RMC[3]	Band1, 23dBm		67	mA
			Band2, 23dBm		65	mA
			Band3, 23dBm		57	mA
			Band4, 23dBm		57	mA
			Band5, 23dBm		55	mA
			Band8, 23dBm		62	mA
			Band12, 23dBm		65	mA
			Band13, 23dBm		60	mA
			Band17, 23dBm		65	mA
			Band18, 23dBm		54	mA
			Band19, 23dBm		55	mA
			Band20, 23dBm		56	mA
			Band25, 23dBm		68	mA
			Band26, 23dBm		55	mA
			Band28, 23dBm		66	mA
			Band66, 23dBm		57	mA
			Band85, 23dBm		65	mA

Table 12: Current consumption ratings TN23-W

Description		Conditions		Typical	Unit
I_{BATT+}[1] (i.e., sum of $BATT+_{BB}$ and $BATT+_{RF}$)	Average LTE NB1/2 supply current	RRC connected Active Transmission UL RMC, single tone mode (1subcarrier),15KHz spacing [3]	Band1, 23dBm	239	mA
			Band2, 23dBm	249	mA
			Band3, 23dBm	182	mA
			Band4, 23dBm	182	mA
			Band5, 23dBm	171	mA
			Band8, 23dBm	215	mA
			Band12, 23dBm	232	mA
			Band13, 23dBm	211	mA
			Band17, 23dBm	234	mA
			Band18, 23dBm	167	mA
			Band19, 23dBm	172	mA
			Band20, 23dBm	176	mA
			Band25, 23dBm	251	mA
			Band26, 23dBm	169	mA
			Band28, 23dBm	234	mA
			Band66, 23dBm	182	mA
			Band85, 23dBm	231	mA

Table 12: Current consumption ratings TN23-W

Description	Conditions		Typical	Unit
I_{BATT+}[1] (i.e., sum of $BATT+_{BB}$ and $BATT+_{RF}$)	Peak Current @ RRC connected Active Transmission UL RMC, single tone mode (1subcarrier),15KHz spacing Vbatt = 3.8V[3]	Band1, 23dBm	482	mA
		Band2, 23dBm	507	mA
		Band3, 23dBm	362	mA
		Band4, 23dBm	361	mA
		Band5, 23dBm	337	mA
		Band8, 23dBm	443	mA
		Band12, 23dBm	492	mA
		Band13, 23dBm	437	mA
		Band17, 23dBm	502	mA
		Band18, 23dBm	331	mA
		Band19, 23dBm	341	mA
		Band20, 23dBm	348	mA
		Band25, 23dBm	508	mA
		Band26, 23dBm	334	mA
		Band28, 23dBm	501	mA
		Band66, 23dBm	361	mA
		Band85, 23dBm	490	mA

1. With an impedance of Z_{LOAD}=50Ohm at the antenna connector, measured at 25°C at 3,8V
2. Measurements start 6 minutes after switching ON the module,
   Averaging times:
   SLEEP mode: 10 minutes, (PSM disabled, eDRX disabled)
   RRC connected modes: 3 minutes,
   Communication tester settings: no neighbor cells, no cell re-selection etc,, RMC (reference measurement channel),
   Sleep/suspend (power save) mode is enabled via AT command
3. Communication tester settings:
   RSRP -80dBm, 10MHz cell bandwidth, HD-FDD and no neighbor cells configured is assumed.
   Modulation: BPSK for 1 UL sub-carrier mode, QPSK for multi-sub-carrier mode.

3.4.2 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 and BATT+ should be a test pad on the external application the module is mounted on. The external GND reference point has to be connected to and positioned close to the SMT application interface's GND pad F17 and the external BATT+ reference point has to be connected to and positioned close to the SMT application interface's BATT+ pads G15 and G16 ($BATT+_{RF}$) or H15 and H16 ($BATT+_{BB}$) as shown in Figure 33.

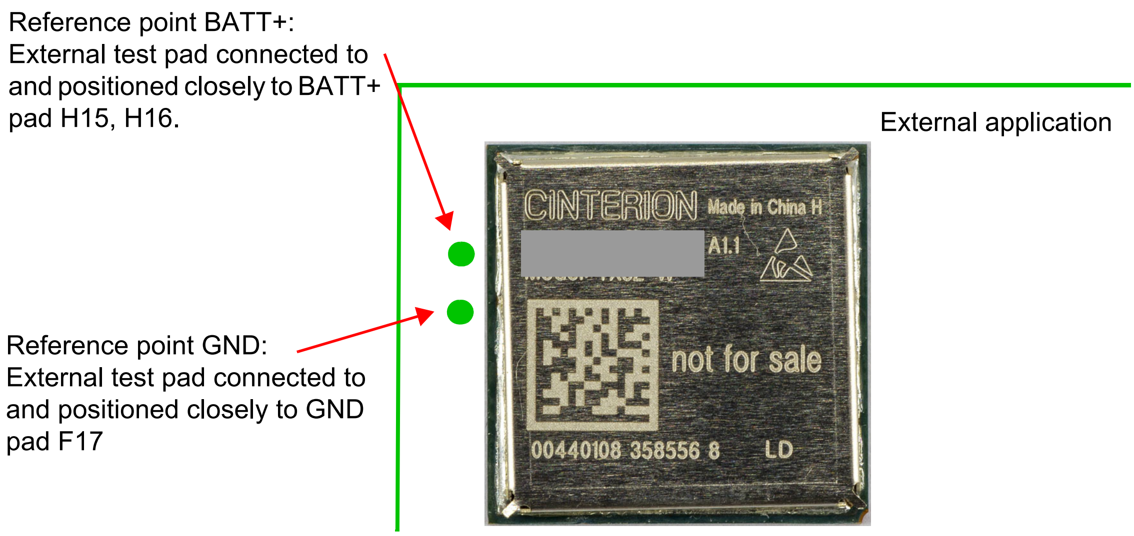


Figure 33: Position of reference points BATT+ and GND

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 13: Board temperature

Parameter	Min	Typ	Max	Unit
Normal operation	-30		+85	°C
Extended operation[1]	-40		+85	°C
Automatic shutdown[2] Temperature measured on TN23-W board	TBD.	---	TBD.	°C

1. Extended operation allows normal mode speech calls or data transmission for limited time. 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 ±3°C on the thresholds may occur.

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

Note: Within the specified operating temperature ranges the board temperature may vary to a great extent depending on operating mode, used frequency band, radio output power and current supply voltage.

The below Table 14 lists the ambient temperature ranges the TN23-W is able to operate in.

Table 14: Ambient temperature

Parameter	Min	Typ	Max	Unit
Normal operation (LTE)	-40		+70	°C

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 TN23-W module.

Special ESD protection provided on TN23-W:
Main antenna interface: Inductor/capacitor
BATT+: Inductor/capacitor
An example for an enhanced ESD protection for the SIM interface is given in Section 2.1.5.1.

TN23-W has been tested according to group standard ETSI EN 301 489-1. Electrostatic values can be gathered from the following table.

Table 15: Electrostatic values

Specification/Requirements	Contact discharge	Air discharge
ETSI EN 301 489-1		
Main antenna interface	± 4kV	± 8kV
BATT+	± 4kV	± 8kV
JEDEC JESD22-A114D (Human Body Model, Test conditions: 1.5 kΩ, 100 pF)		
All other interfaces	± TBD	n.a.

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

3.6.1 ESD Protection for RF Antenna Interface

The following Figure 34 shows how to implement an external ESD protection for the RF antenna interface with either a T pad or PI pad attenuator circuit (for RF line routing design see also Section 2.2.3).

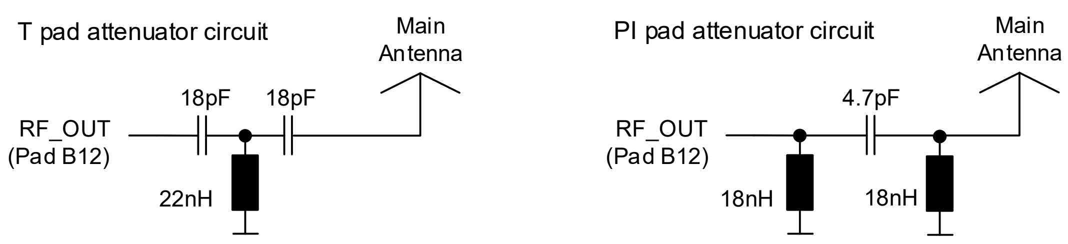


Figure 34: ESD protection for RF antenna interface

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

3.7 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 (cp. Section 2.3). However, all other signal lines have no EMI measures on the module and there are no blocking measures at the module's interface to an external application.

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

There are five possible variants of EMI measures (A-E) that may be implemented between module and external application depending on the signal line (see Figure 35 and Table 16). Pay attention not to exceed the maximum input voltages and prevent voltage overshots if using inductive EMC measures.

The maximum value of the serial resistor should be lower than 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.

TBD.

Figure 35: EMI circuits

Note: In case the application uses an internal LTE antenna that is implemented close to the TN23-W module, Thales 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 16: EMI measures on the application interface (TBD.)

Signal name	**EMI measures**					**Remark**
	A	**B**	**C**	**D**	**E**	
CCRST						
CCIO						
CCCLK						
RXD0						
TXD0						
CTS0						
RTS0						
RING0						
DTR0						
RXD1						
TXD1						
CTS1						
RTS1						
V180						
VFLASH						
STATUS						
FST_SHDN						
$BATT+_{RF}$ **(pad G15, G16)**						
$BATT+_{BB}$ **(pad H15, H16)**						

3.8 Reliability Characteristics

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

Table 17: Summary of reliability test conditions

Type of test	Conditions	Standard
Vibration	Frequency range: 10-20Hz; acceleration: 5g Frequency range: 20-500Hz; acceleration: 20g Duration: 20h per axis; 3 axes	DIN IEC 60068-2-6[1]
Shock half-sinus	Acceleration: 500g Shock duration: 1ms 1 shock per axis 6 positions (± 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 TN23-W

Figure 36 shows the top and bottom view of TN23-W and provides an overview of the board's mechanical dimensions. For further details see Figure 37. Figure 38 shows the area at the module’s bottom side where possible markings might be printed.

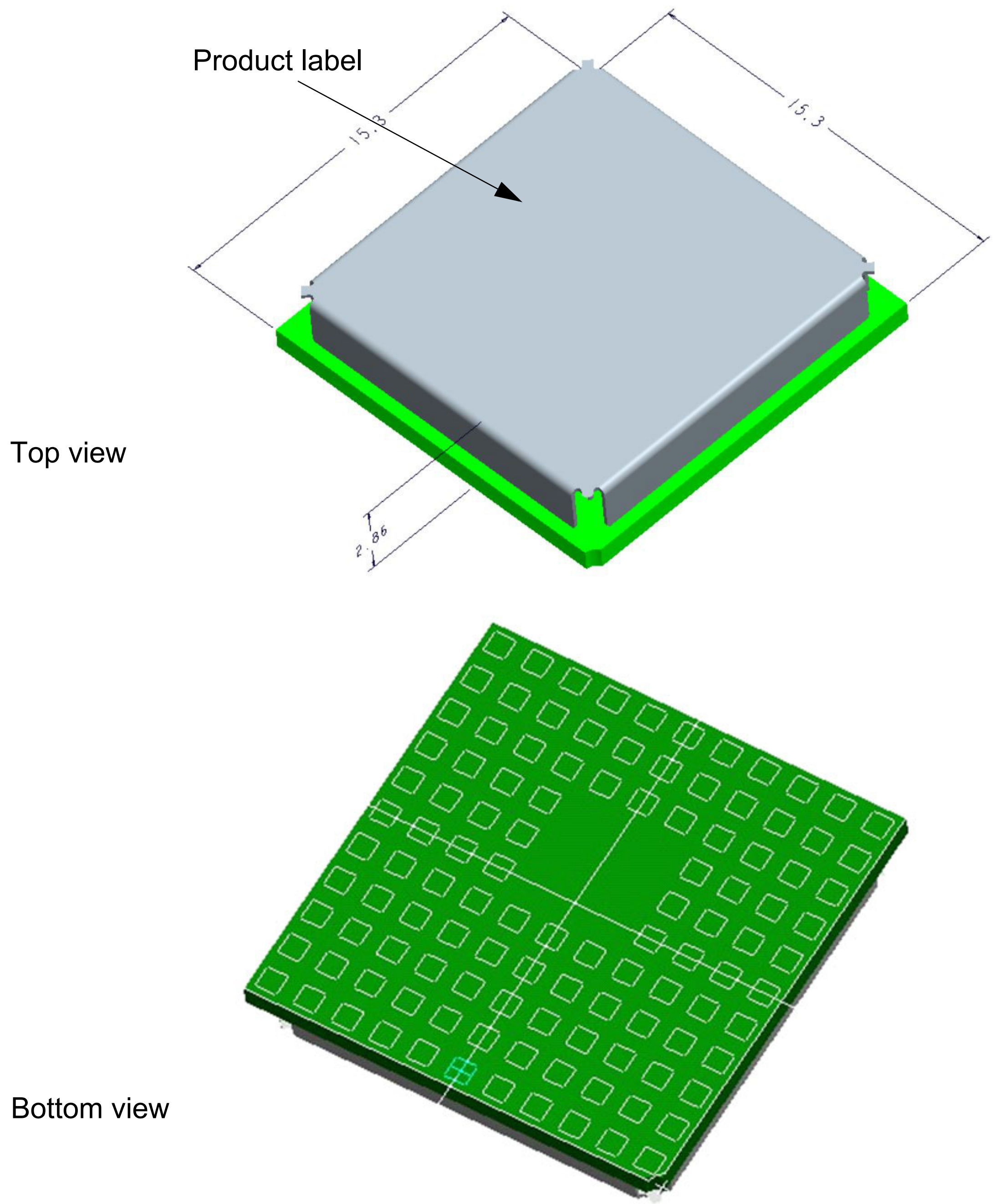


Figure 36: TN23-W– top and bottom view

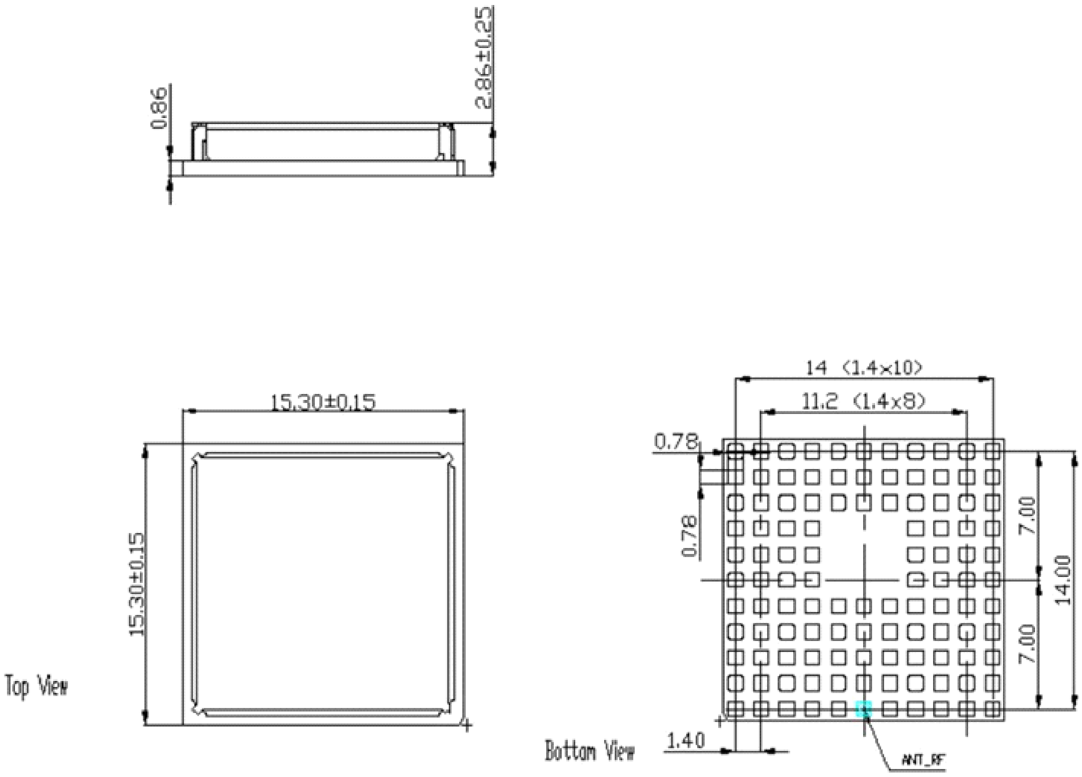


Figure 37: Dimensions of TN23-W (all dimensions in mm)

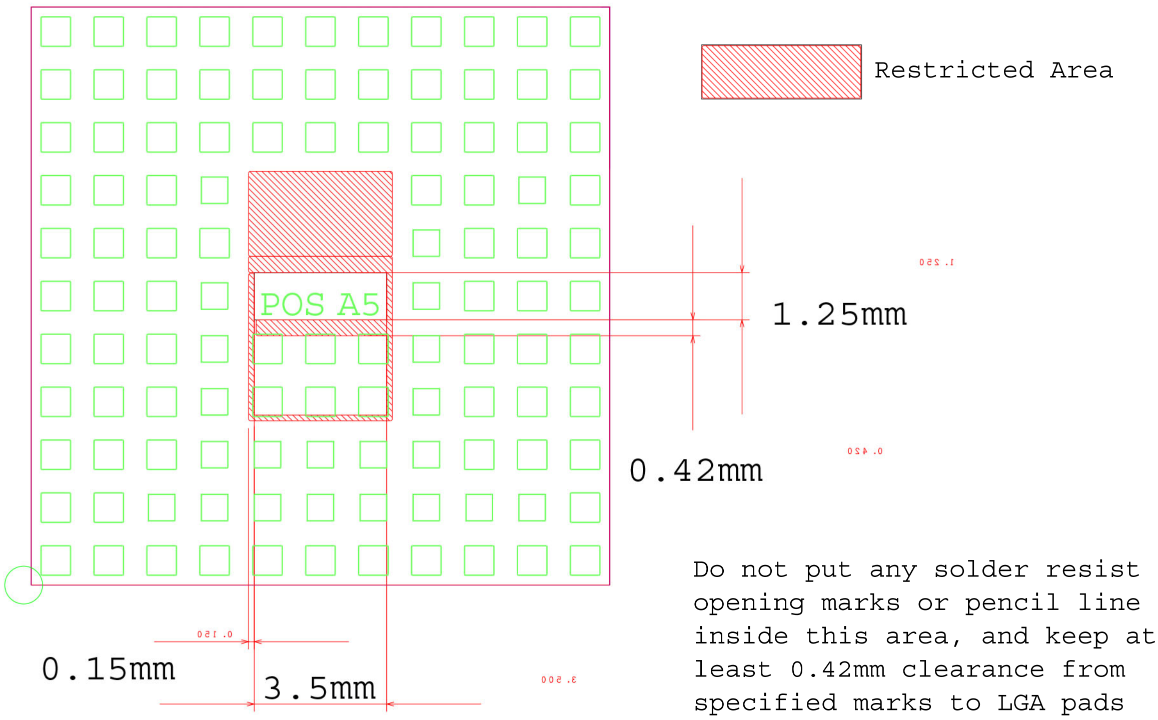


Figure 38: Dimensions of area for possible markings TN23-W (bottom view)

4.2 Mounting TN23-W onto the Application Platform

This section describes how to mount TN23-W onto the PCBs, including land pattern and stencil design, board-level characterization, soldering conditions, durability and mechanical handling. For more information on issues related to SMT module integration see also [4].

Note: To avoid short circuits between signal tracks on an external application's PCB and various markings at the bottom side of the module (see Figure 38 and Figure 4.2), 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.

Note: Do not place external components or devices that might cause any pressure on the module’s shielding. See [3] and [4] for further details of thermal and integration guidance.

4.2.1 SMT PCB Assembly

4.2.1.1 Land Pattern and Stencil

The land pattern and stencil design as shown below is based on Thales characterizations for lead-free solder paste on a four-layer test PCB and a 110 micron thick stencil.

The land pattern given in Figure 39 reflects the module‘s pad layout, including signal pads and ground pads (for pad assignment see Section 2.1.1).

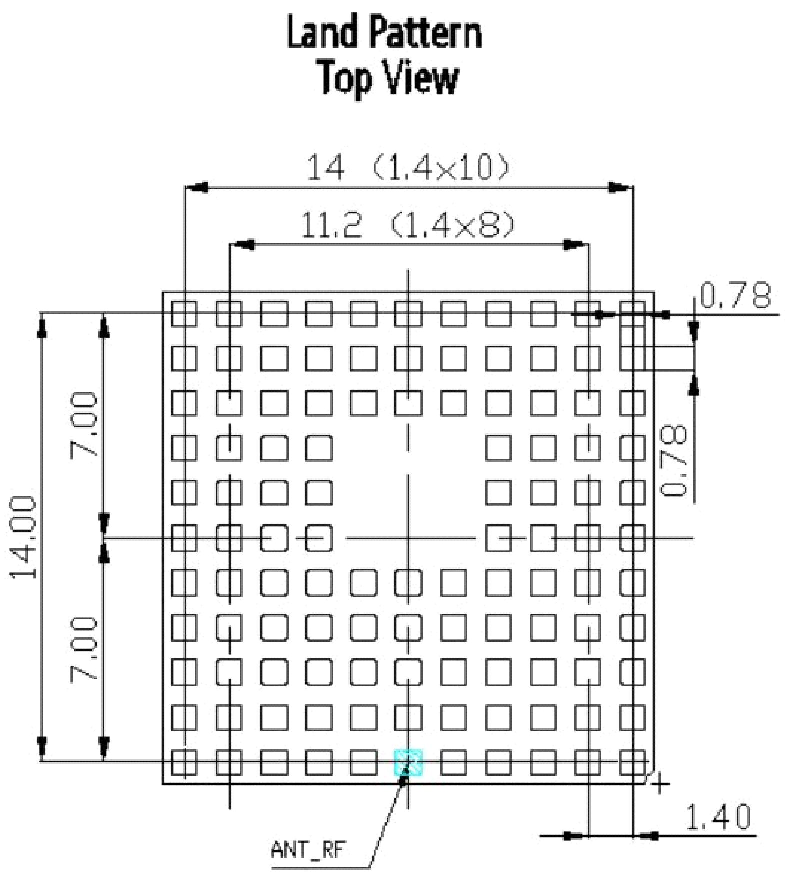


Figure 39: Land pattern TN23-W (top view)

The stencil design illustrated in Figure 40 s recommended by Thales as a result of extensive tests with Thales Daisy Chain modules.

The central ground pads are primarily intended for stabilizing purposes, and may show some more voids than the application interface pads at the module's rim. This is acceptable, since they are electrically irrelevant.

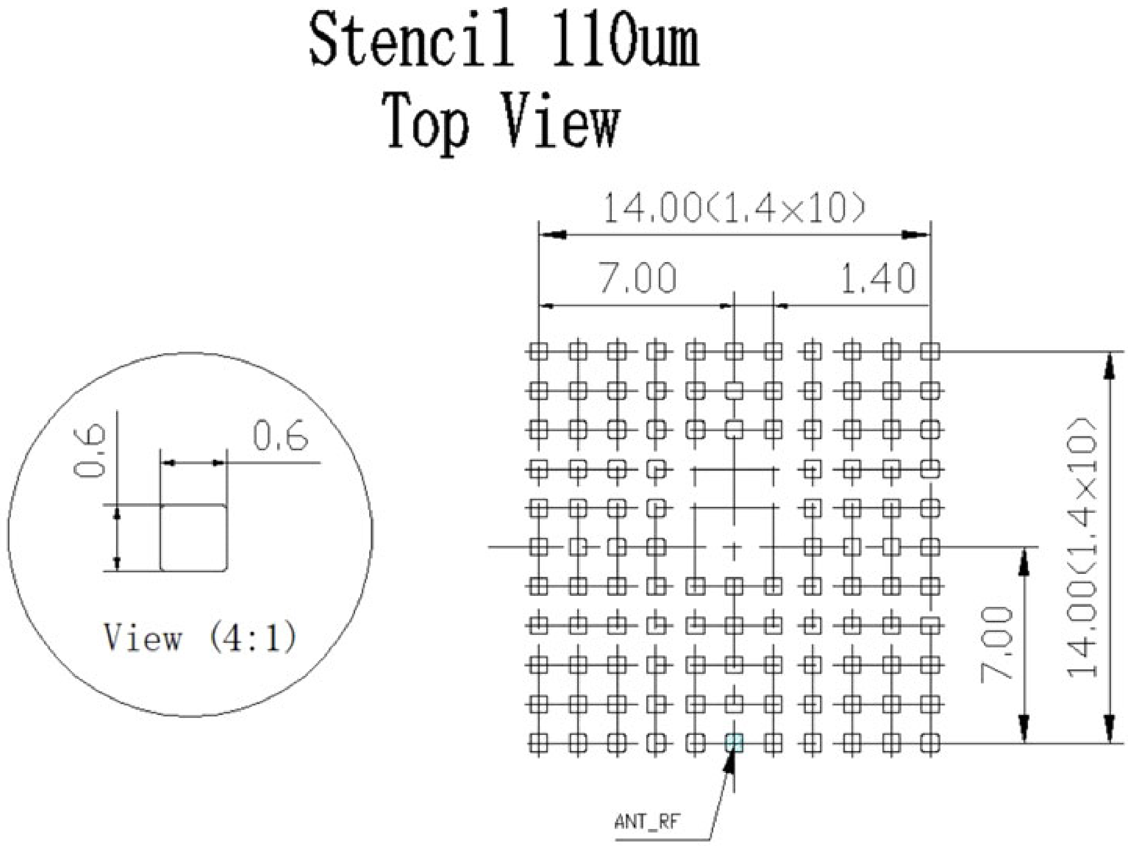


Figure 40: Recommended design for 110µm thick stencil for TN23-W (top view)

4.2.1.2 Board Level Characterization

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

Characterization tests should attempt to optimize the SMT process with regard to board level reliability. This can be done by performing the following physical tests on sample boards: Peel test, bend test, tensile pull test, drop shock test and temperature cycling. Sample surface mount checks are described in [4].

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

Daisy chain modules for SMT characterization are available on request. For details refer to [4].

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

TN23-W comprises components that are susceptible to damage induced by absorbed moisture.

Thales's TN23-W 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

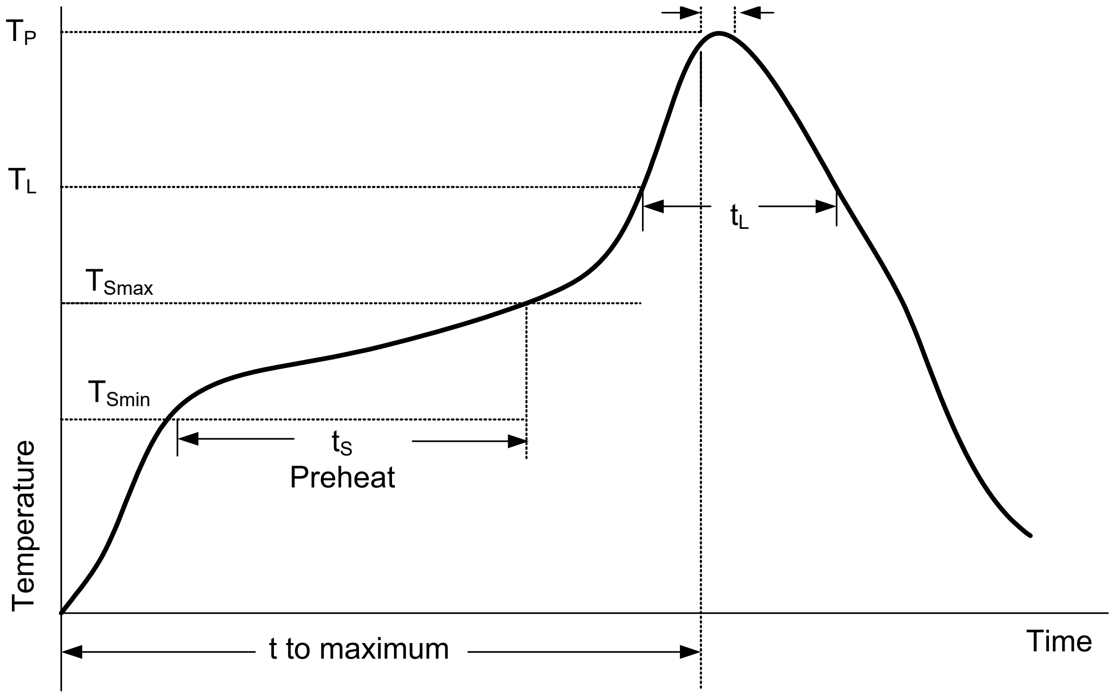


Figure 41: Reflow Profile

Table 18: 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 180°C 60-120 seconds
Average ramp up rate (T_{Smax} 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.
Limited ramp-down rate (Tp-200°C) Average ramp-down rate from 200°C	1K/second max. 3K-6K/second max.
Time 25°C to maximum temperature	8 minutes max.

1. Please note that the reflow profile features and ratings listed above are based on the joint industry standard IPC/JEDEC J-STD-020D.1, and are as such meant as a general guideline. For more information on reflow profiles and their optimization please refer to [4].

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 15 seconds at this temperature.

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

TN23-W is specified for one soldering cycle only. Once TN23-W 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

TN23-W modules, as delivered in tape and reel carriers, must be stored in sealed, moisture barrier anti-static bags. The conditions stated below are only valid for modules in their original packed state in weather protected, non-temperature-controlled storage locations. Normal storage time under these conditions is 12 months maximum.

Table 19: Storage conditions

Type	Condition	Unit	Reference
Air temperature: Low High	-25 +40	°C	IPC/JEDEC J-STD-033A
Humidity relative: Low High	10 90 at 40°C	%	 IPC/JEDEC J-STD-033A
Air pressure: Low High	70 106	kPa	IEC TR 60271-3-1: 1K4 IEC TR 60271-3-1: 1K4
Movement of surrounding air	1.0	m/s	IEC TR 60271-3-1: 1K4
Water: rain, dripping, icing and frosting	Not allowed	---	---
Radiation: Solar Heat	1120 600	W/m^2	ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb ETS 300 019-2-1: T1.2, IEC 60068-2-2 Bb
Chemically active substances	Not recommended		IEC TR 60271-3-1: 1C1L
Mechanically active substances	Not recommended		IEC TR 60271-3-1: 1S1
Vibration sinusoidal: Displacement Acceleration Frequency range	 1.5 5 2-9 9-200	 mm m/s^2 Hz	IEC TR 60271-3-1: 1M2
Shocks: Shock spectrum Duration Acceleration	 semi-sinusoidal 1 50	 ms m/s^2	IEC 60068-2-27 Ea

4.2.4.2 Processing Life

TN23-W 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 TN23-W, if the conditions specified in Section 4.2.4.1 and Section 4.2.4.2 were not exceeded.
- It is *necessary* to bake TN23-W, 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 irreversible damage for the module. It is therefore advisable to develop measures and methods to counter ESD and to use these to control the electrostatic environment at manufacturing sites.

Please refer to Section 3.6 for further information on electrostatic discharge.

4.3 Packaging

4.3.1 Tape and Reel

The single-feed tape carrier for TN23-W is illustrated in Figure 42. The figure also shows the proper part orientation. The tape width is 32mm and the TN23-W modules are placed on the tape with a 20mm pitch. The reels are 330mm in diameter with a core diameter of 77.50mm. Each reel contains 900 modules.

4.3.1.1 Orientation

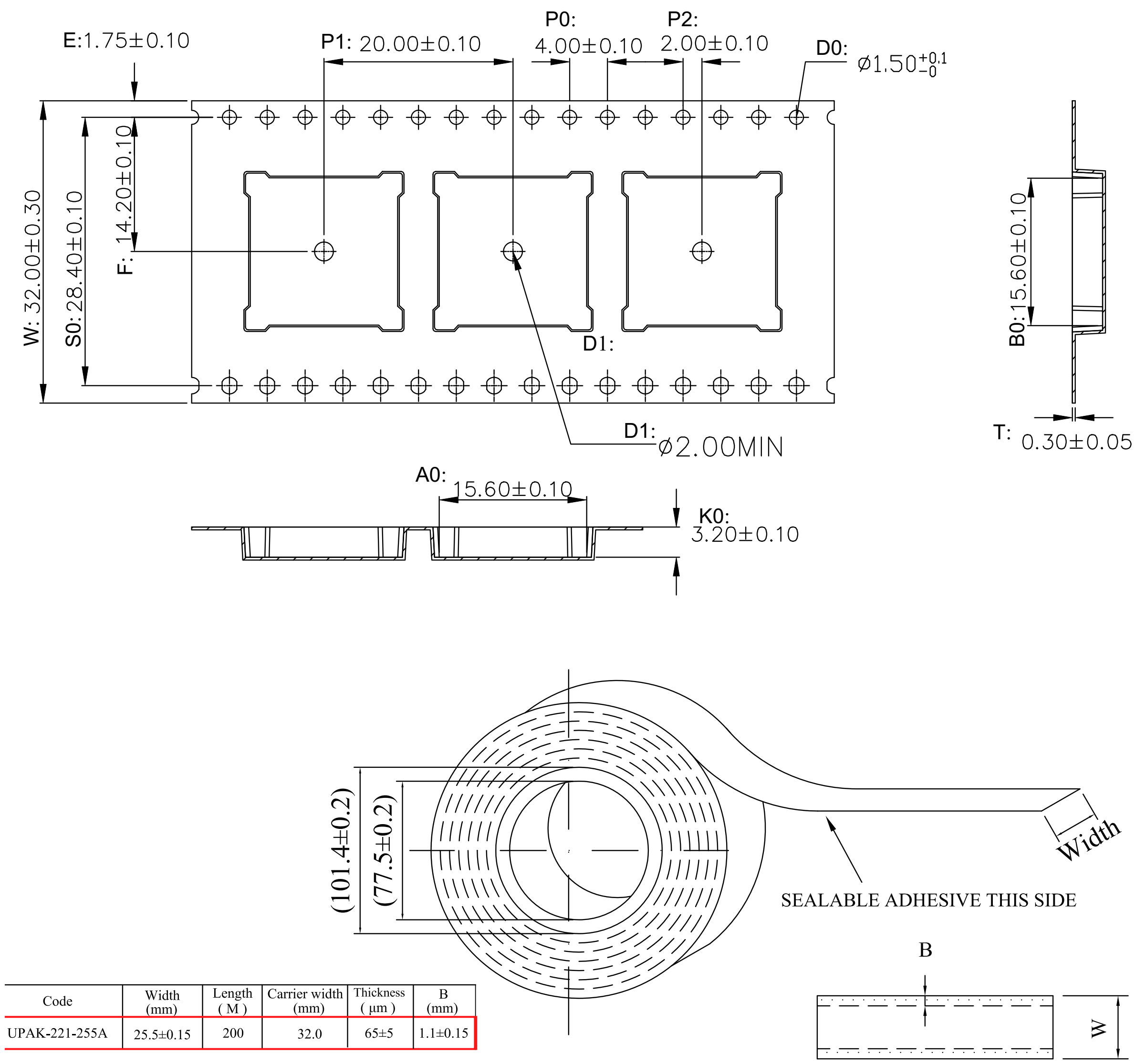


Figure 42: Carrier tape

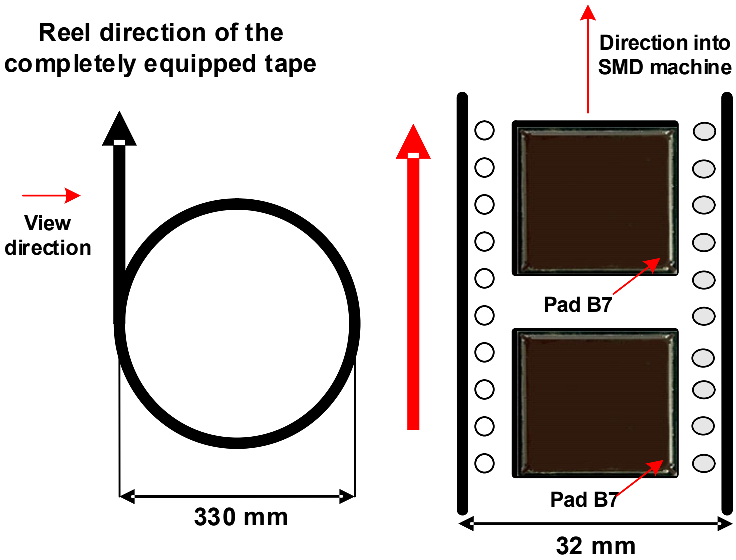


Figure 43: Reel direction

4.3.1.2 Barcode Label

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

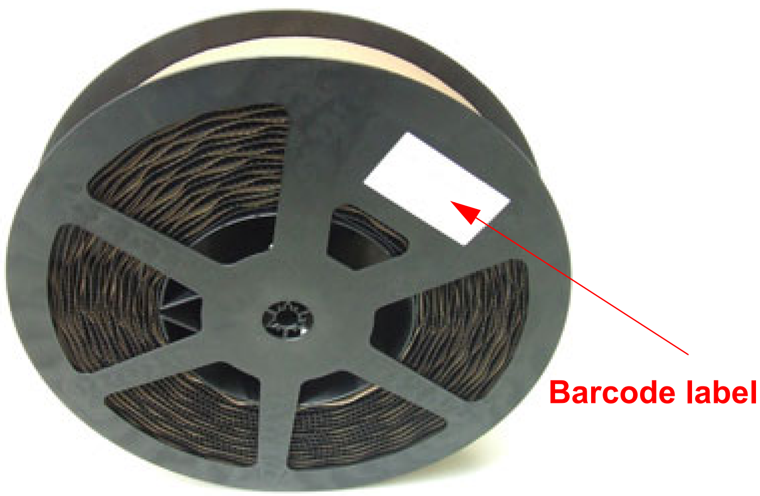


Figure 44: Barcode label on tape reel (generic photo)

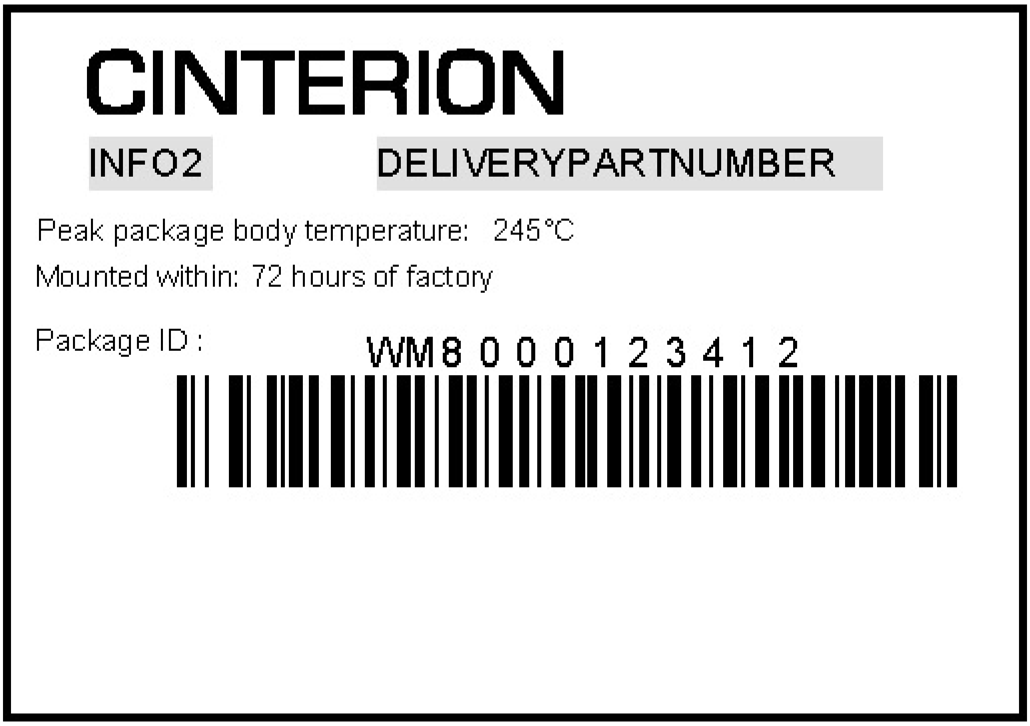


Figure 45: Barcode label on tape reel - layout

Variables on the label are explained in Table 20.

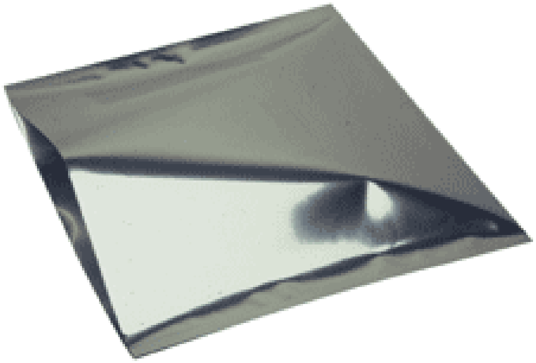
4.3.2 Shipping Materials

TN23-W is distributed in tape and reel carriers. The tape and reel carriers used to distribute TN23-W 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 46. 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 TN23-W modules from moisture exposure. It should not be opened until the devices are ready to be soldered onto the application.



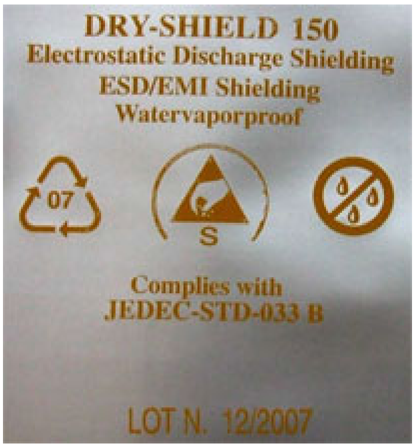


Figure 46: Moisture barrier bag (MBB) with imprint

The label shown in Figure 47 summarizes requirements regarding moisture sensitivity, including shelf life and baking requirements. It is attached to the outside of the moisture barrier bag. Variables on the label are explained in Table 20.

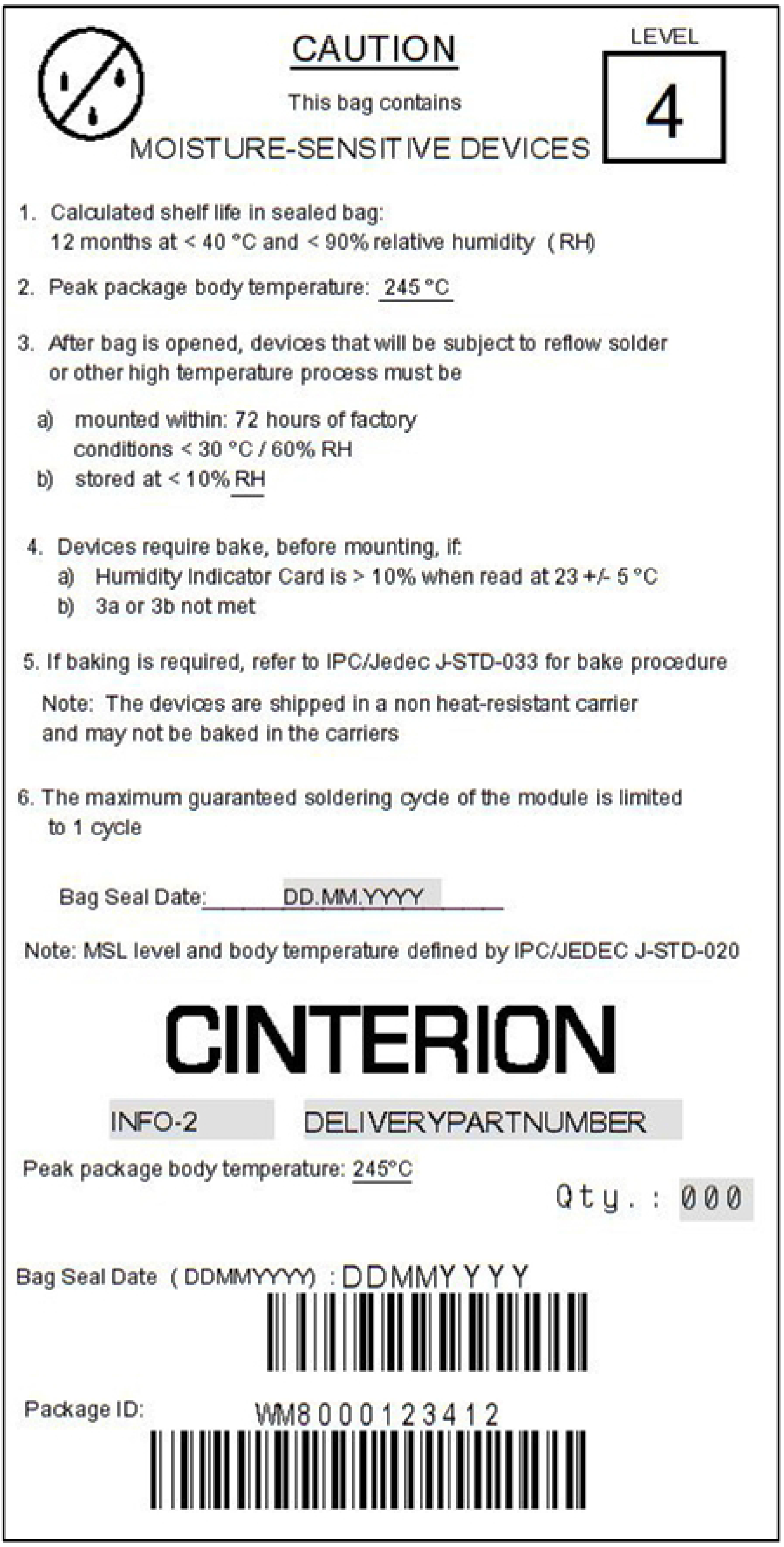


Figure 47: Moisture Sensitivity Label

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

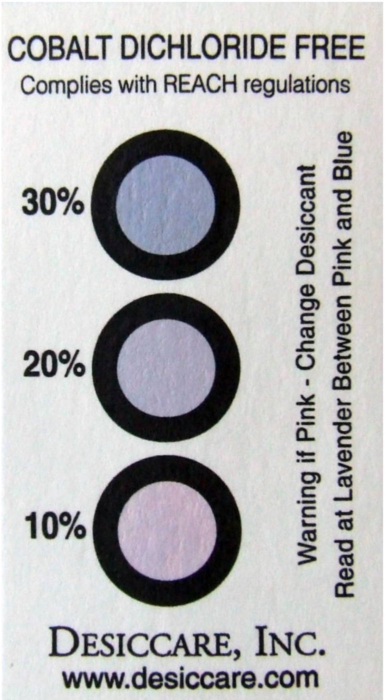


Figure 48: Humidity Indicator Card - HIC

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.

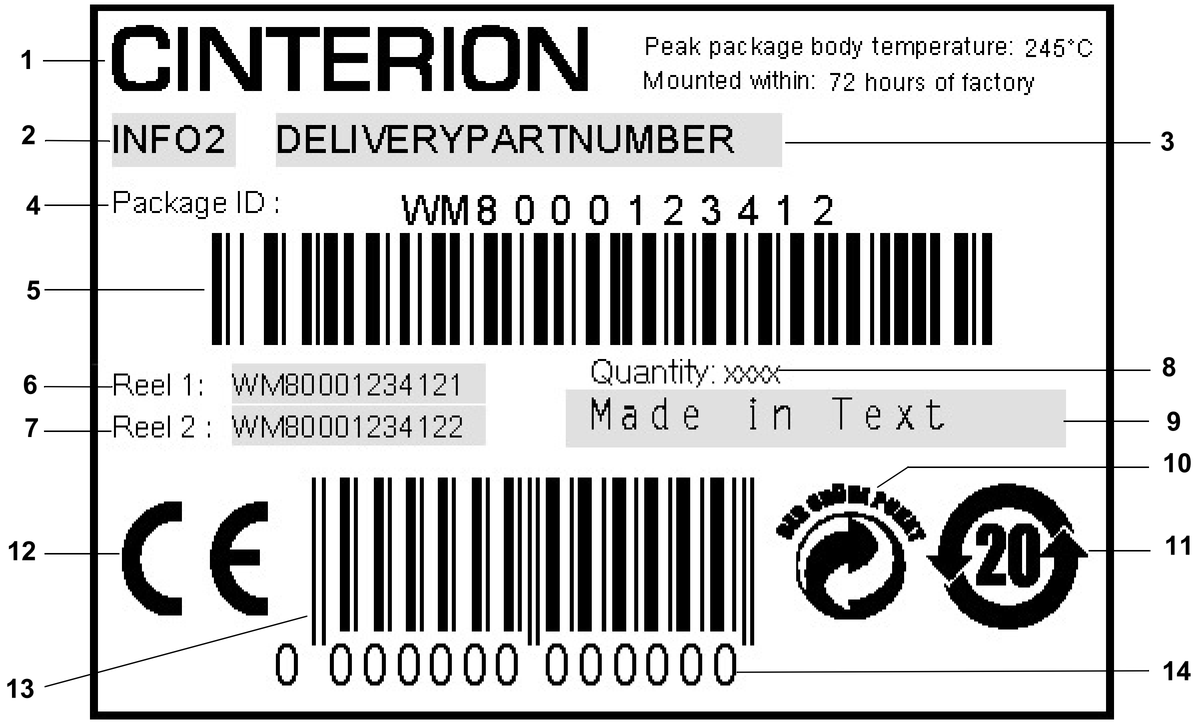


Figure 49: Sample of VP box label

Table 20: 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 modules inside the VP box (max. 1800 pcs)
9	Country of production
10	Der Grüne Punkt (Green Dot) symbol
11	Chinese RoHS symbol
12	CE logo (CE mark on VP box label is present only for modules with CE imprinted on the shielding)
13	European Article Number (EAN-13) barcode
14	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, TN23-W may be distributed in trays (see Figure 50). 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).

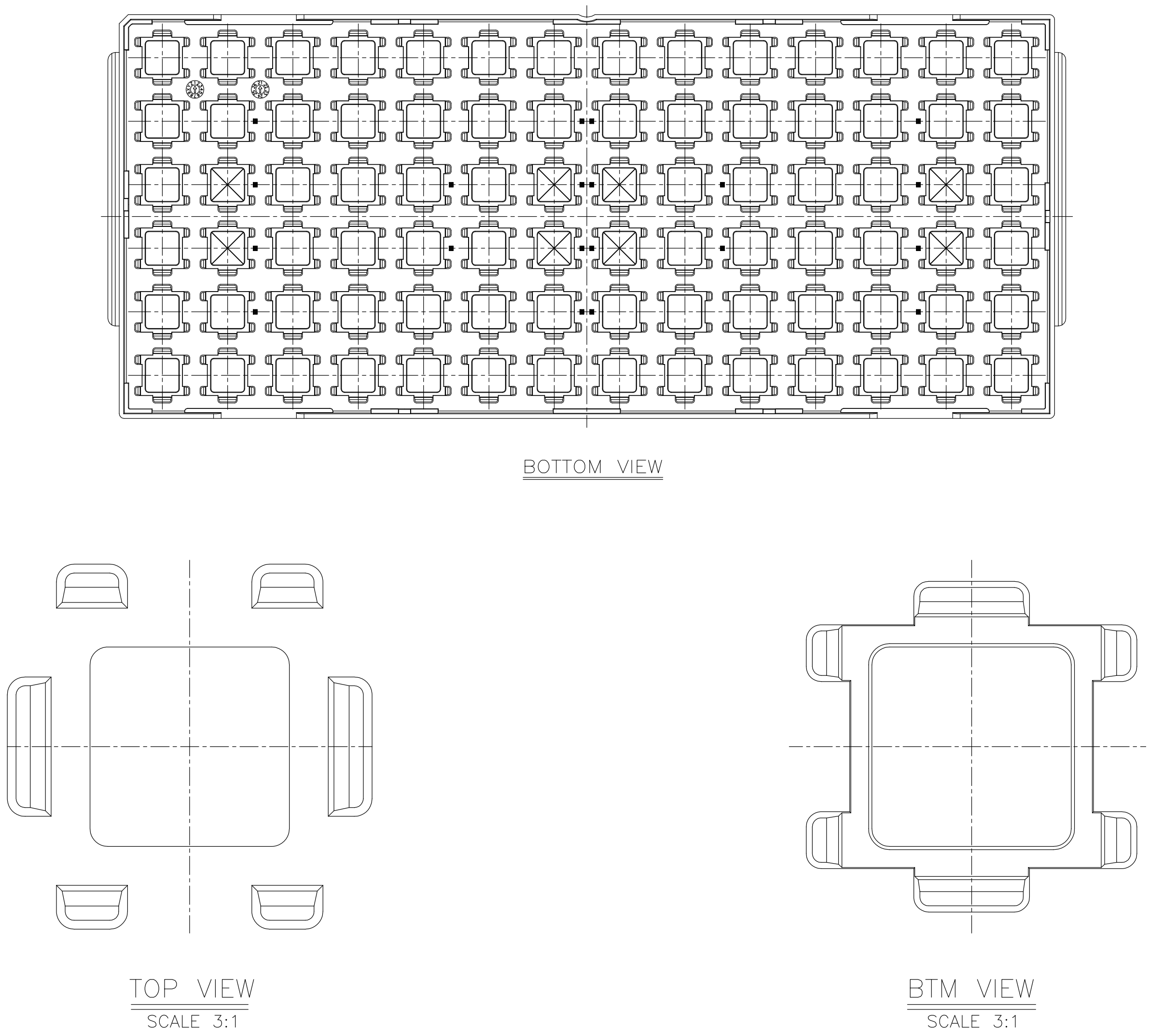


Figure 50: Tray to ship odd module amounts

5 Regulatory and Type Approval Information

5.1 Directives and Standards

TN23-W 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® TN23-W Hardware Interface Description".[1]

Table 21: Directives

2014/53/EU	Directive of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/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 on 4 June 2015) on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)
1907/2006/EC (REACH)	Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC. Cinterion® modules comply with the REACH regulation that specifies a content of less than 0.1% per substance mentioned in the SVHC candidate list (Release 16.06.2014).

Table 22: Standards of North American type approval

CFR Title 47	Code of Federal Regulations, Part 22, Part 24, Part 27, and Part 90; US Equipment Authorization FCC
OET Bulletin 65 (Edition 97-01)	Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields

Table 23: Standards of European type approval

ETSI EN 301 908-1 V13.1.1	IMT cellular networks; Harmonised Standard for access to radio spectrum; Part 1: Introduction and common requirements; 2019-11
ETSI EN 301 908-13 V13.1.1	IMT cellular networks; Harmonised Standard for access to radio spectrum; Part 13: Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE); 2019-11
ETSI EN 301 489-1 V2.2.3	ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements; Harmonised Standard for ElectroMagnetic Compatibility; 2019-11

1. Manufacturers of applications which can be used in the US shall ensure that their applications have a PTCRB approval.

Table 23: Standards of European type approval

ETSI EN 301489-17 V3.2.4	ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 17: Specific conditions for Broadband Data Transmission Systems; Harmonised Standard for ElectroMagnetic Compatibility; 2020-09
EN 62368-1:2014 +A11:2017	Audio/video, information and communication technology equipment - Part 1: Safety requirements

Table 24: Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes
EN IEC 62311:2020	Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)

5.1.1 IEC 62368-1 Classification

With respect to the safety requirements for audio/video, information and communication technology equipment defined by the hazard based product safety standard for ICT and AV equipment - i.e., **IEC-62368-1** (**EN 62368-1**, **UL 62368-1**) - Cinterion® modules are classified as shown below:

Standalone operation of the modules is not possible. Modules will always be incorporated in an external application (Customer Product).

Customer understands and is responsible that the product incorporating the Cinterion® module must be designed to be compliant with IEC-62368-1 (EN 62368-1, UL 62368-1) to ensure protection against hazards and injuries. When operating the Cinterion® module the external application (Customer Product) must provide safeguards not to exceed the power limits given by classification to Power Source Class 1 (15 Watts) under normal operating conditions, abnormal conditions, or in the presence of a single fault. When using a battery power supply the external application must provide safeguards not to exceed the limits defined by PS-1, as well. The external application (Customer Product) must take measures to limit the power, the voltage or the current, respectively, if required, and must provide safeguards to protect ordinary persons against pain or injury caused by the voltage/current.

In case of a usage of the Cinterion® module not in accordance with the specifications or in single fault condition the external application (Customer Product) must be capable to withstand levels according to ES-1 / PS-1 also on all ports that are initially intended for signaling or audio, e.g., USB, RS-232, GPIOs, SPI, earphone and microphone interfaces.

In addition, the external application (Customer Product) must be designed in a way to distribute thermal energy generated by the intended operation of the Cinterion® module. In case of high temperature operation, the external application must provide safeguards to protect ordinary persons against pain or injury caused by the heat.

Table 25: IEC 62368-1 Classification

Source of Energy	Class	Limits
Electrical energy source	ES-1	The Cinterion® modules contain no electrical energy source - especially no battery. The electrical components and circuits have to be externally power supplied: DC either smaller 60 V Or less than 2 mA AC up to 1kHz smaller 30 V-rms or 42.4 V peak AC above 100kHz smaller 70 V rms
Power Source (potential ignition source causing fire)	PS-1	Power source provided by the external application must not exceed 15W, even under worst case and any single fault condition defined by IEC-62368-1: Section 6.2.2.3.
Hazardous Substances, Chemical reaction	--	Under regular conditions, the Cinterion® module does not contain any chemically reactive substances, and no chemical energy source, especially no battery. Module is compliant with RoHS and REACH (see above). In very rare cases however - under abnormal conditions (i.e. wrong supply voltage, burned module) or in the presence of single electrical component faults (i.e. shortcut) - health hazardous substances might be released if the worst comes to the worst.
Kinetic / mechanical energy source	MS-1	The Cinterion® modules have no sharp edges and corners, no moving parts, no loosing, exploding or imploding parts. The mass is well below 1kg.
Thermal energy source	TS-2	Under normal operating conditions, abnormal operating conditions or single fault conditions the temperature does not exceed +100°C on the metal surface (shielding)
Radiated energy source	RS-1	The Cinterion® module does not contain a radiant energy source, any lasers, lamps, LEDs, X-Ray emitting components or acoustic couplers.

5.2 SAR requirements specific to portable mobiles

Mobile phones, PDAs or other portable transmitters and receivers incorporating a module must be in accordance with the guidelines for human exposure to radio frequency energy. This requires the Specific Absorption Rate (SAR) of portable TN23-W based applications to be evaluated and approved for compliance with national and/or international regulations.

Since the SAR value varies significantly with the individual product design manufacturers are advised to submit their product for approval if designed for portable use. For European and US markets the relevant directives are mentioned below. The manufacturer of the end device is in the responsibility to provide clear installation and operating instructions for the user, including the minimum separation distance required to maintain compliance with SAR and/or RF field strength limits, as well as any special usage conditions required to do so, such as a required accessory, the proper orientation of the device, the max antenna gain for detachable antennas, or other relevant criteria. It is the responsibility of the manufacturer of the final product to verify whether or not further standards, recommendations or directives are in force outside these areas.

Products intended for sale on US markets

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

Products intended for sale on European markets

EN 50360	Product standard to demonstrate the compliance of mobile phones with the basic restrictions related to human exposure to electromagnetic fields (300MHz - 3GHz)
EN 62311:2020	Assessment of electronic and electrical equipment related to human expo-sure restrictions for electromagnetic fields (0 Hz - 300 GHz)

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

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

5.3 Reference Equipment for Type Approval

The Thales reference setup submitted to type approve TN23-W (including a special approval adapter for the DSB75) is shown in the following figure:

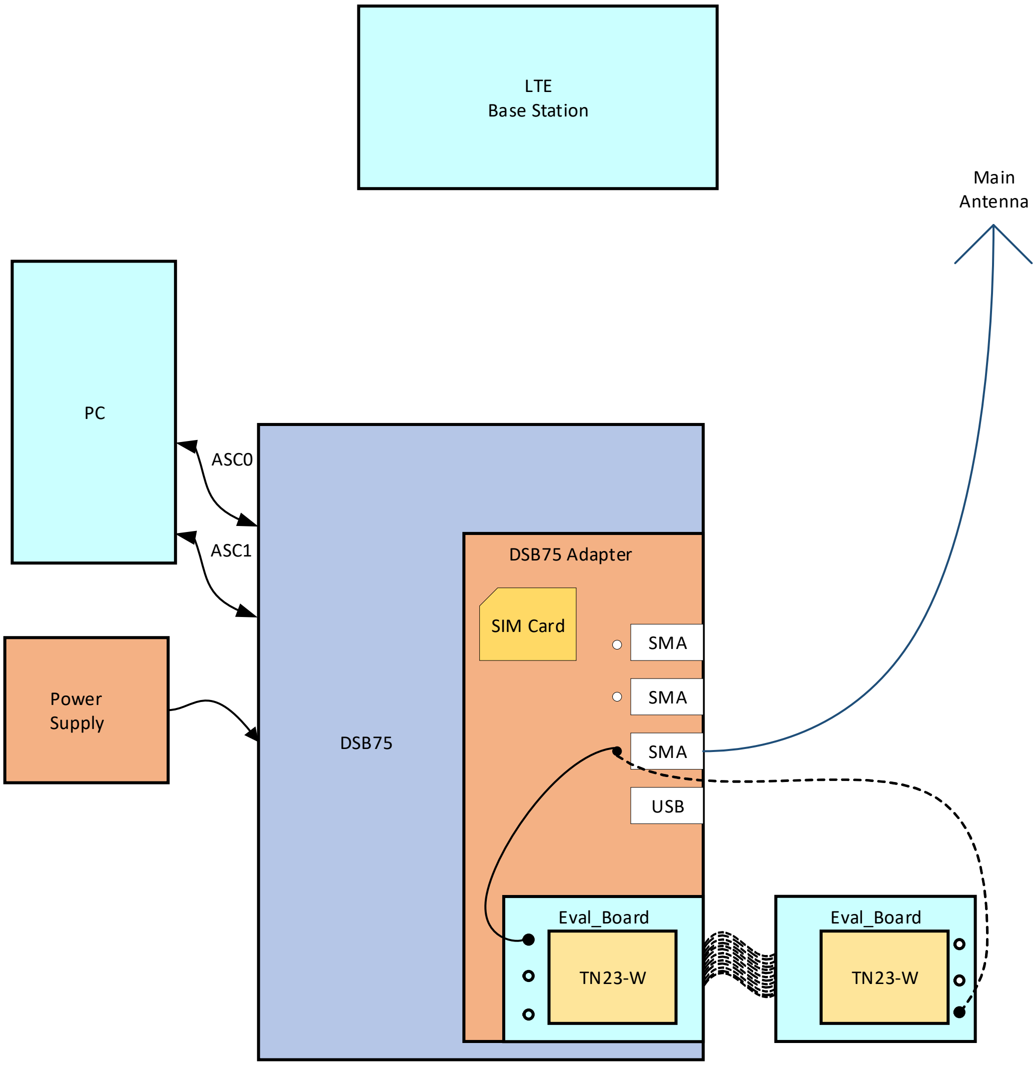


Figure 51: Reference equipment for type approval

5.4 Compliance with FCC Rules and Regulations

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

FCC Identifier: QIPTN23-W
Granted to THALES DIS AIS Deutschland GmbH

Note: Manufacturers of mobile or fixed devices incorporating TN23-W modules are authorized to use the FCC Grant of the TN23-W modules for their own final products according to the conditions referenced in these documents. In this case, an FCC label of the module shall be visible from the outside, or the host device shall bear a second label stating "Contains FCC ID: QIPTN23-W". The integration is limited to fixed or mobile categorized host devices, where a separation distance between the antenna and any person of min. 20cm can be assured during normal operating conditions.

For mobile and fixed operation configurations the antenna gain, including cable loss, must not exceed the limits listed in the following Table 26 for FCC.

Table 26: Antenna gain limits for FCC for TN23-W

Maximum gain in operating band	FCC limit	Unit
LTE Cat NB1/2 Band 2	9.78	dBi
LTE Cat NB1/2 Band 4	6.64	dBi
LTE Cat NB1/2 Band 5	10.94	dBi
LTE Cat NB1/2 Band 12	10.19	dBi
LTE Cat NB1/2 Band 13	10.87	dBi
LTE Cat NB1/2 Band 17	9.78	dBi
LTE Cat NB1/2 Band 18	10.30	dBi
LTE Cat NB1/2 Band 19	10.42	dBi
LTE Cat NB1/2 Band 25	9.78	dBi
LTE Cat NB1/2 Band 26	10.80	dBi
LTE Cat NB1/2 Band 66	6.55	dBi
LTE Cat NB1/2 Band 71	10.26	dBi

IMPORTANT:
Manufacturers of portable applications incorporating TN23-W modules are required to have their final product certified and apply for their own FCC Grant related to the specific portable mobile. This is mandatory to meet the SAR requirements for portable mobiles (see Section 5.2 for detail).

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

Manufactures/OEM integrators must ensure that the final user documentation does not contain any information on how to install or remove the module from final product. The manufactures/ OEM user manual shall include all required regulatory information/warnings as shown in this manual.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. The final product (i.e., host/module combination) may also need to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Part 15.19 Warning Statement
THIS DEVICE COMPLIES WITH PART 15 OF THE FCC RULES. OPERATION IS SUBJECT TO THE FOLLOWING TWO CONDITIONS: (1) THIS DEVICE MAY NOT CAUSE HARMFUL INTERFERENCE, AND (2) THIS DEVICE MUST ACCEPT ANY INTERFERENCE RECEIVED, INCLUDING INTERFERENCE THAT MAY CAUSE UNDESIRED OPERATION.

6 Document Information

6.1 Revision History

Preceding document: "Cinterion® TN23-W Hardware Interface Description" v00.003
New document: "Cinterion® TN23-W Hardware Interface Description" v**00.028**

Chapter	What is new
Throughout document	Removed support for PSM Indicator/SUSPEND_MON signal.
1.2	Added note regarding channel support for LTE Cat NB1/2 bands.
3.2.4.1	Added Figure 32 showing switch off timing behavior.
3.4.1	Revised PSM current consumption rating in Table 12.
3.8	Updated Table 17 listing reliability characteristics.
4.2.3.1	Revised reflow profile.
4.3.1.1	Revised section on tape&reel orientation.
4.3.3	Revised section on trays.
5.1	Added directives and standards TN23-W complies with.
5.3	Added Figure 51 showing reference equipment for TN23-W
5.4	Updated section describing compliance with FCC rules and regulations.

Preceding document: "Cinterion® TN23-W Hardware Interface Description" v00.002
New document: "Cinterion® TN23-W Hardware Interface Description" v00.003

Chapter	What is new
1.2	Revised module weight. Updated operating temperature range. Added remark regarding discharging of $BATT+_{BB}$.
1.4	Revised Figure 2 (block diagram).
2.1.8	Revised Figure 13 (I^2C interface).
3.2.1	Revised ON timings shown in Figure 29 and Figure 30.
3.2.2.2	Revised Figure 31 (emergency restart timing).
3.4.1	Added power supply ratings.
3.5	Updated operating temperature range.
3.6	Updated Table 15 (ESD values).
3.6.1	Completed Figure 34 (ESD protection for RF interface).
7.1	Updated ordering information.

Preceding document: "Cinterion® TN23-W Hardware Interface Description" v00.001
New document: "Cinterion® TN23-W Hardware Interface Description" v00.002

Chapter	What is new
4.2	Added note regarding placement of external components.

New document: "Cinterion® TN23-W Hardware Interface Description" v00.001

Chapter	What is new
--	Initial document setup.

6.2 Related Documents

[1] TN23-W AT Command Set
[2] TN23-W Release Note
[3] Application Note 40: Thermal Solutions - TBD.
[4] Application Note 48: SMT Module Integration - TBD.
[5] Differences between Selected Cinterion® Modules, Hardware Migration Guide - TBD.
[6] Cinterion® IoT Module Services User Guide - TBD.
[7] Cinterion® IoT SDK User Guide - TBD.

6.3 Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-digital converter
AGC	Automatic Gain Control
ANSI	American National Standards Institute
ARFCN	Absolute Radio Frequency Channel Number
ARP	Antenna Reference Point
ASC0/ASC1	Asynchronous Controller. Abbreviations used for first and second serial interface of TN23-W
B	Thermistor Constant
BER	Bit Error Rate
BTS	Base Transceiver Station
CB or CBM	Cell Broadcast Message
CE	Conformité Europééne (European Conformity)
CHAP	Challenge Handshake Authentication Protocol
CPU	Central Processing Unit
CS	Coding Scheme

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

Abbreviation	Description
Li-Ion/Li+	Lithium-Ion
Li battery	Rechargeable Lithium Ion or Lithium Polymer battery
LPM	Link Power Management
Mbps	Mbits per second
MMI	Man Machine Interface
MO	Mobile Originated
MS	Mobile Station (GSM module), also referred to as TE
MSISDN	Mobile Station International ISDN number
MT	Mobile Terminated
NTC	Negative Temperature Coefficient
OEM	Original Equipment Manufacturer
PA	Power Amplifier
PAP	Password Authentication Protocol
PBCCH	Packet Switched Broadcast Control Channel
PCB	Printed Circuit Board
PCL	Power Control Level
PCM	Pulse Code Modulation
PCN	Personal Communications Network, also referred to as DCS 1800
PDU	Protocol Data Unit
PLL	Phase Locked Loop
PPP	Point-to-point protocol
PSK	Phase Shift Keying
PSU	Power Supply Unit
R&TTE	Radio and Telecommunication Terminal Equipment
RAM	Random Access Memory
RF	Radio Frequency
RLS	Radio Link Stability
RMS	Root Mean Square (value)
RoHS	Restriction of the use of certain hazardous substances in electrical and electronic equipment.
ROM	Read-only Memory
RTC	Real Time Clock
RTS	Request to Send
Rx	Receive Direction
SAR	Specific Absorption Rate
SELV	Safety Extra Low Voltage
SIM	Subscriber Identification Module
SMD	Surface Mount Device

Abbreviation	Description
SMS	Short Message Service
SMT	Surface Mount Technology
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
TA	Terminal adapter (e.g. GSM module)
TE	Terminal Equipment, also referred to as DTE
TLS	Transport Layer Security
Tx	Transmit Direction
UART	Universal asynchronous receiver-transmitter
URC	Unsolicited Result Code

6.4 Safety Precaution Notes

The following safety precautions must be observed during all phases of the operation, usage, service or repair of any cellular terminal or mobile incorporating TN23-W. Manufacturers of the cellular terminal are advised to convey the following safety information to users and operating personnel and to incorporate these guidelines into all manuals supplied with the product. Failure to comply with these precautions violates safety standards of design, manufacture and intended use of the product. Thales assumes no liability for customer’s failure to comply with these precautions.

	When in a hospital or other health care facility, observe the restrictions on the use of mobiles. Switch the cellular terminal or mobile off, if instructed to do so by the guidelines posted in sensitive areas. Medical equipment may be sensitive to RF energy. The operation of cardiac pacemakers, other implanted medical equipment and hearing aids can be affected by interference from cellular terminals or mobiles placed close to the device. If in doubt about potential danger, contact the physician or the manufacturer of the device to verify that the equipment is properly shielded. Pacemaker patients are advised to keep their hand-held mobile away from the pacemaker, while it is on.
	Switch off the cellular terminal or mobile before boarding an aircraft. Make sure it cannot be switched on inadvertently. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communications systems. Failure to observe these instructions may lead to the suspension or denial of cellular services to the offender, legal action, or both.
	Do not operate the cellular terminal or mobile in the presence of flammable gases or fumes. Switch off the cellular terminal when you are near petrol stations, fuel depots, chemical plants or where blasting operations are in progress. Operation of any electrical equipment in potentially explosive atmospheres can constitute a safety hazard.
	Your cellular terminal or mobile receives and transmits radio frequency energy while switched on. Remember that interference can occur if it is used close to TV sets, radios, computers or inadequately shielded equipment. Follow any special regulations and always switch off the cellular terminal or mobile wherever forbidden, or when you suspect that it may cause interference or danger.
	Road safety comes first! Do not use a hand-held cellular terminal or mobile when driving a vehicle, unless it is securely mounted in a holder for speakerphone operation. Before making a call with a hand-held terminal or mobile, park the vehicle. Speakerphones must be installed by qualified personnel. Faulty installation or operation can constitute a safety hazard.
	IMPORTANT! Cellular terminals or mobiles operate using radio signals and cellular networks. Because of this, connection cannot be guaranteed at all times under all conditions. Therefore, you should never rely solely upon any wireless device for essential communications, for example emergency calls. Remember, in order to make or receive calls, the cellular terminal or mobile must be switched on and in a service area with adequate cellular signal strength. Some networks do not allow for emergency calls if certain network services or phone features are in use (e.g. lock functions, fixed dialing etc.). You may need to deactivate those features before you can make an emergency call. Some networks require that a valid SIM card be properly inserted in the cellular terminal or mobile.

7 Appendix

7.1 List of Parts and Accessories

Table 27: List of parts and accessories

Description	Supplier	Ordering information
TN23-W	Thales	Standard module Thales IMEI: Packaging unit (ordering) number: L30960-N7200-A100. Module label number[1]: S30960-S7200-A100 Customer IMEI mode: Packaging unit (ordering) number: L30960-N7200-A100. Module label number[1]: S30960-S7200-A100
DSB75 Evaluation Kit	Thales	Ordering number: L36880-N8811-A100
DSB Mini Compact Evaluation Board	Thales	Ordering number: L30960-N0030-A100
LGA DevKit	Thales	LGA DevKit consists of Cinterion® LGA DevKit T Base PCB: Ordering number: L30960-N0113-A100 Cinterion® LGA DevKit Socket T: Ordering number: L30960-N0114-A100
EVAL DSB Adapter for mounting TN23-W evaluation modules onto DSB75	Thales	TBD.
SIM card holder incl. push button ejector and slide-in tray	Molex	Ordering numbers: 91228 91236 Sales contacts are listed in Table 28.

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

Table 28: Molex sales contacts (subject to change)

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

7.2 Module Label Information

The label engraved on the top of TN23-W comprises the following information[1].

Figure 52: TN23-W label

Table 29: TN23-W label information

No.	
1	Cinterion logo
2	Manufacturing country (e.g., “Made in China”)
3	Factory code
4	Product name/variant (e.g., “TN23-W”)
5	Product order code
6	Manufacturer 2D barcode
7	Product IMEI
8	2-digit date code of product production (for decoding see Table 30 below)

Table 30: 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.

1. To be continued - Revised full label information will be available with a next document version.

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