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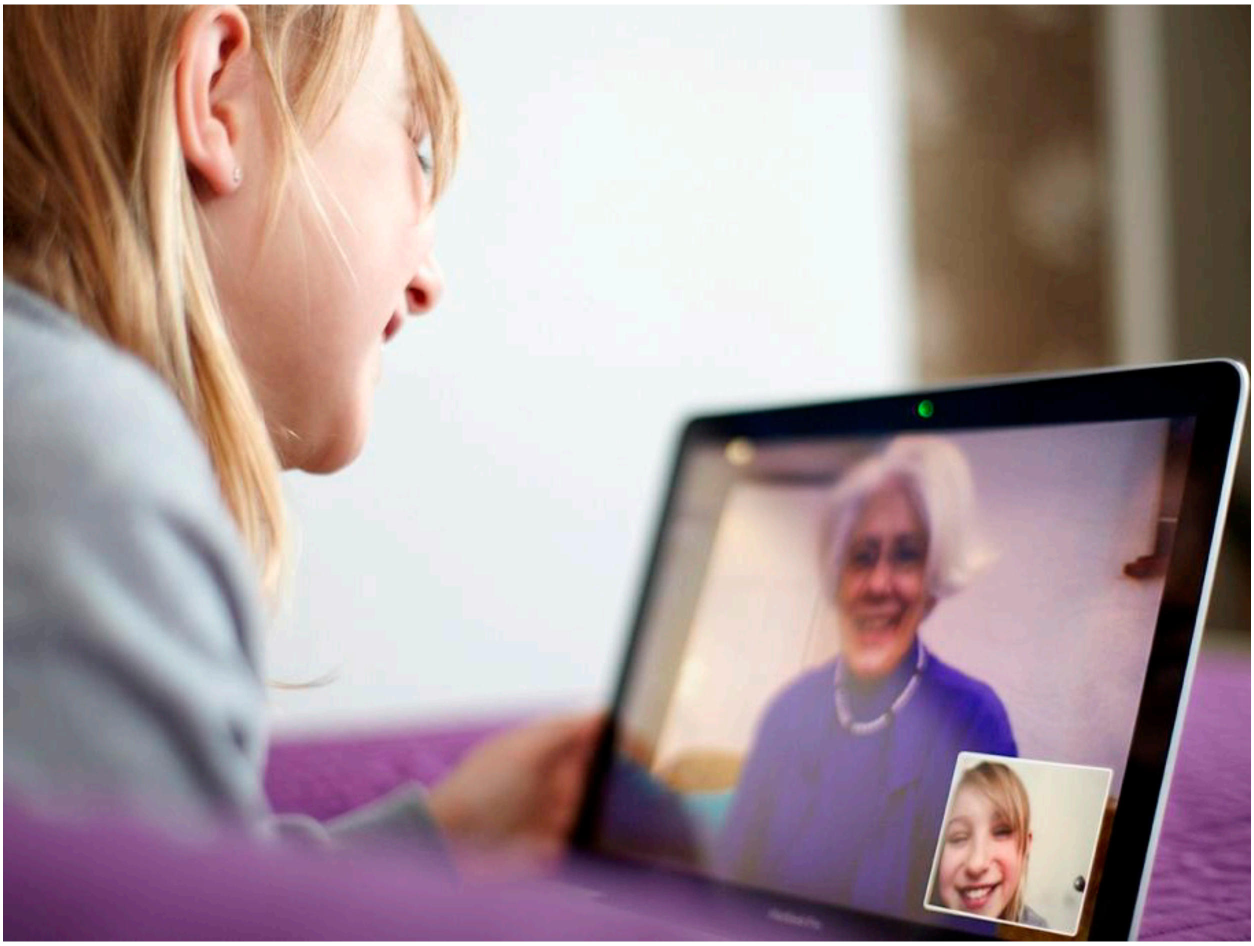
Integrator's Guide - C5621 / C33

OPERATING MANUAL



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Abstract

This document describes the Ericsson Mobile Broadband Module and is intended to support developers when integrating the product into host devices.

Purpose

The Integrator’s Guide is designed to give the reader a deeper technical understanding of the Ericsson Mobile Broadband Modules and information needed for integrating the product into host devices. It also describes the PC software for the Mobile Broadband Modules that has been developed by Ericsson.

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Contents

1 Introduction

Ericsson's C5621/C33 Mobile Broadband Module is a 277 pin LGA subassembly, which enables end users to have mobile access to the internet or corporate network with flexibility and high speed, including 'always online' capability. It supports data services HSPA Evolution, HSPA, UMTS, EDGE, GPRS, and SMS. The C5621 module also has an integrated GPS receiver, which can be used by positioning applications.

The Ericsson Mobile Broadband Module is a solution designed as an add-in option for various host devices such as netbooks, tablets, Personal Navigation Devices (PND), e-Readers, handheld gaming devices, cameras and other consumer devices.

The integration of HSI and SPI are not covered in this document. However, they will be covered in future revisions.

Product introduction and general information can be found in the Technical Description and User Guide for the mobile broadband module, see [1].

1.1 Target Users

The Ericsson Mobile Broadband Modules are designed for the embedded community for integration into any host device. Target focus is mainstream PC-OEM businesses making slim tablet devices, Personal Navigation Devices (PND), e-Readers and other consumer devices.

1.2 Prerequisites

Integration of the Ericsson Mobile Broadband Module should be performed at facilities under host device management. The necessary integration instruction, driver software and user documentation will be provided. No special prerequisite knowledge is necessary. In general, it is recommended to follow the guidelines presented by GSMA for the integration of 3G WWAN modules into notebook computers, see 3G in Notebooks Guidelines [2].

2 Product Details and Key Features

This section explains the key features of the C5621/C33 Mobile Broadband modules.

2.1 USB Quick Enumeration

The USB start-up time is defined as the time from the module power-up to USB enumeration (USB_D+ signal high), and is, normally, less than 3 s. To further shorten the USB start-up time, quick enumeration can be used as described below.

The Mobile Broadband Module supports USB quick enumeration to minimize the time it takes until the USB_D+ signal becomes high. The feature can be used to improve performance if the host BIOS includes a lock mechanism which restricts the Mobile Broadband Modules that can be used with the host.

The quick-enumeration process is described below and is depicted in Figure 1.

1. When the module is powered, it will quickly bring up USB functionality to set the USB_D+ signal high.

2. When the host device detects the module and asks for descriptors, the module will reply with a descriptor giving VID and PID (PID will not be the same as in the full enumeration that follows), model name and vendor name.

3. When the descriptor has been received, the host will send a Set Configuration command.

4. When the module has replied its descriptor and received the set configuration command, it will make a soft detach from the USB. If the host does not ask for the descriptor within a certain time limit, the module will make a soft detach anyway to continue the module start-up sequence.

5. After the module has made the soft detach, it will make a full enumeration. The descriptor for the full enumeration will include configuration and interface descriptors.

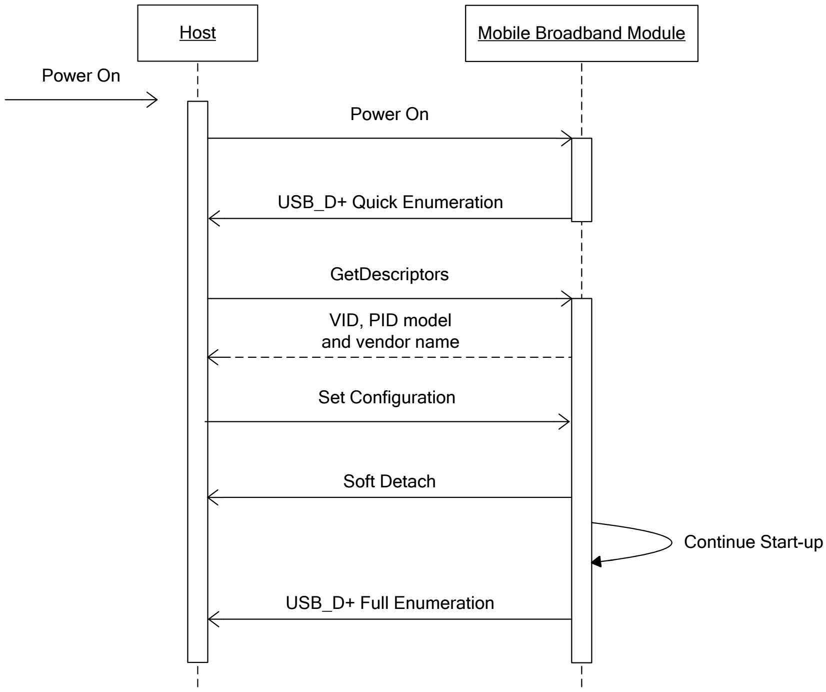


Figure 1, USB quick-enumeration process

2.2 Always On

The Mobile Broadband Module behavior when the host enters Sleep (ACPI S3) or Hibernate (ACPI S4) is configurable by registry key settings. The WMCore service can command the module to either shut down or stay registered to the network - “Always On”. When the Always On setting is enabled, the module shall be kept powered-on while the host device goes into sleep/hibernate. When the Always On setting is disabled, the module power supply shall be turned off when host device enters Sleep.

If “Always On” is enabled, the WWAN LED and WWAN disable functionality shall also be supported by the host device when in S3. This requirement is to ensure that the WWAN LED indication is available even if the host device is in Sleep state.

For implementations that do not use the WMCore service, such as Linux or 3rd party connection managers, the host device software is required to handle the Always On functionality if implemented.

It is also possible to configure the Mobile Broadband Module to automatically enable the radio and register to the network without interaction with the host device software. The module checks this configuration at each start-up and changes the radio state accordingly. Please refer to ME Radio Policy in the AT command manual [4].

Note: In Windows 8, there is no background service (WMCore) available to handle OS power events for ACPI states S3 and S4. If radio management (that differs from Windows 8 native handling) during S3 is needed, additional host device software is required. For more information regarding radio management handing and interface, see [18].

For implementations that do not use the WMCore service, such as Linux or 3rd party connection managers, the host device software is required to handle the Always On functionality if implemented.

It is also possible to configure the Mobile Broadband Module to automatically enable the radio and register to the network without interaction with software located on the host device. The module checks this configuration at each start-up and changes the radio state accordingly. Please refer to ME Radio Policy in the AT command manual [4].

2.3 Wake on Wireless

The module supports Wake on Wireless (WoW) functionality, i.e. wake the host from sleep states. The WoW feature requires the host device to have the Always On feature enabled. The WoW trigger-rules can be set by AT commands. The WoW functionality can be configured to use the USB interface or WAKE signal to trigger a wake-up signal in order to wake up the host.

Table 1 WoW support

Model	Interface	Host State (ACPI)
C5621 / C33	USB, WAKE signal	Sleep (S3), Hibernate (S4) and Off (S5).

Note: In Windows 8, we will not have support for Wake on Wireless.

The module can be configured to wake the host when an SMS, starting with a predefined text string (payload) and/or with a predefined originating address, is received by the module. When an SMS, which corresponds to the above criteria, is received an unsolicited AT response is generated. The wake event is signaled using the USB and the normal USB wakeup procedure is triggered. Additionally it is possible to configure out of band wakeup signaling using the WAKE signal.

In addition to wakeup triggered by SMS, the module can be configured to wake the host when other predefined events occur, which generate unsolicited AT responses. Examples are changes in network status, reception of any SMS and SMS memory full.

If the wake up was triggered by an SMS, the payload can be fetched using the SDK or AT commands [4] when the host has resumed from its sleep state.

For further details see [15].

2.4 Idle Mode Power Management

The Mobile Broadband Module supports features to minimize power consumption when in idle mode. Based on the ongoing activities in the module, the module is able to remove or decrease power in various parts of the platform.

2.4.1 USB Selective Suspend

The Mobile Broadband Module and the drivers support USB selective suspend. The USB selective suspend functionality is available for both Windows and Linux (autosuspend). When there is no communication over the module's USB interface, the interface will automatically be suspended independently of other devices connected to the host device. When the selective suspend mode is reached the power consumption in the module decreases significantly, and it also allows the host platform to enter lower power modes.

To optimize the time the module spends in USB selective suspend, it is important that software applications on the host device subscribes to events from the WMCore service or utilize unsolicited AT commands instead of periodically polling for information. Please see note in chapter 4.3.4.1 for host design recommendations.

Note: In Windows 8, WMCore service will not be available.

2.4.2 Continuous Packet Connectivity

The C5621 module has support for the CPC feature available in 3GPP release 7. CPC is a set of features to save battery power. The most important features are DRX and DTX.

DRX (Discontinuous Reception): When module is in HSPA mode it has to monitor a certain signaling channel from the base station to see if data packets will be delivered to it in coming time slots. If the data traffic is bursty, the base station can instruct the module to listen to the signaling channel less frequently than normal. In this way the module's receiver can be switched off and save power.

DTX (Discontinuous Transmission): When module is in HSPA mode it has to stay synchronized to the base station. The module does this by sending control information on a dedicated signaling channel to the base station. This is done continuously. If data traffic is bursty, the base station can let the module send information in bursts rather than continuously. In this way the module's transmitter can be switched off and save power.

The CPC feature also helps to improve the initial data latency which occurs while moving from the idle channels to high speed data channels. The CPC feature needs to be supported in the radio network to be effective.

2.4.3 Fast Dormancy

The C5621 module has support for the Fast Dormancy feature. It is a feature for saving battery life. This functionality enables a way around the network timers for downgrading from Cell_DCH/Cell_FACH to the least power state in a faster manner.

The module sends a 'Signalling Connection Release Indication' Cause to the network. The UTRAN (network) upon reception of this IE may decide to trigger an RRC State transition to a more battery efficient state, ultimately IDLE.

Fast Dormancy is triggered and is steered from the host and it's a feature available in 3GPP release 8.

Note: The fast dormancy support in C5621 has one of the timers (T323) set to a default value of 60 seconds.

2.5 Over-temperature protection

To protect the Mobile Broadband Module hardware from over-heating, and to ensure radio performance and component life length, the module supports over-temperature protection.

The over-temperature protection function consists of three parts:

- Over-temperature signaling
- GPS thermal throttling
- PA thermal throttling

2.5.1 Over-temperature signaling

This function reports to the host SW, e.g. connection manager software, when the temperature passes through some configurable temperature threshold; refer to the SDK [5] and the AT Command Manual [4] for details.

2.5.2 GPS Thermal Throttling

The GPS Thermal Throttling function limits the GPS functionality according to module temperature. This is done to prioritize module functionality in higher temperatures.

GPS will automatically turn off when temperature exceeds Threshold A, see Figure 2. Any changes in the GPS status depending on this function is reported, unsolicited, to the host software; see the SDK [5] and the AT Command Manual [4] for details.

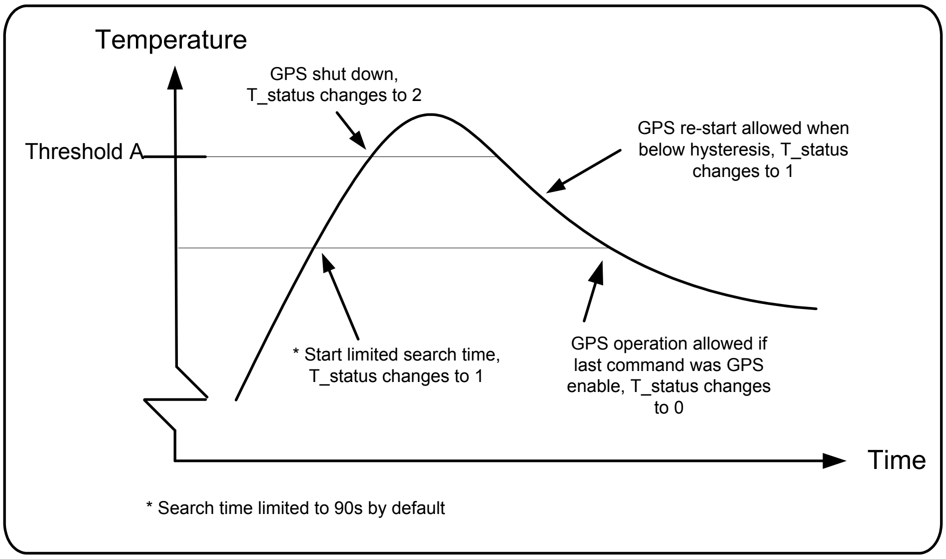


Figure 2, GPS Thermal Throttling

2.5.3 PA Thermal Throttling

The PA Thermal Throttling function limits the output power according to module temperature. The temperature thresholds and back-off values are set in module firmware see Figure 3. The decreased maximal output power will cause the mobile network to take action, for instance limit uplink throughput or handover to 2G.

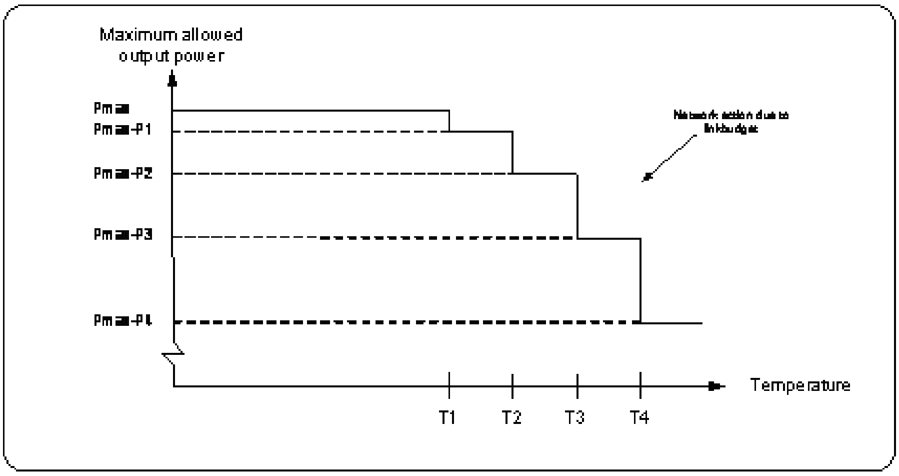


Figure 3, Maximal output power reduction due to PA throttling

3 System Integration Overview

C5621/ C33 Mobile Broadband Module is a 277 pin LGA SIP module. Interfaces and functionality needed on the host device side are shown in Figure 4.

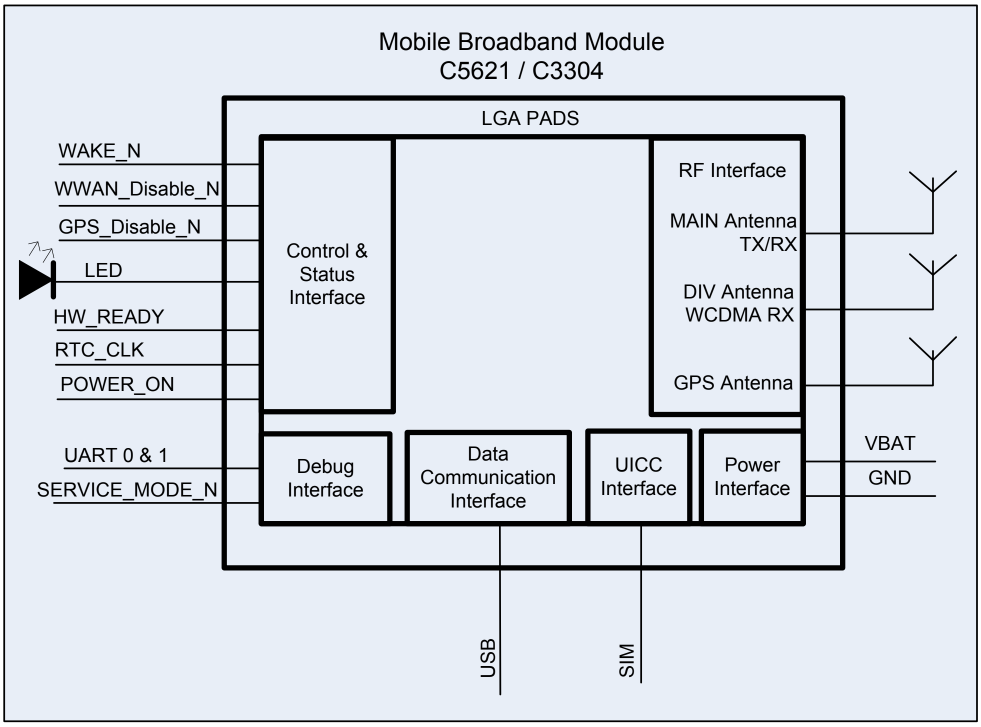


Figure 4, Mobile Broadband module interface overview.

3.1 Power On

The module start-up is controlled the POWER_ON signal. Once VBAT and RTC_CLK signals are fed to the module, the host device has to drive POWER_ON signal high for starting the module. The module asserts HW_READY signal high. Though HW_READY is not an mandatory signal to setup the interface towards the module, the host system can utilize this signal to avoid back feeding. Refer to chapter 0 for the signal description. The power on sequence is explained in Figure 5.

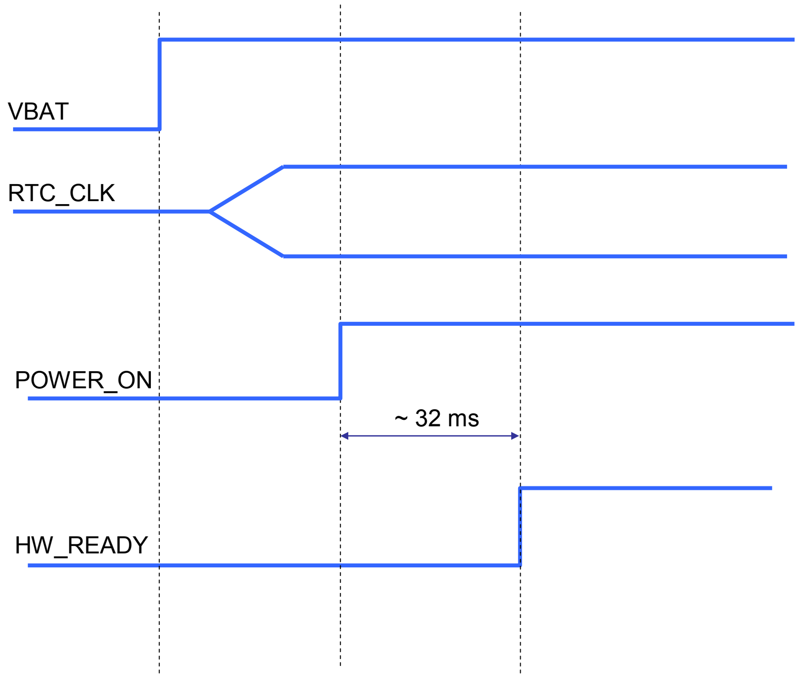


Figure 5, Example of Module Power on Sequence

3.2 Power off

The module can be powered off by pulling down the POWER_ON signal low. The power down sequence is explained in Figure 6.

Though a hardware interface is available for the module shutdown, one shall use it along with the software method to shutdown the module safely. The software solution is realized by using a background service (WMCore) in Windows, which subscribes to Windows OS power events. When the host switches state into hibernate (ACPI S4) or power off (ACPI S5), a shut down command is sent to the module. The module will autonomously de-register from the radio network, save the mobile network list, turn off the radio and shut down the SIM. Finally the module itself is turned off, including the USB interface.

Note: We recommend that the host device designer ensures that the module is kept ON for atleast 2 seconds after the AT command ((AT+CFUN=0) is issued, to ensure that there is time for the module to shut down properly. The shut down behavior towards the SIM and network has to comply with 3GPP requirements, please refer to 3GPP TS 24.008 chapter 4.3.4.

Note: In Windows 8 there is no background service (WMCore) available to handle OS power events for ACPI states S3. If module power is not kept during these states, shutdown behavior needs to be handled by the host device designer to comply with 3GPP requirements. Host device designer should disable the radio using W_Disable (active low) or a CID (MBIM_CID_MBM_SIM_DEINITIALIZE, see ref[19]) via MB API extensions and then wait for at least 2 seconds (preferable 5 seconds) before module power is removed.

Note: In Windows 8, the OS handles signaling ACPI S4 & S5 transition signaling natively. An event that will trigger the same behavior as when CID: **MBIM_CID_MBM_SIM_DEINITIALIZE** is sent. To ensure complete graceful shutdown of the module and network deregistration in S4 & S5, host device designer needs to keep the module powered between 2 to 5 seconds after a transition to S4 & S5.

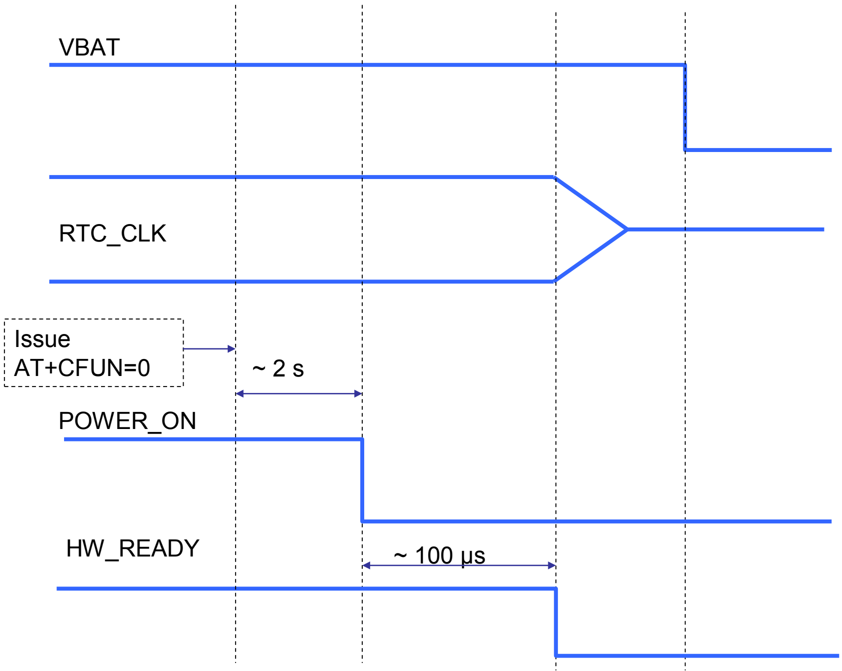


Figure 6, Example of Module Power down Sequence

Implementations that do not use the background service, such as Linux or 3rd party connection managers, needs to issue the shutdown command to the module and wait until the module disables its USB interface before turning off the power supply to the module. This procedure is recommended to ensure that the module properly de-registers from the radio network and saves the current network list. The procedure guarantees quick registration on previous available radio network during the next power-on cycle.

Please refer to chapter 4.3.3.1 for more information about module electrical requirements.

3.2.1 Module Restart/Reset

POWER_ON signal can be utilized to reset/restart the C5621/C33 module. This can be done by driving this signal low for minimum 200 µs before driving it high again. This will eventually power cycle the module. It is recommended that this method of module reset shall be utilized only under irrecoverable error conditions. For other conditions, it is always recommended to do a soft reset using AT-Command.

3.2.2 Module Shutdown on host crash

The POWER_ON signal is clocked by an internal RTC_CLK and not the external one. This means that if POWER_ON signal go low when the host crashes, the module will power off irrespective of the external RTC_CLK status.

Note: We recommend the host designer to make sure that POWER_ON signal goes low if the host crashes.

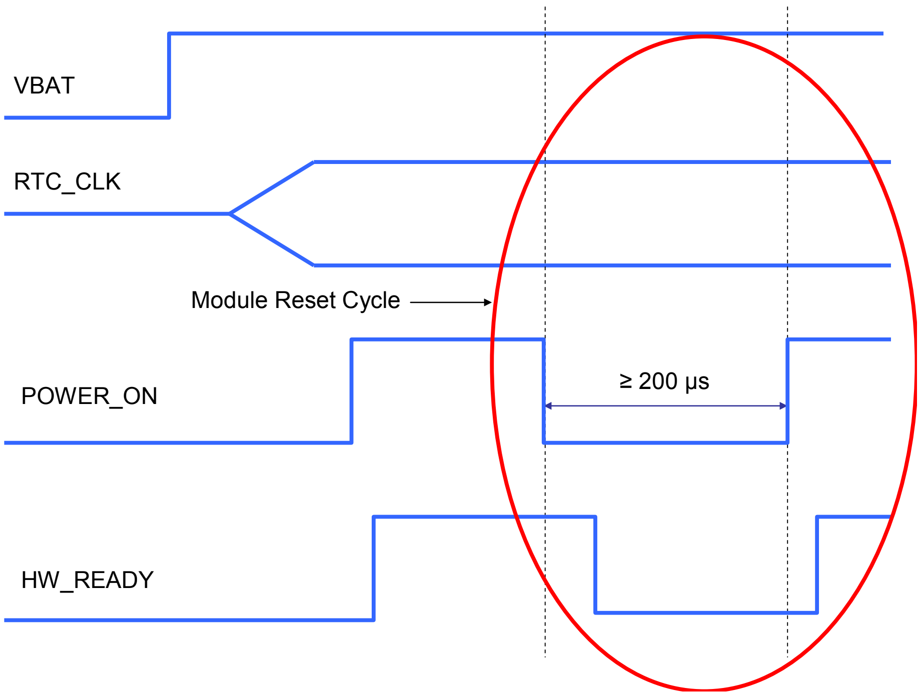


Figure 7, Example of Module Reset Sequence

3.3 GPS Interface

The Mobile Broadband Module supports different kinds of assisted GPS features, which put requirements on SW to be installed on the host side and in some use cases also agreements to be signed by the integrator.

3.3.1 Antenna Recommendations

The GPS performance when integrated in a host device is dependent on antenna efficiency (including cable loss), antenna pattern/polarization and host-generated noise. The internal noise can be generated from DC/DC converter, LCD, CPU, hard drives etc and other co-existing radio transceivers (e.g. WLAN and Bluetooth). To achieve good performance the host-generated noise level should be less than -116.5 dBm/MHz in 1575.42 $\pm$ 1 MHz band.

The noise level is not possible to measure with conventional instruments. However, there is a way to estimate the noise added by the host platform using an Over-The-Air (OTA) measurement setup. The test setup is described in chapter 13.1.

General recommendation for designing 3G, 2G and GPS antenna is stated in the ‘Antenna Performance Guideline’ document [10].

3.3.2 External antenna amplifier

If an external antenna amplifier is to be used, the gain of the amplifier coupled with front end losses in cables and other components must be considered. If strong jammers are picked up by the antenna and after that amplified by the antenna amplifier there is a risk that the LNA in the C5621 module will work in the nonlinear area and thereby degrading performance of the GPS.

Therefore, if an antenna amplifier is to be used, try to avoid placing transmitting antennas close to the GPS antenna and do not use a more powerful antenna amplifier than necessary. I.e. the amplifier does not add any performance improvement by amplifying the signals more than losses in cables and passives before entering the LNA in the C5621 module.

3.3.3 Assisted GPS Features

Assisted GPS can be divided into Internet-assisted and network-assisted GPS. There exist multiple variants of both Internet- and network-assisted GPS.

Table 2 Assisted GPS features in Mobile Broadband Modules

Model	A-GPS Technologies	Internet Assisted Variant	Network Assisted Variant
C5621	Extended Ephemeris, SUPL	PGPS (RX Networks)	OMA SUPL 1.0

Internet-assisted GPS is based on the ephemeris data that is downloaded over Internet and transferred to the module. To collect the ephemeris data, proprietary code of the provider of the Internet-assisted service (stated in Table 2) need to be run. The proprietary code is included in Ericsson's PC software for Windows.

3.3.4 2-antenna version

In the case that 2 antennas are preferred and main and diversity functionality, as well as GPS functionality is required, a split of antenna signals is needed outside the C5621 module.

An example of how this can be achieved is illustrated in Figure 8 below.

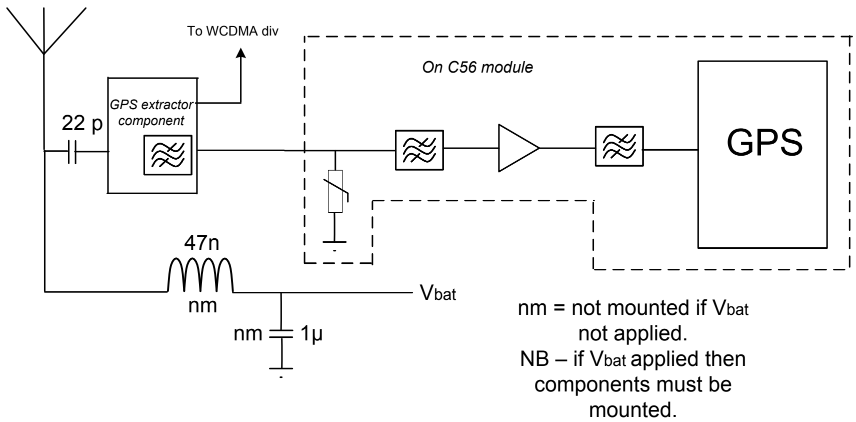


Figure 8 Example of antenna signal split for 2 antenna version

The "*GPS extractor component*" in Figure 8 can be chosen as follows:

TDK-EPC: B39162B7742E310

Taiyo Yuden: G6KU1G575L4WF

Be careful to read the application note of the chosen "*GPS extractor component*" in order to include matching components or other external components in the design.

Also included in the illustration in Figure 8 is an example of how an antenna amplifier can be power fed. Be aware that capacitors and inductors must not be omitted. This is in order not to risk damaging components or degrade performance of the system.

The signal trace from the antenna to the C5621 module is carrying RF signals. Thus, the trace must refer to a ground plane and the trace width must be calculated by considering the distance to the ground plane and the dielectric constant of the circuit board used. For all RF signals it is really important not to place them close to any source of distortion such as digital signals, clock signals, power signals or any other signal with sharp transients or high power.

Preferably the antenna should be placed as close as possible to the module to minimize signal losses and risks for distortions being picked up.

3.4 UICC (USIM Card)

An external SIM card with 3 V or 1.8 V technology must be connected to the Mobile Broad Band Module via the UIM interface pins. It is recommended that the host device design minimizes the connection length between the Ericsson Mobile Broadband Module and the UICC reader. It is also recommended to minimize the potential for coupling of interfering signals to the UICC interface.

Note: The UICC design (UICC reader, signal strength and integrity), is part of the 3GPP testing on system level.

Note: UICC electrical requirements are not guaranteed by the module in the event of UICC Hot swap. Host device design is required to choose a UICC socket which offers such protection.

Note: This is a software-based solution. The SIMOFF_N signal is not used.

3.4.1 UICC Hot Swap

The Mobile Broadband module will autonomously detect and reset its internal logic to handle a UICC hot swap. The module can be configured to send an unsolicited AT response when a UICC removal event is registered. When a UICC detection event is registered, the host will be alerted by an unsolicited response before the module is automatically restarted. The WMCore service handles this logic and will issue UICC event notifications on the C++ API [5]. The host must be prepared for an automatic module restart when a UICC detection event is registered. For implementations that do not use the WMCore service, such as Linux or 3rd party connection managers, the host device software is required to handle the UICC hot swap functionality, if implemented.

3.5 Electrostatic Discharge (ESD) Precautions

The Ericsson Mobile Broadband Module is Electrostatic Discharge (ESD) protected. However, it is recommended that integrators follow electronic device handling precautions when working with any electronic device system to prevent damage to the host or the radio device.

When the Ericsson Mobile Broadband Module is mounted in the host, it is the responsibility of the integrator to ensure that static discharge protection is designed in to the host product. If exposed, the antenna and UICC interfaces are vulnerable contact points for ESD.

4 Electrical Integration

This chapter describes the electrical interface between the Ericsson Mobile Broadband Module and the host device. A summary of the function of each signal is provided, together with any additional relevant information.

Signals are described from the perspective of the Ericsson Mobile Broadband Module. Consequently, signals described as ‘Input’ are input signals to the module, driven by the host [Host ⇒ Module]. Likewise, signals described as ‘Output’ are driven by the module into the host [Module ⇒ Host]. Bi-directional signal flow (I/O) is indicated by a double-headed arrow [Module ⇔ Host]. In cases like UICC interface, which utilizes the host circuitry to interface to the module, it will be indicated as an interface between the module and the respective component, like [Module ⇒ UICC].

Apart from the module soldering process, the system radio performance depends also on host system design, host device noise, antenna design and performance etc. The host antenna system design is very important for total radio performance. For minimal system 3G performance recommendations see [2]. Note that the operators may have stricter radio performance requirements than stated in [1].

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment if the equipment is installed and operated with minimum distance of 20 cm between the radiator and your body. Depending on host design and antenna location there are requirements on human body exposure to RF emissions, please refer to [11] and [12] for more information.

The transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

4.1 Physical size

Width: 29 (±0.1) mm

Length: 29 (±0.1) mm

Height: 2.1 (±0.1) mm

4.2 Pinout

The pin out is configured as a 277 pin LGA. Pad diameter is 0.63mm, pitch 1.27mm. The coordinate F6 in Figure 8 is the reference point.

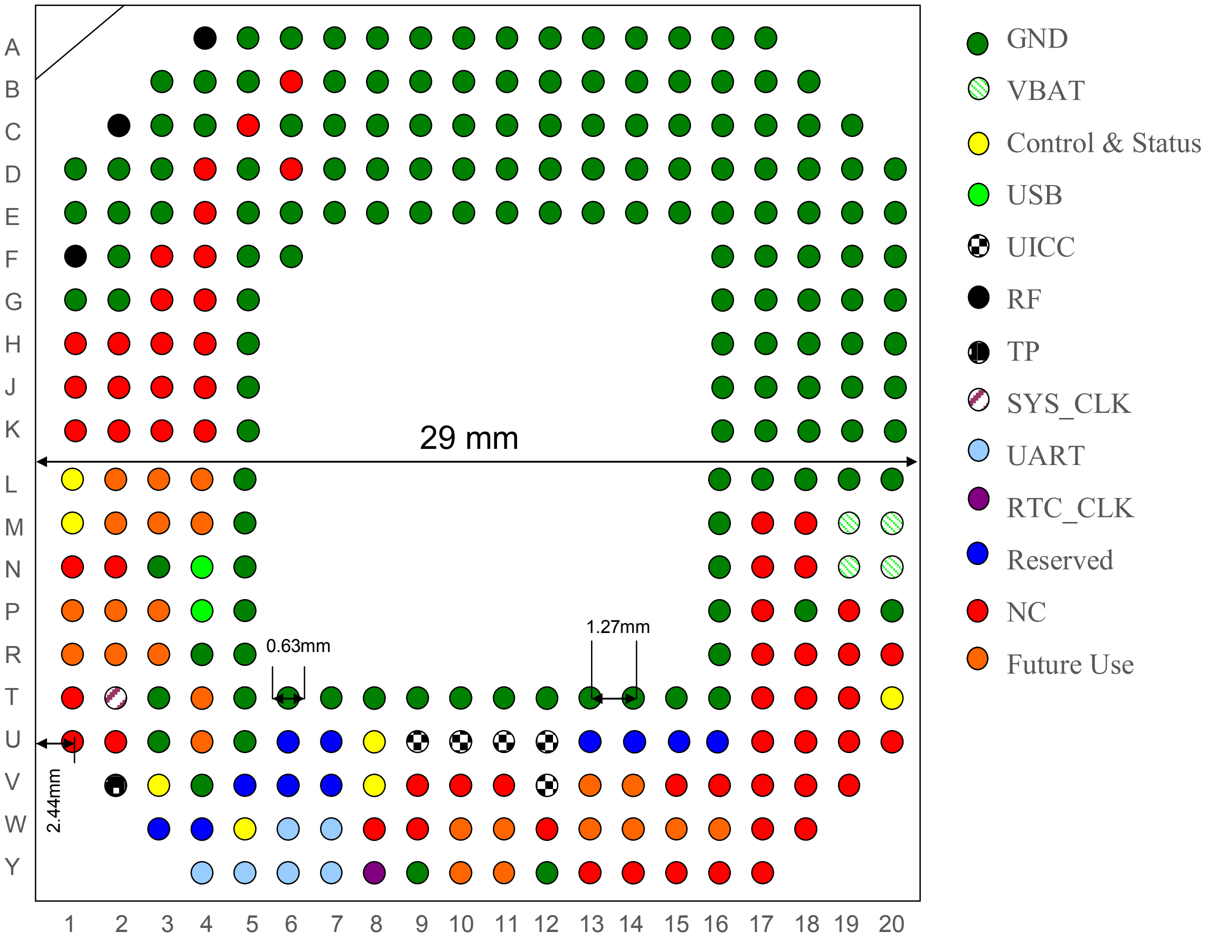


Figure 9, C5621/C33 Top View (looking through the module)[1]. The coordinate F6 is the reference point.

[1] Please use electronic format to view this figure to get better clarity on the details

4.3 System Connector

All signals are routed through the LGA pads for interfacing with the host device - power, ground, data, control, status and UICC interface.

Table 3, Pin List

Pin	Name	Function
A4	RF_MAIN	Main RF Interface for GSM and WCDMA
A5	GND	
A6	GND	
A7	GND	
A8	GND	
A9	GND	
A10	GND	
A11	GND	
A12	GND	
A13	GND	
A14	GND	
A15	GND	
A16	GND	
A17	GND	
B3	GND	
B4	GND	
B5	GND	
B6	Reserved	NC[1]
B7	GND	
B8	GND	
B9	GND	
B10	GND	
B11	GND	
B12	GND	
B13	GND	
B14	GND	
B15	GND	
B16	GND	
B17	GND	
B18	GND	
C2	RF_GPS	GPS Receiver RF Interface
C3	GND	
C4	GND	
C5	Reserved	NC[1]
C6	GND	
C7	GND	

Pin	Name	Function
C8	GND	
C9	GND	
C10	GND	
C11	GND	
C12	GND	
C13	GND	
C14	GND	
C15	GND	
C16	GND	
C17	GND	
C18	GND	
C19	GND	
D1	GND	
D2	GND	
D3	GND	
D4	Reserved	NC[1]
D5	GND	
D6	Reserved	NC[1]
D7	GND	
D8	GND	
D9	GND	
D10	GND	
D11	GND	
D12	GND	
D13	GND	
D14	GND	
D15	GND	
D16	GND	
D17	GND	
D18	GND	
D19	GND	
D20	GND	
E1	GND	
E2	GND	
E3	GND	
E4	Reserved	NC[1]
E5	GND	
E6	GND	
E7	GND	
E8	GND	
E9	GND	
E10	GND	

Pin	Name	Function
E11	GND	
E12	GND	
E13	GND	
E14	GND	
E15	GND	
E16	GND	
E17	GND	
E18	GND	
E19	GND	
E20	GND	
F1	RF_DIV	RF Interface for WCDMA Diversity
F2	GND	
F3	Reserved	NC[1]
F4	Reserved	NC[1]
F5	GND	
F6	GND	
F16	GND	
F17	GND	
F18	GND	
F19	GND	
F20	GND	
G1	GND	
G2	GND	
G3	Reserved	NC[1]
G4	Reserved	NC[1]
G5	GND	
G16	GND	
G17	GND	
G18	GND	
G19	GND	
G20	GND	
H1	Reserved	NC[1]
H2	Reserved	NC[1]
H3	Reserved	NC[1]
H4	Reserved	NC[1]
H5	GND	
H16	GND	
H17	GND	
H18	GND	
H19	GND	
H20	GND	
J1	Reserved	NC[1]

Pin	Name	Function
J2	Reserved	NC[1]
J3	Reserved	NC[1]
J4	Reserved	NC[1]
J5	GND	
J16	GND	
J17	GND	
J18	GND	
J19	GND	
J20	GND	
K1	ANTENNA_CTRL_0	NC[1]
K2	ANTENNA_CTRL_1	NC[1]
K3	ANTENNA_CTRL_2	NC[1]
K4	ANTENNA_CTRL_3	NC[1]
K5	GND	
K16	GND	
K17	GND	
K18	GND	
K19	GND	
K20	GND	
L1	GPS_DISABLE	GPS RX Disable
L2	HSI_ACDATA	HSI[1]
L3	HSI_ACFLAG	HSI[1]
L4	HSI_CAREADY[3]	HSI[1]
L5	GND	
L16	GND	
L17	GND	
L18	GND	
L19	GND	
L20	GND	
M1	WAKE	Host Wake up signal
M2	HSI_CADATA	HSI[1]
M3	HSI_CAFLAG	HSI[1]
M4	HSI_ACREADY[3]	HSI[1]
M5	GND	
M16	GND	
M17	Reserved	NC[1]
M18	Reserved	NC[1]

[1] Referenced for future use; Leave open in the host design
[2] Referenced for future use; Pull low or tie to GND in the host design
[3] HSI_CAREADY and HSI_ACREADY mistakenly had swapped positions in Rev C of IG.

Pin	Name	Function
M19	VBAT	Power supply
M20	VBAT	Power supply
N1	Reserved	NC[1]
N2	Reserved	NC[1]
N3	GND	
N4	USB_DP	USB 2.0
N5	GND	
N16	GND	
N17	Reserved	NC[1]
N18	Reserved	NC[1]
N19	VBAT	Power supply
N20	VBAT	Power supply
P1	IPC_CA_WAKE	HSI/SPI [1]
P2	SPI0_MOSI	SPI [1]
P3	SPI0_CLK	SPI [1]
P4	USB_DM	USB 2.0
P5	GND	
P16	GND	
P17	Reserved	NC[1]
P18	GND	
P19	Reserved	NC[1]
P20	GND	
R1	IPC_AC_WAKE	HSI/SPI [1]
R2	SPI0_CS0	SPI [1]
R3	SPI0_MISO	SPI [1]
R4	GND	
R5	GND	
R16	GND	
R17	Reserved	NC[1]
R18	Reserved	NC[1]
R19	Reserved	NC[1]
R20	Reserved	NC[1]
T1	Reserved	NC[1]
T2	SYSCLK	Reference WWAN System Clock[1]
T3	GND	
T4	HSIC_STROBE	HSIC [1]
T5	GND	
T6	GND	
T7	GND	
T8	GND	

[1] Referenced for future use; Leave open in the host design
[2] Referenced for future use; Pull low or tie to GND in the host design

Pin	Name	Function
T9	GND	
T10	GND	
T11	GND	
T12	GND	
T13	GND	
T14	GND	
T15	GND	
T16	GND	
T17	Reserved	NC[1]
T18	Reserved	NC[1]
T19	Reserved	NC[1]
T20	POWER_ON	Module Power On / Reset control
U1	Reserved	NC[1]
U2	AUX_5V	NC[1]
U3	GND	
U4	HSIC_DATA	HSIC [1]
U5	GND	
U6	Reserved	NC[1]
U7	Reserved	NC[1]
U8	WWAN_LED	LED interface for WWAN status indication
U9	UIM_SIMOFF_N	UICC[1]
U10	UIM_CLK	UICC
U11	UIM_DATA	UICC
U12	UIM_PWR	UICC
U13	Reserved	NC[1]
U14	Reserved	NC[1]
U15	Reserved	NC[1]
U16	Reserved	NC[1]
U17	Reserved	NC[1]
U18	Reserved	NC[1]
U19	RESET_N	NC[1]
U20	Reserved	NC[1]
V2	SERVICE_MODE_N	Module Service Mode
V3	WWAN_DISABLE_N	Radio Disable Control
V4	GND	
V5	Reserved	NC[1]
V6	Reserved	NC[1]
V7	Reserved	NC[1]
V8	TX_ON	GSM TX Burst Indication[1]
V9	Reserved	NC[1]

[1] Referenced for future use; Leave open in the host design
[2] Referenced for future use; Pull low or tie to GND in the host design

Pin	Name	Function
V10	SW_READY	HSI/SPI [1]
V11	Reserved	NC[1]
V12	UIM_RST	UICC
V13	PCM1_ULD	PCM1 [2]
V14	PCM1_SCK	PCM1 [2]
V15	Reserved	NC[1]
V16	Reserved	NC[1]
V17	Reserved	NC[1]
V18	Reserved	NC[1]
V19	Reserved	NC[1]
W3	Reserved	NC[1]
W4	Reserved	NC[1]
W5	HW_READY	Module start-up indication
W6	UART0_CTS	UART0
W7	UART0_RTS	UART0
W8	Reserved	NC[1]
W9	Reserved	NC[1]
W10	PCM0_DLD	PCM0 [2]
W11	PCM0_WS	PCM0 [2]
W12	Reserved	NC[1]
W13	PCM1_WS	PCM1 [2]
W14	PCM1_DLD	PCM1 [2]
W15	SMB_CLK	SMB [1]
W16	SMB_DATA	SMB [1]
W17	Reserved	NC[1]
W18	Reserved	NC[1]
Y4	UART1_TX	UART1
Y5	UART1_RX	UART1
Y6	UART0_TX	UART0
Y7	UART0_RX	UART0
Y8	RTC_CLK	32kHz Module Boot-up Clock
Y9	GND	
Y10	PCM0_ULD	PCM0[2]
Y11	PCM0_SCK	PCM0 [2]
Y12	GND	
Y13	Reserved	NC[1]
Y14	Reserved	NC[1]
Y15	Reserved	NC[1]
Y16	Reserved	NC[1]
Y17	Reserved	NC[1]

[1] Referenced for future use; Leave open in the host design
[2] Referenced for future use; Pull low or tie to GND in the host design

4.3.1 Electrical Interface Detail Format

The description of each interface follows a common format. An example is shown below:

Interface name:	Name of the interface. Preferably, this is the actual name of the interface in the pin list, but some interfaces are grouped and the interface name is a collection of interface signals.
Function:	Describe the basic function of the interface; some interface signals are grouped according to function.
Description:	Basic description of the interface and the relationship to the host.
Signal name:	All signal names associated to the interface, all names are given
Direction:	Signal flow direction.
If not used:	Specific details for each signal how to terminate the physical connection if not used by the host. Failure to observe this convention can result in unpredictable behavior.
LVTTL:	TTL signal level.
Details:	Any specific details noted.

4.3.2 TTL Levels

The table below defines the TTL levels of C5621/ C33 Mobile Broadband Module.

Table 4 TTL signal level definitions

Voltage level	1.8V
V_{Max}	V_{High} + 0.3
V_{High}	1.8
$V_{OutHigh}$	>1.35
V_{InHigh}	>1.17
$V_{Threshold}$	0.9
V_{InLow}	<0.63
V_{OutLow}	<0.45
V_{Low}	0
V_{Min}	-0.3

4.3.3 Power Interfaces

This chapter describes the power, ground and other signals that control or indicate power states.

- VBAT
- GND

4.3.3.1 VBAT

Function:	Power supply
Description:	Voltage supply to module
Signal name:	VBAT
Direction:	Host => Module
If not used:	Required
LVTTL:	N/A
Details:	Voltage provided by the host must range within 3.0V (minimum) to 4.2V (maximum), the typical value being 3.6V. It is essential that the host platform provides sufficient voltage during peak current conditions.

Note: The supported voltage range is absolute and including voltage ripple and glitches. Function and performance are undefined outside supported range.

Note: When turning off the power to the module, if the host wants to turn-off VBAT completely, we recommend that the host ensures VBAT voltage is less than 1.2 V during 100 ms time frame, in order for the module to properly enter its power-off state. Please refer to parameter T_{off} in Figure 9.

Note: There is a limited amount of power supply capacitance mounted on the module. It is essential that the host platform provides sufficient voltage during the peak current conditions. There should also be decoupling (10-22uF) located close to the VBAT pins on the module. Make sure that VBAT has a low impedance connection directly to a battery source. Please refer to Figure 11.

Note: When designing the power supply on the host side, the bursty nature of GSM TDMA transmission should be taken into consideration. Please refer to Figure 12 and Figure 13

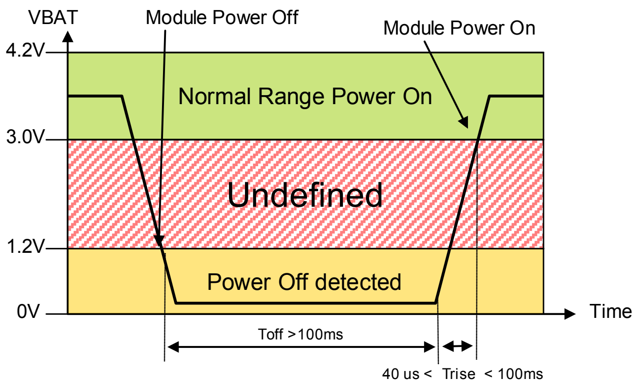


Figure 10, VBAT Electrical Characteristics

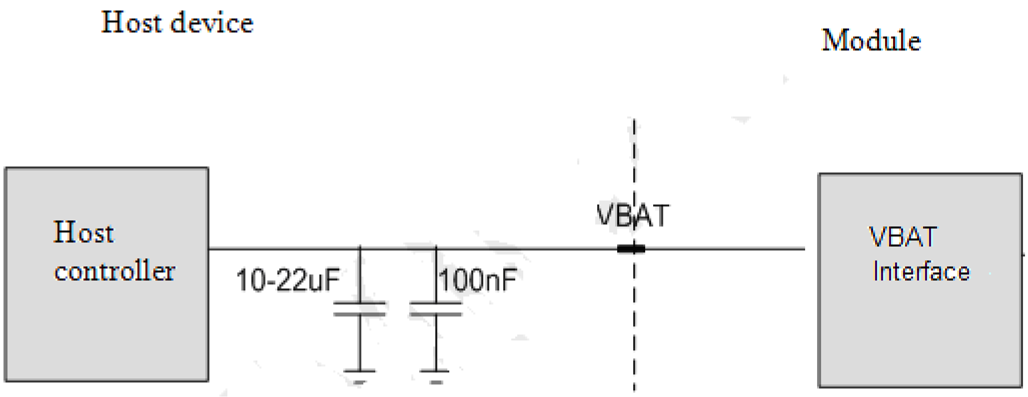


Figure 11, VBAT Implementation

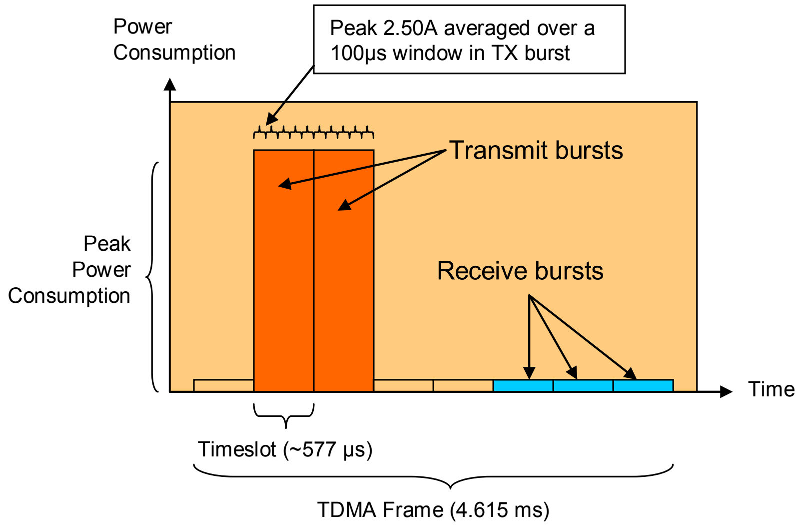


Figure 12, Example GPRS/EDGE 3+2 multislot transmission

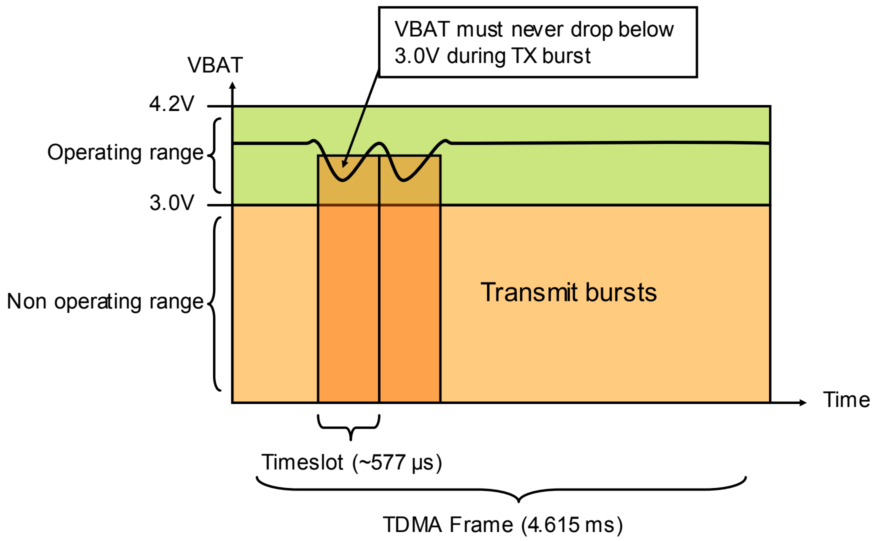


Figure 13, VBAT during GPRS/EDGE TX burst

Table 5, VBAT Electrical Characteristics

Parameter	Condition	Low	Mid	High	Unit
Voltage		3.0	3.6	4.2V	V
Current Consumption (worst case)	Peak Average		2200 850		mA

4.3.3.2 GND

Function:	Ground
Description:	Ground connection(s)
Signal name:	GND
Direction:	N/A
If not used:	Required
LVTTL:	N/A
Details:	Return path for all currents and ground reference.

4.3.4 Data communication interfaces

4.3.4.1 USB 2.0

Function:	USB2.0 data communication port
Description:	USB transmit and receive port for data communication between module and host
Signal name:	USB_DP USB_DM
Direction:	Module ⇔ host
If not used:	Required
LVTTL:	N/A
Details:	The module USB interface is designed to the High Speed USB specifications; see Universal Serial Bus Specification 2.0 [3]. Power to the USB interface is provided by VBAT input from the host. The USB start-up time, i.e. from module startup to D+ high, is less than 3 s. The module has support for quick enumeration which allows for even shorter BIOS detection times, please see chapter 2.1

Note: Ericsson strongly recommends that the USB is connected directly to the root HUB, which is not shared with other USB devices. This ensures that the module USB selective suspend function is not limited by other devices connected to the same HUB.

Note: To achieve full throughput performance, the USB host controller should adhere to USB2.0 specification and be configured for High Speed Mode.

4.3.5 Debug Interface

UART 0 & 1 signals along with SERVICE_MODE_N signal can be utilized for various purposes:

- As an interface for re-flashing the module firmware (Mandatory)
- As a debug interface, when USB interface is disconnected or suspended (Optional)
- As a stand-alone debug interface during the initial development phase of the host system (Optional)

The various options are described further in this section.

4.3.5.1 Module Re-flashing Interface

C5621/C33 module firmware is upgradable through the standard USB interface. To take care of those conditions where the module has to be re-flashed either at OEM/ODM factories or at the service center, Ericsson require that SERVICE_MODE_N can be controlled and recommends that UART0 signals are connected to the host CPU, as detailed in Figure 14.

In case of a daughter board design it is required to route the SERVICE_MODE_N signal in the connector.

Ericsson will also utilize this interface during the claims process. For this purpose, it is recommended that the mentioned signals are, also, terminated on test pads. For better accessibility, the test pads shall be placed in a single row at the edge of the host PCB.

4.3.5.1.1 UART0

Function:	UART0 data communication port (for debugging & re-flashing)
Description:	UART data communication port with flow control
Signal name:	UART0_TX UART0_RX UART0_CTS UART0_RTS
Direction:	Module ⇔ host
If not used:	Required
LVTTL:	1.8V
Details:	115200 baud, 8 data bit, 1 stop bit, no parity, flow control. Electrical specification and signaling levels according to

[13].

Note: UART0 can optionally be used to boot the module from an external application CPU.

Note: UART0 CTS & RTS signals can be left as 'NC'.

Note: There is cable detection functionality. Thus, if the signal goes high on these lines then the module will not go to suspend.

Note: UART0 signals shall be tri-stated when the host CPU is not using the interface for flashing; otherwise, there is a risk that the module will not go to suspend state.

4.3.5.1.2 SERVICE_MODE_N

Function:	Service Mode
Description:	Active low input to boot the module in Service Mode
Signal name:	SERVICE_MODE_N
Direction:	Host => module
If not used:	Required
LVTTL:	1.8V
Details:	When the signal is driven LOW, the module will boot in Service Mode. When in service mode, the module can be re-flashed over USB interface or UART0 interface. This signal is internally pulled high to 1.8V supply with 47k Ohm.

Note: It is strongly recommended that this signal is routed via an open-drain transistor. The signal shall not be asserted HIGH before HW_READY is active.

Note: This signal shall be utilized only when the module is re-flashed or during those applications where the module is booted from an external application CPU.

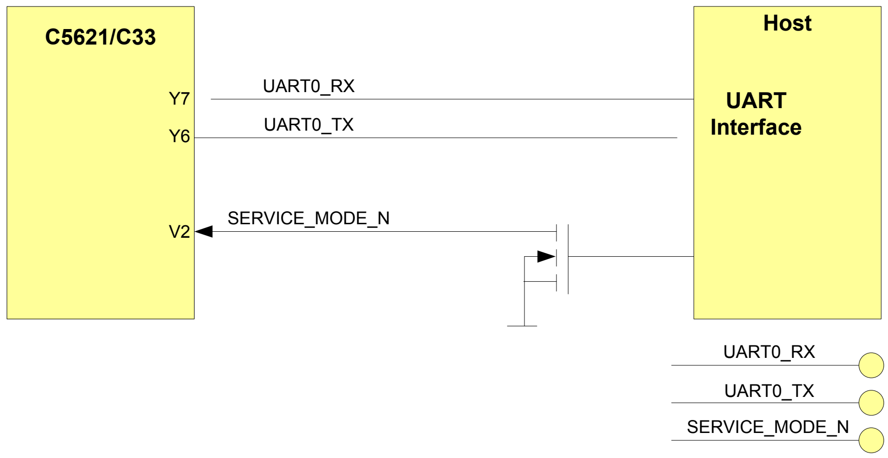


Figure 14 Module Re-flashing Interface

4.3.5.2 Debug Interface – FW Logging

USB is the main interface which one will use for debugging the module. UART 0 & 1 signals can used for debugging purpose, when USB interface is disconnected or suspended. It is an optional interface and the host designer can choose to terminate the signals on test pads or at a test connector. UART0 CTS & RTS signals can be left as 'NC' as they are not utilized for debugging purpose.

4.3.5.2.1 UART1

Function:	UART1 data communication port (for debugging)
Description:	UART data communication port without flow control
Signal name:	UART1_TX UART1_RX
Direction:	Module ⇔ host
If not used:	Leave open
LVTTL:	1.8V
Details:	115200 baud, 8 data bit, 1 stop bit, no parity, no flow control. Electrical specification and signaling levels according to [13]. This port is used for debugging purpose.

Note: There is cable detection functionality. Thus, if the signal goes high on these lines then the module will not go to suspend.

4.3.5.3 Stand-alone Debug Interface

During the initial development phase of the host system, the host designer can implement this interface to test C5621/C33 module in stand-alone debug mode, if any issues in the system functionality or performance is reported. This will help to isolate the root cause of the issue. This is an optional interface and shall be used for debugging during the R&D phase of the device designers. Refer to Figure 15 for more details.

To start up the module in stand-alone, the following recommendations are to be considered:

- There shall be possibility to power-up the module in the stand-alone mode, preferably from an external power source (VBAT), bypassing the host power-on control logic.
- RTC_CLK (32.768 kHz) shall be available to start up the module in this mode. Terminating RTC_CLK to a test pad enables the possibility to connect this signal to an external clock source.
- A default pull-up option for POWER_ON signal enables the module to power-up even when this signal is isolated from the host control logic.
- Possibility to connect USB traces to an external host – by soldering cable to the test pads or by routing USB traces to a test USB connector.
- Series zero ohm resistors are to be provided on USB_DP, USB_DN, POWER_ON and RTC_CLK signals so that these signals can be isolated to the external test pads in the stand-alone mode.
- The placement of the test pads for USB_DN, USB_DP and RTC_CLK shall be close to the corresponding zero ohm resistor to make the stubs on the traces as short as possible.
- UICC interface on the host PCB shall be available, by default, so that the module is able to communicate with the SIM.

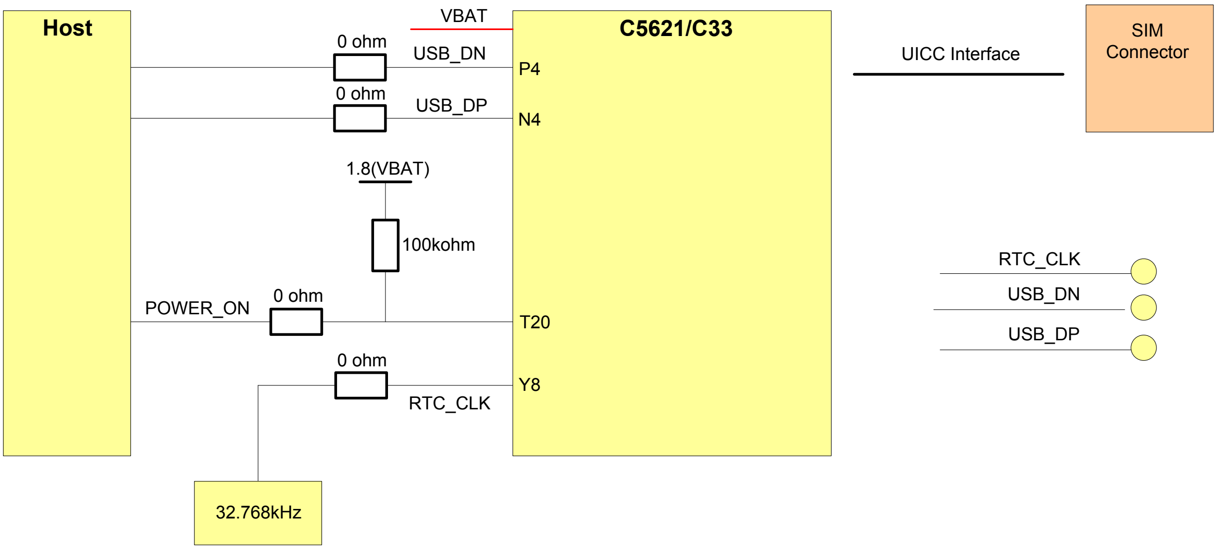


Figure 15 Stand-alone Debug Interface

4.3.6 Control and Status Interfaces

The Control and Status interfaces consist of the following signals:

- WAKE
- WWAN & GPS Disable
- WWAN LED
- HW Ready
- POWER_ON
- RTC CLK

4.3.6.1 WWAN_DISABLE_N

Function:	Wireless disable input signal
Description:	Active low input to disable radio functionality
Signal name:	WWAN_DISABLE_N
Direction:	Host => module
If not used:	Leave open
LVTTL:	1.8V
Details:	The function of the WWAN_DISABLE_N signal is dependant on the software configuration of the GPS_DISABLE signal. The GPS_DISABLE signal can be configured as disabled (default) or enabled.

When the GPS_DISABLE signal is disabled through software configuration, all radio transmitters and receivers will be disabled when the WWAN_DISABLE_N signal is asserted.

When the GPS_DISABLE is enabled through software configuration, all radio transmitters and receivers except the GPS receiver will be disabled when the WWAN_DISABLE_N signal is asserted.

This signal is internally pulled high to 1.8v supply with 100k Ohm.

Note: The host has to ensure that the WWAN_DISABLE_N signal is not driven high when VBAT is powered down.

4.3.6.2 GPS_DISABLE

Function:	GPS disable input signal
Description:	Active high input to disable GPS functionality
Signal name:	Note: The host has to ensure that the WWAN_DISABLE_N signal is not driven high when VBAT is powered down. GPS_DISABLE
Direction:	Host => module
If not used:	Leave open
LVTTL:	1.8V
Details:	Signal is used in conjunction with WWAN_DISABLE_N. The function of GPS_DISABLE is software configurable in two states; enabled and disabled. When GPS_DISABLE signal is enabled through software configuration, the GPS receiver shall be disabled when the signal is asserted. When GPS_DISABLE signal is disabled through software configuration, nothing shall happen when the signal is asserted. This signal is internally pulled high to 1.8v supply with 100k Ohm.

Note: The host has to ensure that the GPS_DISABLE signal is not driven high when VBAT is powered down.

Note: The module must be customized to allow the signal to control the GPS. The default configuration uses the WWAN_DISABLE_N signal to disable both WWAN and GPS functions.

4.3.6.3 WAKE

Function:	Wake up host signal
Description:	Wake up the host, active high
Signal name:	WAKE
Direction:	Module => host
If not used:	Leave open
LVTTL:	1.8V
Details:	The WAKE pin can be used to provide an out-of-band signal for waking up the host device from sleep states. This signal is internally pulled down with 100k Ohm.

4.3.6.4 WWAN_LED

Function:	Wireless WAN LED control
Description:	LED control
Signal name:	WWAN_LED
Direction:	Module => host
If not used:	Leave open
LVTTL:	N/A
Details:	The Ericsson Mobile Broadband Module uses this pin for LED control. The pin is driven as a current sink of approximately 10mA maximum. The LED will reflect the current WWAN radio status. If the WWAN radio is on, the led will be lit and vice versa.

Note: It is recommended that the power supply for the LED is disabled when the VBAT power rails are disabled.

Table 6, WWAN_LED Electrical Characteristics

Parameter	Condition	Min	Typ	Max	Unit
WWAN_LED	ON	-	10	-	mA
	OFF	High Z			
	Input voltage level			5.5	V

4.3.6.5 HW_READY

Function:	Status signal intended for preventing back

	feeding
Description:	Status signal for host I/O.
Signal name:	HW_READY
Direction:	Module => host
If not used:	Leave open
LVTTL:	1.8V
Details:	The signal has an initial low state from the start-up of the module. The signal is indicating the modules on/off/reset state. • Via a low signal is the module indicating a power off or a reset state. • Via a high signal is the module indicating a power on state. When the HW_READY signal is high, the host can set input signals to the module high without risk for current leakage. HW_READY signal is actively driven as soon as the VBAT is applied to the module.

4.3.6.6 POWER_ON

Function:	Signal to turn on the module
Description:	Active high signal to start the module
Signal name:	POWER_ON
Direction:	Host => module
If not used:	Required
LVTTL:	1.8V (VBAT Compatible)
Details:	The POWER_ON signal is used by the host to start up the module. This signal is level-sensitive. A high level on POWER_ON triggers the module start up sequence. The POWER_ON signal is gated with the internal 32kHz clock signal. After 1024 pulses (32ms) the modem starts the boot process. The module has an internal pull down of 1M Ohm and requires the host system to drive this signal HIGH to start the module. The host controller must pull this pin high in order for the module to startup.

4.3.6.7 RTC_CLK

Function:	Main clock input
Description:	Single ended clock input
Signal name:	RTC_CLK
Direction:	Host => module
If not used:	Required
LVTTL:	N/A
Details:	The signal is primarily used in sleep mode when the 26 MHz clock is powered on. The clock should always be available except in shut-down mode when the platform is powered off. The RTC clock should be switched off when the power to the module is switched off to prevent back leakage.

Table 7 RTC_CLK Electrical Characteristics

Parameter	Condition	Min	Typ	Max	Unit
High level input voltage, V_{IH}		1.7	1.8	2.1	V
Low level input voltage, V_{IL}		-0.3	0	0.3	V
Input frequency, f_{IN}			32.768		kHz
Duty cycle, t_{DCin}		40	50	60	%
Frequency tolerance		20ppm[1]			
Rise/fall time		4		200	ns

[1] **Note:** *The frequency tolerance of 20ppm is the expected accuracy of the crystal that is used to generate a 32 kHz clock. Over temperature, its expected that the 32 kHz clock will drift more in frequency, following the typical parabolic curve of the crystal oscillator*

4.3.7 UICC Interface

The UICC interfaces consist of the following signals:

- UIM Power
- UIM Data
- UIM Clock
- UIM Reset
- UIM SIMOFF

The picture below illustrates the UICC (SIM) interface.

Note: The UICC interface should be ESD protected on the host side.

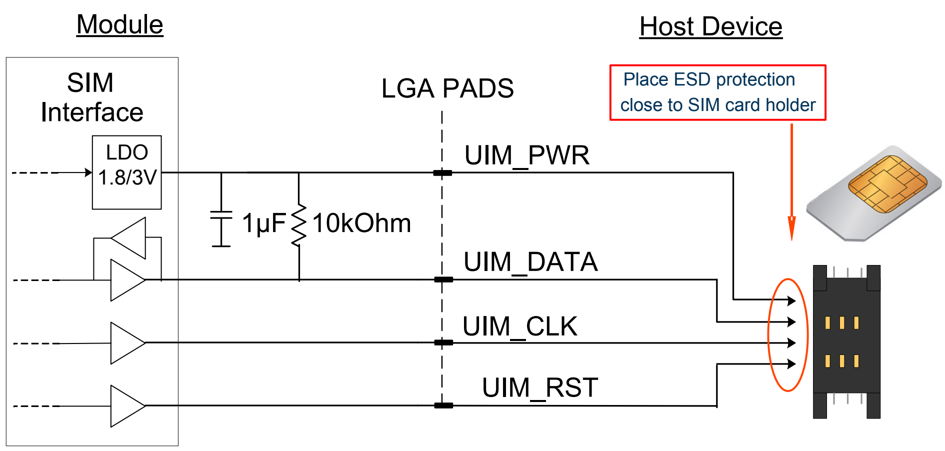


Figure 16, UICC interface

4.3.7.1 UIM_PWR

Function:	UIM Power
Description:	1.8 V or 3 V power supply to the UICC
Signal Name:	UIM_PWR [Module⇒UICC]
If not used:	Required
LVTTL:	N/A
Details:	The UIM_PWR signal is the Ericsson Mobile Broadband Module power supply to the UICC. The Ericsson Mobile Broadband Module supports UICC of Class B and C.

The signal details shall be according to [14].

Note: Only the UICC reader may be connected to UIM_PWR. The UIM_PWR signal should not be fitted with decoupling capacitors in the host design. Maximum current allowed on UIM_PWR is 150 mA.

Table 8, UIM_PWR Electrical Characteristics

Parameter	Condition	Min	Type	Max	Unit
UIM_PWR	1.8 V mode	1.67	1.8	1.98	V
	3 V mode	2.8	2.85	2.9	V

4.3.7.2 UIM_DATA

Function: UIM Data

Description: Single-ended data signal

Signal Name: UIM_DATA [Module⇔UICC]

If not used: Required

LVTTL: N/A

Details: The Ericsson Mobile Broadband Module provides this data signal interface to the host mounted UICC. A 10 kOhm pull-up resistor to UIM_PWR is mounted on the module.

The signal details shall be according to [14].

Table 9, UIM_DATA Electrical Characteristics:

Parameter	Condition	Min	Type	Max	Unit
UIM_DATA	Input low level			0.2 x UIM_PWR	V
	Input high level	0.7 x UIM_PWR			V
	Output low level	0		0.3	V
	Output high level	UIM_PWR -0.3		UIM_PWR	V

4.3.7.3 UIM_CLK

Function: UIM Clock

Description: Single-ended clock signal

Signal Name: UIM_CLK [Module⇒UICC]

If not used: Required

LVTTL: N/A

Details: The Ericsson Mobile Broadband Module provides this clock signal interface to the host mounted UICC. The signal details shall be according to [14].

Table 10, UIM_CLK Electrical Characteristics

Parameter	Condition	Min	Type	Max	Unit
UIM_CLK	1.8 V mode, low level	0		0.2	V
	1.8 V mode, high level	1.6		UIM_PWR	V
	3 V mode, low level	0		0.35	V
	3 V mode, high level	2.4		UIM_PWR	V

4.3.7.4 UIM_RST

Function: UIM Reset

Description: Reset signal to the UICC

Signal Name: UIM_RST [Module⇒UICC]

If not used: Required

LVTTL: N/A

Details: The Ericsson Mobile Broadband Module provides this reset signal interface to the host mounted UICC. The signal details shall be according to [14].

Table 11, UIM_RST Electrical Characteristics

Parameter	Condition	Min	Type	Max	Unit
UIM_RST	1.8 V mode, low level	0		0.2	V
	1.8 V mode, high level	1.6		UIM_PWR	V
	3 V mode, low level	0		0.35	V
	3 V mode, high level	2.4		UIM_PWR	V

4.3.8 PCM 0 & 1 Interface

The module is hardware prepared to support digital voice interface between the module and the host. PCM 0 & 1 are intended for that purpose. For C5621/C33 module configuration, this interface is not enabled.

Hence, the signals corresponding to PCM 0 /1 interface shall be pulled-low or tied to GND. Refer to Table 3 for pin details.

Note: All the PCM0 signals can be tied together and pulled-low by a 100k Ohm resistor. Similarly all the PCM1 signals as well can be tied together and pulled-low by a 100k Ohm resistor.

4.3.9 RF interface

4.3.9.1 RF_MAIN

Function:	Main antenna port for E-GSM and WCDMA
Description:	50Ω antenna interface used for main RF branch
Signal name:	RF_MAIN
Direction:	Module ⇔ antenna system
If not used:	Required
LVTTL:	N/A
Details:	No DC protection implemented on this interface.

4.3.9.2 RF_DIV

Function:	Antenna port for WCDMA diversity
Description:	50Ω antenna interface used for receive diversity branch
Signal name:	RF_DIV
Direction:	Antenna system => module
If not used:	Required
LVTTL:	N/A
Details:	No DC protection implemented on this interface.

4.3.9.3 RF_GPS

Function:	Antenna port for GPS interface
Description:	50Ω antenna interface used for GPS
Signal name:	RF_GPS
Direction:	Antenna system => module
If not used:	Leave open
LVTTL:	N/A
Details:	Maximum DC rating on this interface is 3V @ -20 to +65 degrees C.

5 Mechanical Dimension

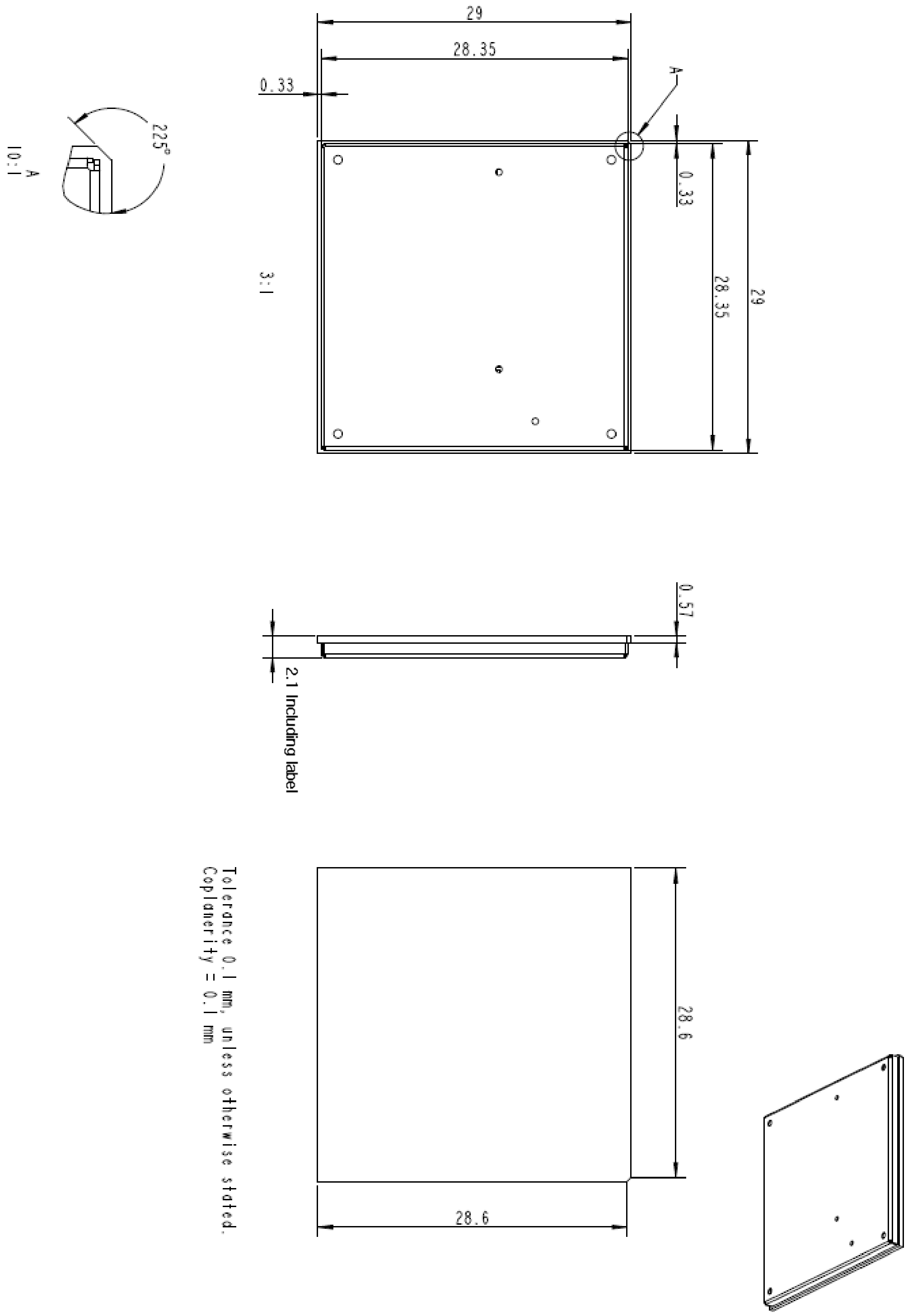


Figure 17, Physical Dimension (All dimensions in mm)

6 Routing guidelines

C5621 / C33 Mobile Broadband module is an LGA subassembly, soldered to the host board, and shares GND plane with the host platform, it is essential that the host board layout follows the recommendation given in this chapter to get the best performance out of the module.

Some of the recommendations provided in this chapter are general PCB design guideline that may be referred from standard texts concerning the subject.

6.1 Recommended PCB Footprint

There are two different PCB footprints recommended for the C5621/ C33 LGA sub-assembly, both of which share common properties. The choice of the footprint is left to the host PCB designer as it is dependent on the process adopted in the host design to integrate the C5621/ C33 module. Ericsson has not seen any difference in process yield depending on which of the two available PCB footprints that is chosen.

6.1.1 Common Properties

The solder lands of the host PCB should be a mirror image of the 277 solder lands on the C5621 / C33 LGA subassembly (1.27 mm pitch). No routing shall be present on the outer Cu-layer under the LGA subassembly. Via-in-pad is the recommended via structure to use, such vias should also be Cu-filled (i.e. solid Cu-microvia).

The solder lands on the host motherboard should have a minimum diameter of 0.63 mm.

6.1.2 Footprint for host PCB without solder mask under package

This version of the PCB footprint has one large solder mask opening under the LGA subassembly. To improve flux outgassing during reflow, the solder mask opening (SMO) is recommended to extend 50 µm outside the package outline on all four sides. Given a square package size of 29 +/- 0.1mm the recommended SMO is 29.2mm, see Figure 18 for more information.

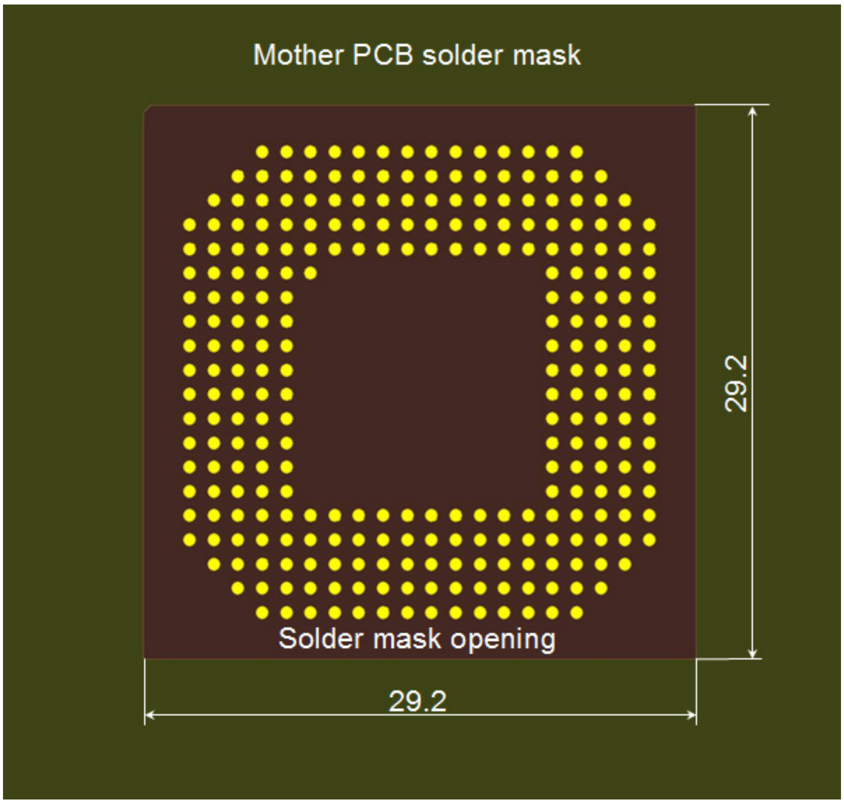


Figure 18, Ø 0.63 mm solder lands with one large solder mask opening extending at least 50 µm outside the package outline on all four sides

6.1.3 Footprint for host PCB with solder mask under package

This version of the PCB footprint has solder mask present on the host PCB underneath the C5621 / C33 LGA subassembly. In this case the recommended solder lands should have a diameter of 0.63 mm with a solder mask opening of Ø ≥0.73 mm (NSMD design). See Figure 19 for more information.

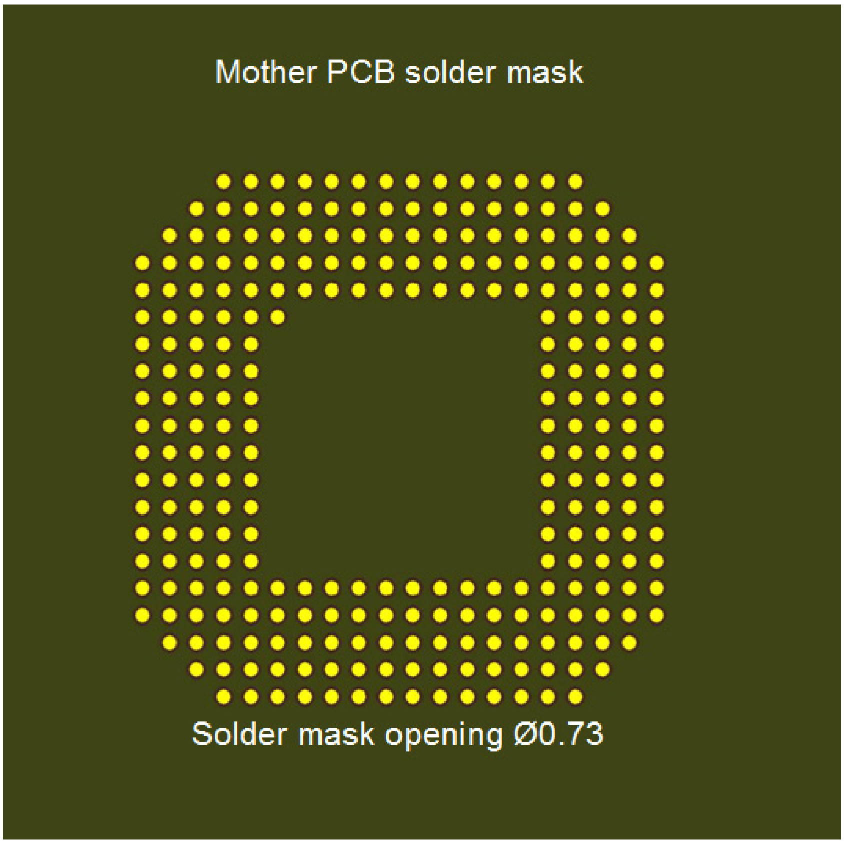


Figure 19, Ø 0.63 mm NSMD solder lands, SMO Ø ≥0.73 mm

6.2 Digital I/O routing

- Keep all trace lengths as short as possible
- Use stripline structure for signals with high frequency content (on the module, all 1.8V I/O signals have a rise/fall time of ~1ns, and should therefore be routed as striplines, since they all are high bandwidth signals)
- Treat all critical (high bandwidth) signals as current loops, and make sure that they have a return path. This means that you should refrain from routing any signals over non-continuous power or ground planes, because this causes interruptions in the impedance and results in reflections, and might also increase EMI emissions.
- Traces routed on adjacent layers should be oriented perpendicular towards each other; this will reduce risk for crosstalk.
- Impedance matching must be maintained to avoid overshoot, undershoot and ringing. Otherwise, radiated emissions increases.
- If nothing else is stated, digital signals should be routed with an impedance of 50-70 Ohm relative GND.

6.2.1 Clock Routing

- Must be routed with a controlled impedance (50-60 Ohm)
- Should not be routed over a discontinuous GND plane
- Keep clock traces as short as possible
- Place serial termination close to transmitter output
- Crosstalk:
  - Crosstalk falls off with the square of the distance, therefore adequate spacing is a good method in reducing crosstalk
  - As a rule of thumb, 3xH can be used for all clock signals:

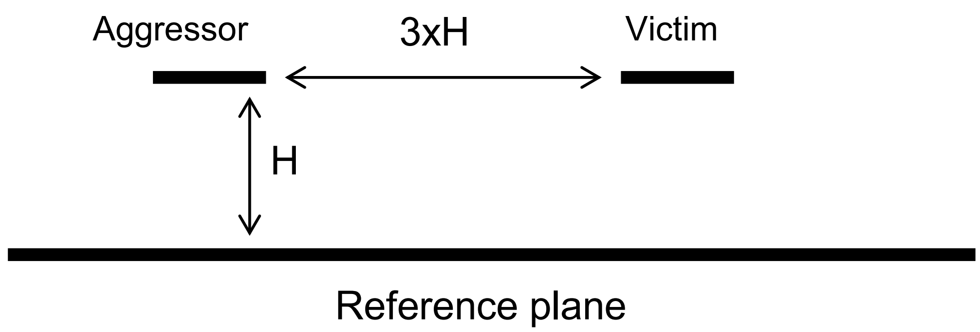


Figure 20, Spacing rule

- Involved signals:
  - RTC_CLK
  - UIM_CLK

6.2.2 USB Routing

- Traces should be routed as a differential pair, matched in length.
- Differential Impedance between the traces shall be 90 Ohm
- Involved signals:
  - USB_DP
  - USB_DM

6.3 Power Routing

6.3.1 VBAT Routing

- The VBAT pads should have a direct, low impedance connection to a battery
- The decoupling should be placed close to VBAT pads
- VBAT net shall be designed such that the supply voltage to the module is always within its operating range even at the maximum current consumption (worst case being 2G transmit operation). Refer to chapter 4.3.3.1 for details

6.3.2 GND

It is important to have proper grounding of the module. Connect the module's GND pads to the main GND plane with as many vias as possible to improve the thermal coupling.

6.4 RF Routing

- RF signals must have a controlled impedance of 50 Ohm
- The signals should be directly connected to respective antennas / antenna connectors
- It is important to isolate the RF-lines from any unwanted signal or noise. RF stripline is a good choice for realization of RF-lines since it provides good shielding from both radiated and conducted noise. Care must also be taken to isolate main/diversity/GPS traces with regards to each other.
- Via fence around the stripline, creating an embedded RF cage in the PCB, will improve isolation. Care shall be taken while calculating trace impedance since via fence placed very close to the RF striplines, may lower the impedance somewhat.
- Via stub should be eliminated or minimized

7 Production Guideline

7.1 Package type

C5621 / C33 module has ENIG bottom terminations with a LGA design; no solder mask is present at the underside of the package.

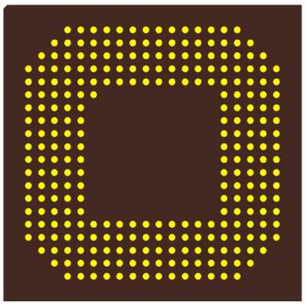


Figure 21, Top view of C5621/C33

7.2 Floor life and dry storage

The CE module should be stored in a dry pack and handled according to IPC/JEDEC J-STD-033B.1 [16], MSL 3 with bake at:

- 125 °C, when supplied on JEDEC tray
- 40 °C ≤5% RH when supplied on 44 mm tape and reel

7.3 Screen stencil design

Material:	Stainless steel
Thickness:	0.1 mm (~4 mil)
Aperture size:	Ø 0.63 mm (277x)

All solder paste deposits should be centered on the PCB pads.

7.4 Assembly

Pick-up position should be centered on the package topside.

Nozzle Ø: 10-20 mm

7.5 Reflow soldering

Forced convection soldering in air or N_2 can be used.

Reflow profile shall be with the stated limits in IPC/JEDEC J-STD-020D.1 [16]

The classification temperature (Tc) is 250 °C[1].

[1] The temperature value is according to the requirements stated in Table 4-2 IPC/JEDEC J-STD-020D.1.

8 Packaging – Tape and Reel Information

C5621/C33 modules are shipped as tape reels.

Each reel has 724 modules placed into the carrier tape and sealed with the cover tape. There will be 8 empty pockets as trailer and 18 empty pockets as leader in each reel.

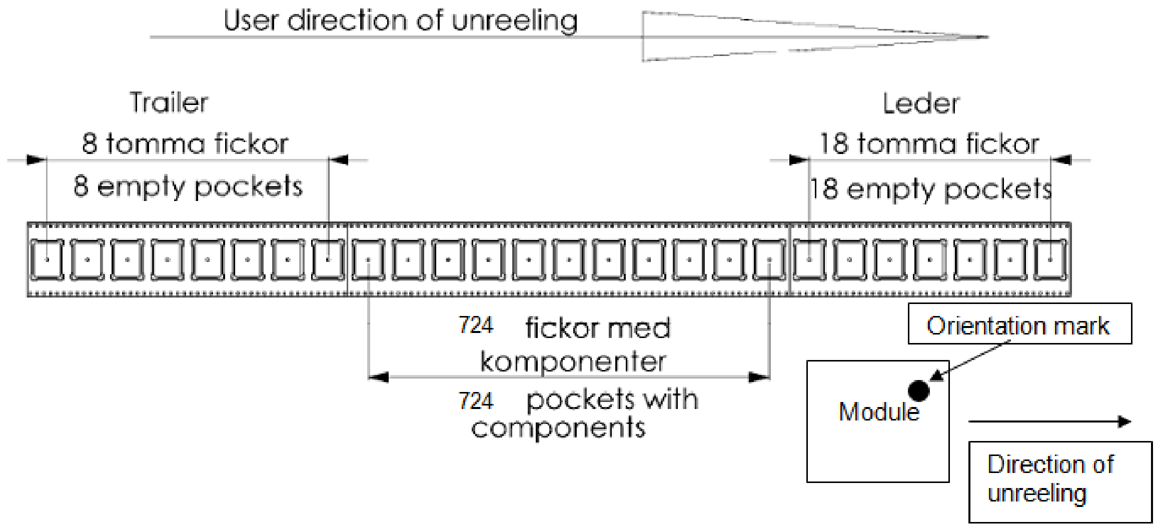
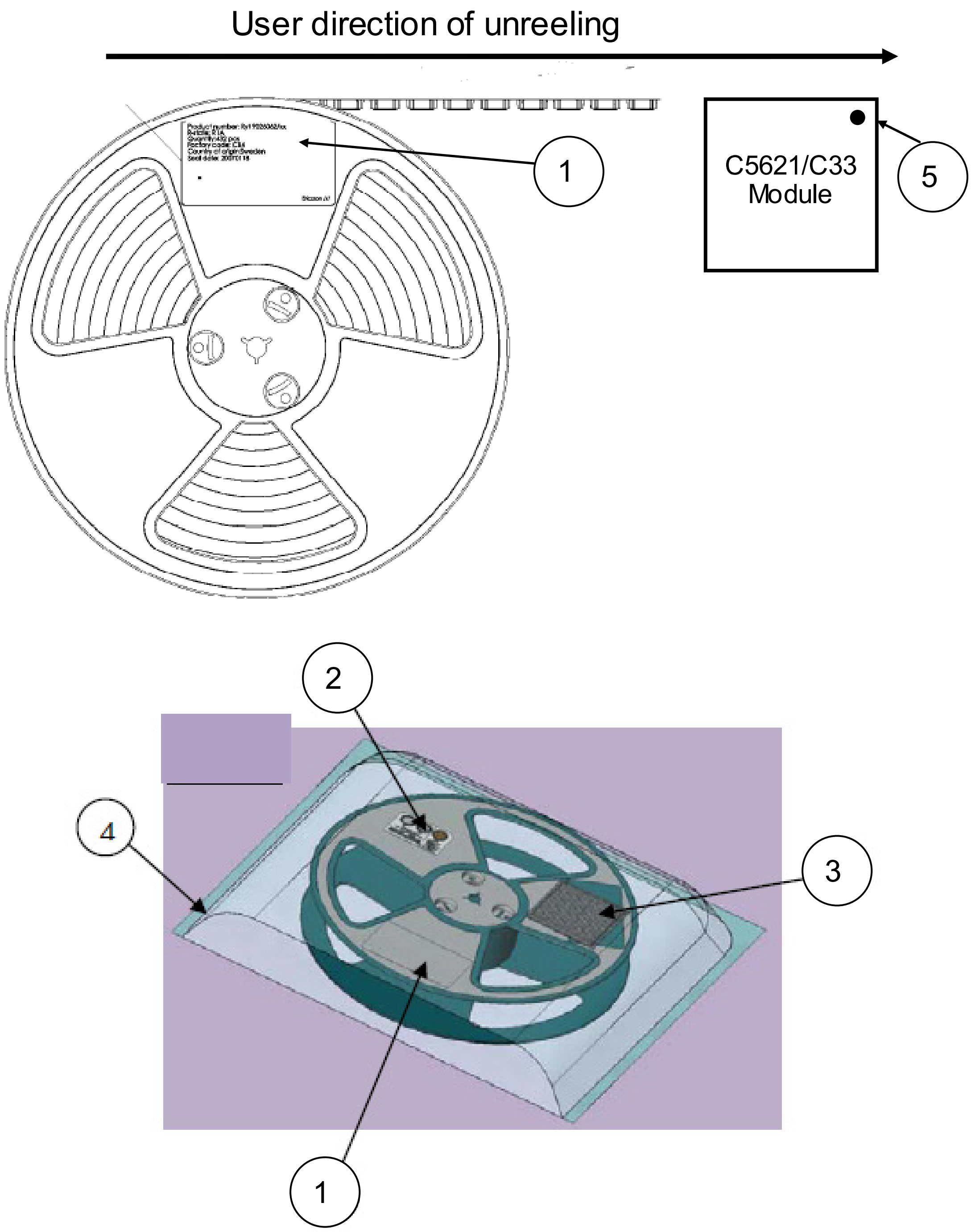


Figure 22, Reel Direction



1	Label
2	Humidity Indicator
3	Desiccant
4	Shielding Bag
5	Module Orientation Mark

Figure 23, Tape Reel Details

9 SW integration

9.1 Driver and Application Architecture

9.1.1 Windows XP and Vista Architecture

The driver and application architecture for XP and Vista is depicted in Figure 24.

The drivers are based on standard USB functionality. The Mobile Broadband Module appears as the following devices when examined in Windows Device Manager:

Device Name	Function
Mobile Broadband Device Management	This port can be used by an application to control and obtain status from the Mobile Broadband Module. Port type WDM
Mobile Broadband Network Adapter (NDIS)	NDIS interface over which Ethernet communication can be established. Appears to Windows as a network adapter. Port type Ethernet
Mobile Broadband GPS Interface	GPS COM port which streams out NMEA. Port type ACM
SIM Card Reader (SC)	PC-Smartcard interface. Port type WDM
Wireless Modem	Modem device which may be used for legacy Dial-Up Networking connection. Port type ACM.

On top of the drivers is an application, WMCore, running as background service. The service is started automatically at Windows startup and can be used to change the state of the Mobile Broadband Module without end-user interaction also prior to Windows login.

The WMCore service provides a number of functions to control the module and retrieve information about the module and its states. The functions are accessible through the Ericsson Mobile Broadband C++ API, see [5]. The service is also used by Ericsson's Wireless Manager.

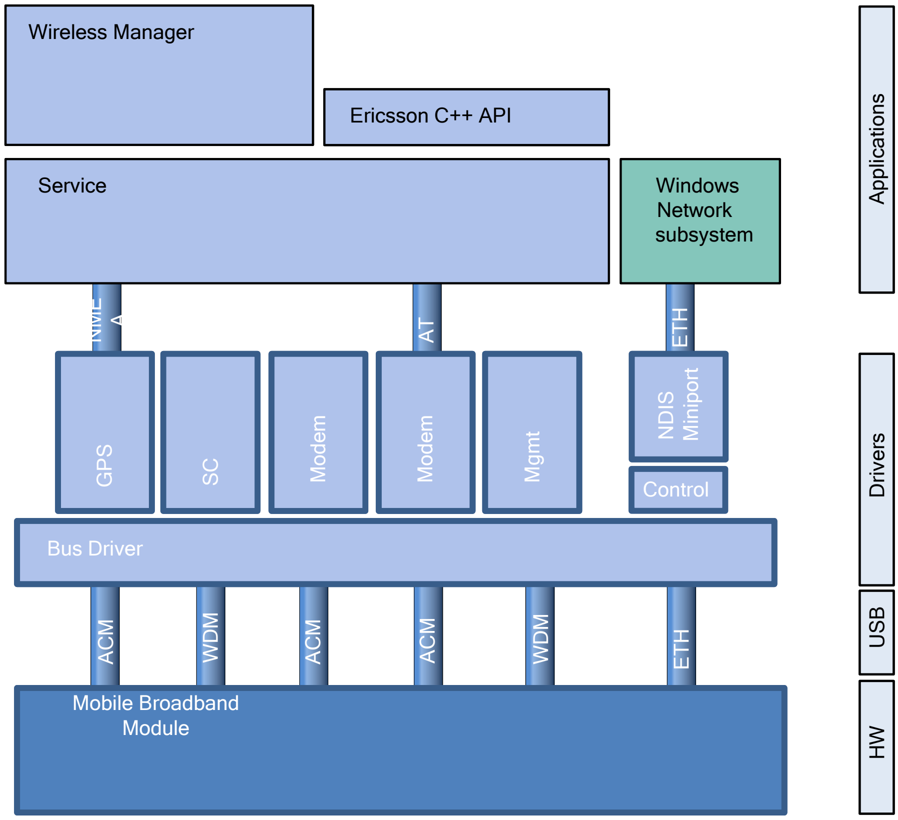


Figure 24, Windows XP/Vista driver architecture

9.1.2 Windows 7 Architecture

The driver and application architecture for Windows 7 is depicted in Figure 25.

The Mobile Broadband Module drivers are based on standard USB functionality. The Windows 7 drivers support the native Windows 7 Mobile Broadband API, resulting in a different architecture compared to Windows XP and Vista, as visualized in Figure 25. The GPS driver also implements support for Microsoft's sensor class. The devices seen in the Windows 7 Device Manager are as follows:

Device Name	Function
Mobile Broadband Device Management	This port can be used by an application to control and obtain status from the Mobile Broadband Module. Port type WDM
Mobile Broadband Network Adapter (NDIS 6.20)	Implements support for the Windows 7 Mobile Broadband API. Appears to Windows as a WWAN adapter. Port type Ethernet and ACM
Mobile Broadband GPS Interface	GPS port that supports the Windows 7 sensor class but can also be used as a

	COM interface. Port type ACM
SIM Card Reader (SC)	PC-Smartcard interface. Port type WDM
Wireless Modem	Modem device which may be used for legacy Dial-Up Networking connection. Port type ACM.

On top of the Windows 7 drivers is located a smaller WMCore service, which handles module functionality not handled by the Microsoft's Mobile Broadband API. The functionality handled by the service can be reached through the Ericsson Mobile Broadband C++ API.

The Wireless Manager works the same way in Windows 7 as it does in Windows XP and Vista. A port layer makes sure that Wireless Manager uses Microsoft's Mobile Broadband API as much as possible and uses the WMCore service only for functionalities not supported by the Mobile Broadband API. This ensures that Wireless Manager is synchronized with any other functionality using the Mobile Broadband API, including the native connection manager in Windows 7.

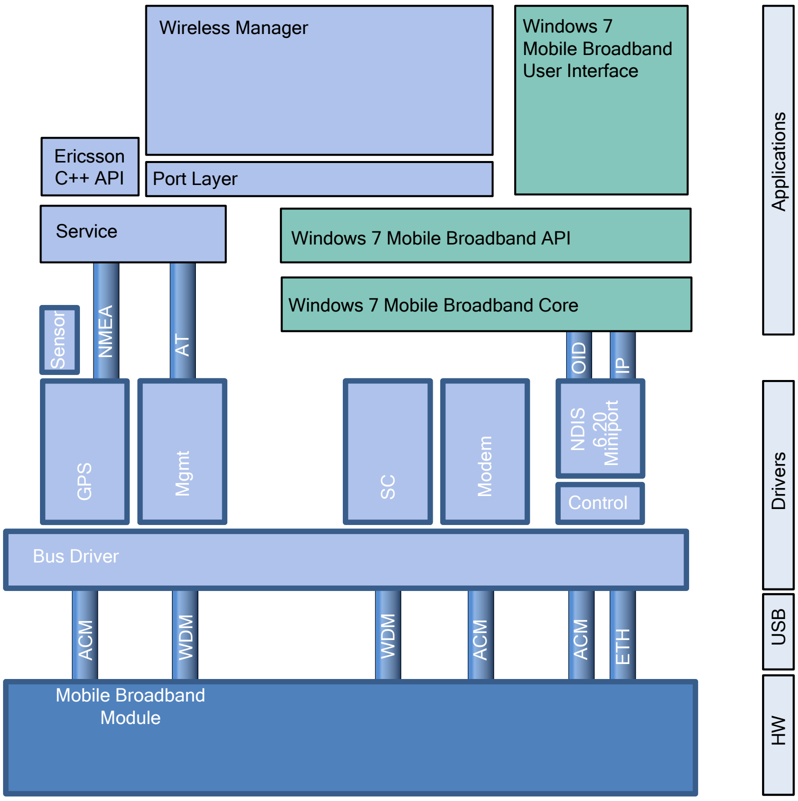


Figure 25, Windows 7 driver and application architecture

9.1.3 Windows 8 Architecture

The driver and application architecture for Windows 8 is depicted in Figure 26.

On Windows 8, the architecture is quite different compared to Windows 7 as most of the mobile broadband functionality is handled natively by Microsoft (MB Class Driver). Ericsson Mobile Broadband-specific functionality is provided through the Microsoft MB API Extensions.

The GPS driver implements support for Microsoft's sensor class. The devices seen in the Windows 8 Device Manager are as follows:

Device Name	Function
Mobile Broadband Device Management	Native MB class driver. Provided by Microsoft to handle WWAN functionality.
Mobile Broadband Geolocation Sensor	GPS driver that supports the Windows 8 sensor class.
Mobile Broadband Serial Port	Port to be used for engineering purpose such as logging, debugging and FW update. Port is only available in engineering mode, see chapter 9.1.3.1

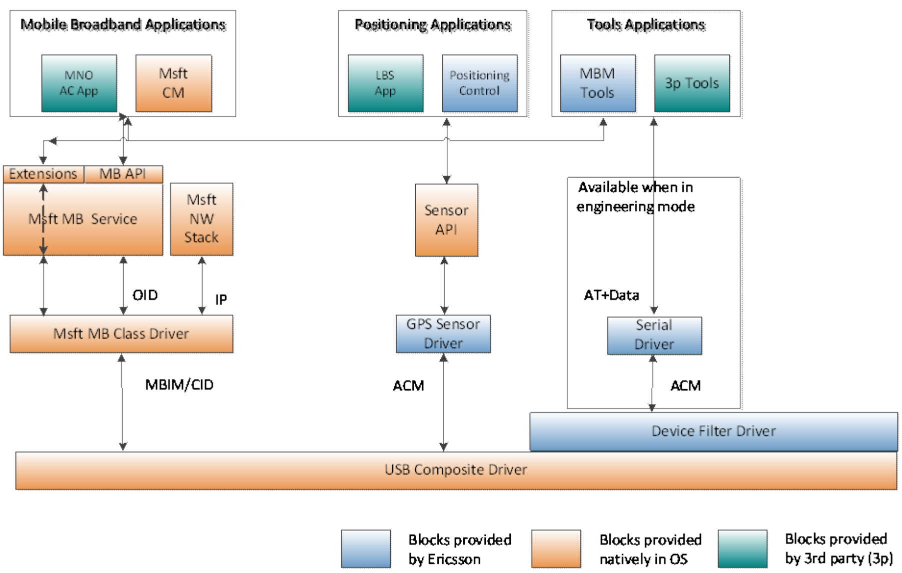


Figure 26 Windows 8 driver and application architecture

9.1.3.1 Engineering mode

Ericsson Windows 8 architecture supports two modes, engineering mode and normal mode. The drivers have been designed to align with the Windows 8 eco-system and during normal operation Windows native device APIs shall be used to interact with the module (APIs are Mobile Broadband API and Sensor API).

Windows native APIs does not have support for legacy engineering tools. To handle scenarios where there is a need for legacy engineering tools, it is possible to switch to *Engineering mode*, thus exposing legacy interfaces.

Note: Engineering mode is not intended for normal operation, nor is it supported by Ericsson. If additional interfaces are used for other purposes than logging, debugging, FW upgrade or other R&D purposes, there will be synchronization issues with the Windows native APIs. Ericsson do not support issues reported if engineering mode is used during normal operation in end-user system (e.g. 3-rd party connection managers using ports exposed in engineering mode).

Switching between the two modes is done by changing specific registry value.

***Engineering Mode**:*

[HKEY_LOCAL_MACHINE\SOFTWARE\Ericsson AB\MBM\gdrvp]
"cfExcludeIntf"=hex:08,09,0a

***Normal Mode**:*

[HKEY_LOCAL_MACHINE\SOFTWARE\Ericsson AB\MBM\gdrvp]
"cfExcludeIntf"=hex:01,02,05,08,09,0a

Drivers need to be re-enumerated in order to expose additional ports and this can be done by resetting the module. Figure 27 shows the normal flow when switching to engineering mode.

Switching back to normal mode works in a similar way, (by setting the above registry key to the correct value) and restarting the module.

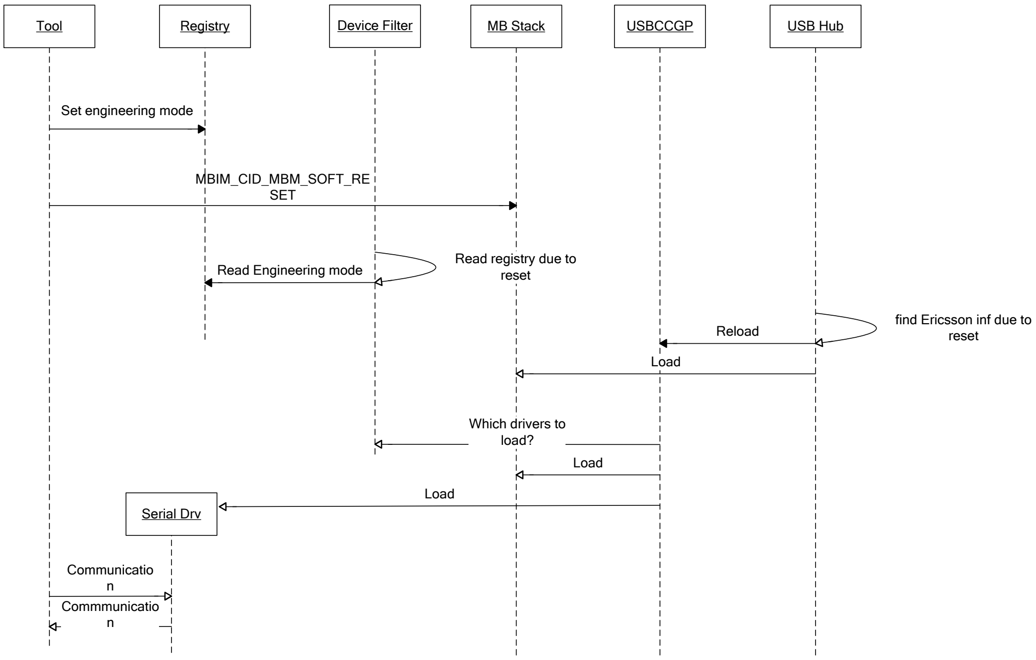


Figure 27 Switching to engineering mode

9.1.4 Linux driver architecture

Ericsson is a part of the Linux community to continuously improve the support in GNU/Linux for Ericsson Mobile Broadband Modules, please see [7] for more information.

The module firmware provides WDM (Wireless Mobile Communications Device Management) interfaces for device management and ACM (Abstract Control Module) interfaces for control and data traffic. The module exposes ACM ports, which can be used for GPS, Connection Manager and SMS. WDM and ACM are both based on CDC (Communication Device Class). Control is handled by AT commands according to the V.25 standard. The network connection uses USBnet architecture as base with support from CDC-NCM. The module supports DUN using PPP on the ACM interface.

Note: Kernel modifications may be needed to support customer requested VID/PID customizations, check with your Linux distributor.

Network Manager and GPS functionality is provided by user space applications.

For more information please refer to [8]

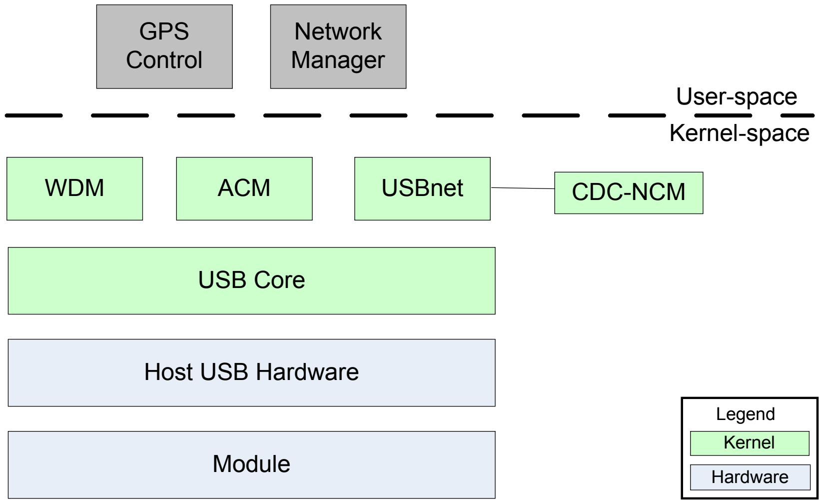


Figure 28, Linux driver architecture

9.2 Connection Profile List

Note: In Windows 8, the connection profile will be handled by Microsoft natively.

In Windows XP and Vista, the WMCore service includes a list with connection profiles which can be used by connection managers when setting up connections. The profile list contains a list of default network operator APN which is automatically selected by the connection manager depending on the detected UICC card. The matching between APN and UICC card is done based on the MCC and MNC (2 or 3 digit). In Windows 7 the list of profiles is part of the WWAN adapter and is accessed and handled through the Windows 7 Mobile Broadband API as specified by Microsoft.

Wireless Manager utilizes the profile list in the WMCore service in Windows XP and Vista. In Windows 7, Wireless Manager carries the profile list itself to facilitate updates of the list without requiring a driver update. Updates of the connection profile list can be made by using a Connection Profile Updater, for more information, see [6]. The connection profile updater updates the profile list in WMCore in XP and Vista and the profile list carried by Wireless Manager in Windows 7.

9.3 Ericsson Mobile Broadband C++ API

Note: In Windows 8, SDK (C++ API) is not supported.

The Ericsson Mobile Broadband C++ API (the C++ API) is part of the Ericsson Mobile Broadband Software Development Kit (SDK), which is available for integration of mobile broadband modules. The C++ API can be used as an extension to the Mobile Broadband API in Windows 7 to access functionality not supported in the Mobile Broadband API. In Windows XP and Vista, the C++ API covers the entire Mobile Broadband API as well as the extensions.

The C++ API is backward compatible. The C++ API supports multi-process and multi-thread access. By using the C++ API, application development becomes easier and more efficient since high-level interfaces can be used. The C++ API also leverages on functionality provided by the WMCore service, which includes:

- Module state and concurrency handling
- Windows Auto-connect and pre-logon connect
- Always-on functionality
- Automatic state transitions after Sleep(S3) and WWAN disable
- GPS configuration
- Internet account (APN) configuration

9.4 State machine

The state machine focuses on the main states of the module; states of the mobile radio (Radio On/Off) and the GPS radio (GPS On/Off). The transitions in the state machine that require the Software (radio) and GPS to be enabled can be made using the WMCore service (recommended) or AT commands directly. In Windows 7, several of the transitions are caused by the WWAN (Network) driver.

The transition between HW Off and states where the radio is on can be made automatically by the module without including any host software, see chapter 2.2.

Note: In Windows 8, WMCore is not supported. GPS and Radio management is handled natively.

In Windows 7 and Windows 8, running modules with older firmware (non-MBIM), several of the transitions are caused by the WWAN (Network) driver.

The module supports a SW Off (D3 hot) state where most functionality is turned off in the mobile broadband module. The main intention with the state is to prepare the module to be powered off. Among other things is the SIM card turned off. In the SW Off state it is possible to turn the module back on again using AT commands (AT+CFUN). When the module is turned on the SIM card is reset and all functionality of the mobile broadband module is turned on again.

Additionally, the module supports a separate HW control of GPS Off, see chapter 0. This feature is not depicted in Figure 29.

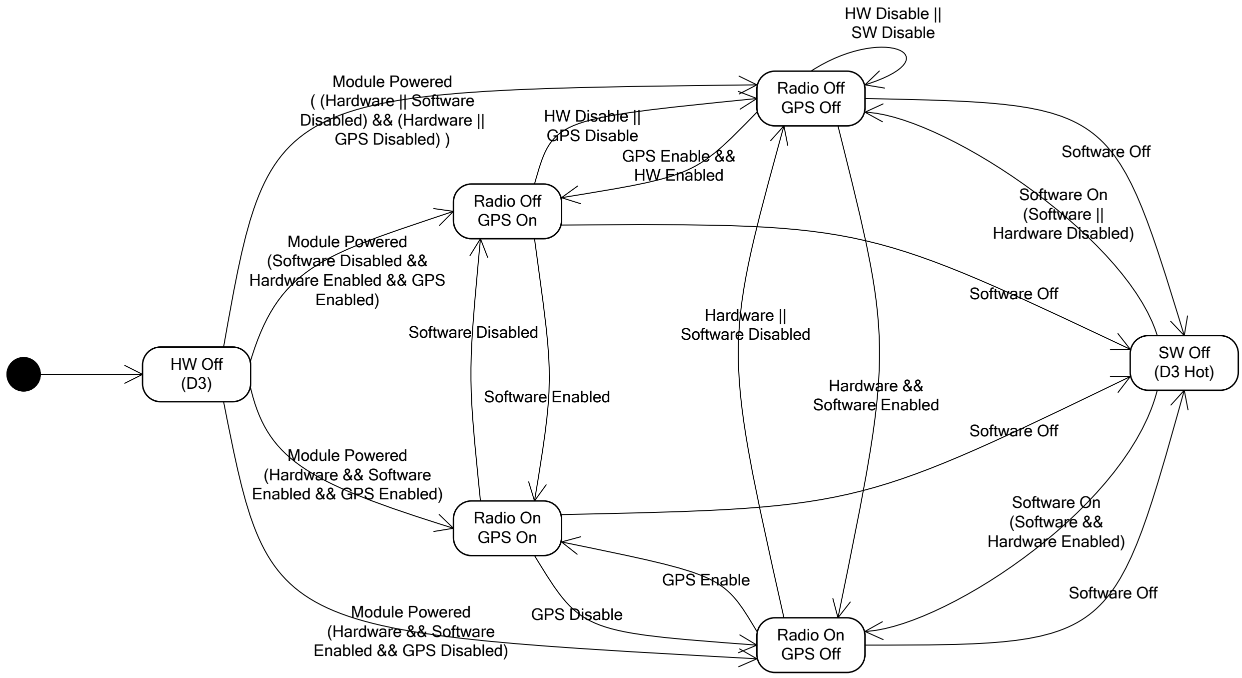


Figure 29, State machine for C5621 (Same applicable for C33 - Excluding GPS events)

9.5 EHCI Controller

It has been observed that there is a gap in the way SOF is implemented on the USB host controller.

The USB selective suspend does not work properly when the EHCI controller issues SOF within 1uS after resume-k signal.

We recommend our customers using any of the below platforms, to check with the corresponding platform vendor for latest fixes on the host controller.

Intel:

Platforms: Moorestown, Clover-trail

There are currently no publicly available solutions for SOF during the first 1ms after USB resume signaling.

NVidia:

Platform: Tegra 2

The only USB controllers working with selective suspend is the EHCI controller 3 with UTMI PHY.

9.6 Service Windows Registry Keys

Note: In Windows 8, WMCore service is not supported

The Ericsson WMCore service uses Windows Registry Keys to control the module behavior during OS power-state changes. Windows TCP/IP settings can also be optimized automatically when installing the drivers. When using the Ericsson Mobile Broadband C++ API there is no need to manually control the registry settings, however, integrators opting for using the module without the API could use these. The register settings are used to control the following features:

- Always On (OS power event behavior)
- Auto connect
- Auto radio enable
- TCP/IP optimization for WWAN devices.

Note: The registry settings are defined within the definition of the WMCore service. The registry settings definition and function can be changed or removed without prior notice.

9.6.1 Module state

The following parameters control the module function state during OS power event changes. They are used to synchronize the module state to OS state. Please refer to the AT Command Manual [4] for details on CFUN state.

The registry keys are set during the driver and WMCore installation.
Search path:

[HKEY_LOCAL_MACHINE\SOFTWARE\WMCore]
(32bit installations)

[HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432Node\WMCore]
(64bit installations)

Table 12 Module state settings

Name	Type	Description
LastKnownRadioState	REG_DWORD	CFUN value to set after boot / reboot.
ShutdownCFUN	REG_DWORD	CFUN value to set before shutdown / reboot.
KeepRadioStateDuringSleep	REG_DWORD	0: Do not keep current radio state 1: Keep radio state when entering sleep

Table 13 Connection state settings

Name	Type	Description
AllowAutoConnectAfterSleep	REG_DWORD	0: Never autoconnect after sleep, regardless of previous state 1: Allow reconnection, if previously connected.
AutoConnectStartup	REG_DWORD	0: Do not automatically connect after boot. 1: Automatically connect after boot.
DisableAutoConnect	REG_DWORD	0: Does nothing 1: Never autoconnect

9.6.2 TCP/IP Configuration

As part of installation in Windows XP, the following registry settings are made in order to optimize the throughput for WWAN devices.

[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters]

Table 14 TCP/IP Optimization

Name	Type	Value
TcpWindowSize	REG_DWORD	0x40290
Tcp1323Opts	REG_DWORD	0x1

Note: Setting Tcp1323Opts="0x3" and thus enabling Timestamp might help in some cases where there is increased packet loss. However, generally better throughput is achieved with Tcp1323Opts="0x1", since Timestamps add 12 bytes to the header of each IP packet.

10 Firmware Updates

Within a single model of the Mobile Broadband Module, different firmware configuration may be introduced for mainly two reasons:

1. A firmware configuration may be accepted by some mobile operators whereas other may require further changes to be made. This will result in that two or more versions have to be available at the same time.

2. Updated firmware configurations with added features and error corrections are created as maintenance releases, which can be supplied to the end-user for improved performance.

The first of these two reasons for different firmware configurations has traditionally resulted in multiple SKUs of the Mobile Broadband Module. The situation is improved now as the module will be able to change firmware configuration automatically, see chapter 10.1.

The second reason for different firmware configurations results in that the updated firmware is distributed to the end-user as a firmware updater application to be run on the host device.

10.1 Network Dependent Firmware Updates

The Mobile Broadband module has the capability of storing several different firmware configurations in the persistent on-board flash memory. A database containing information about all operators that have approved a specific firmware configuration is stored in the module. When a new firmware configuration is released the database will be updated. During module manufacturing the latest database available is stored in the module memory together with the valid released and approved firmware configurations.

During startup, the module will use the UICC card to identify the network operator that is currently used. The module can, based on this information select to use a different firmware configuration.

The host software can supply the end user with information regarding the updates as well as provide interfaces for 3rd party applications to implement own support for showing update information.

For more information regarding Network dependent firmware updates, see [9].

11 Terminology and abbreviations

2G	Generic term for the second generation of cellular networks. GSM is a 2G network.
3G	Generic term for the third generation of cellular networks such as UMTS
3GPP	The 3rd Generation Partnership Project
ACM	Abstract Control Model USB communications device class
ACPI	Advanced Configuration and Power Interface
APN	Access Point Name
ARP	Antenna Reference Point
CDC	USB communications device class
Cu	Copper
DRX	Discontinuous reception
ECN	Engineering Change Notice
EDGE	Enhanced Data rates for GSM Evolution
ENIG	Electroless Nickel/Immersion Gold
ESD	Electro-Static Discharge
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communications
GSMA	GSM Association
HSPA	High Speed Packet Access
LED	Light-Emitting Diode
LGA	Land Grid Array
LTO	Long Term Orbits (Internet Assisted GPS)
MSL	Moisture Sensitivity Level

N2	Nitrogen
NCM	Network Control Model USB communications device class
NDIS	Network Driver Interface Specification
NSMD	Non Solder Mask Defined
PCB	Printed Circuit Board
PC OEM	Personal Computer Original Equipment Manufacturer
PGPS	Predicted GPS
PLMN	Public Land Mobile Network
RF	Radio Frequency
RH	Relative Humidity
Rx	Receive
SAR	Specific Absorption Rate
SC	Smart Card
SIM	Subscriber Identity Module
SIP	System In Package
SKU	Stock-Keeping Unit
SMO	Solder Mask Opening
SUPL	Secure User PLane (Network Assisted GPS)
Tx	Transmit
UICC	Universal Integrated Circuit Card
UMTS	Universal Mobile Telecommunications System
USIM	Universal Subscriber Identity Module
USB	Universal Serial Bus
WCDMA	Wideband Code Division Multiple Access
WDM	Wireless Mobile Communications Device Management USB communications device class
WoW	Wake on Wireless

WWAN	Wireless Wide Area Network

12 References

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1/1550-KRD 131 24
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Copyright © 2007 GSM Association

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Copyright © 2000, Compaq Computer Corporation, Hewlett-Packard Company, Intel Corporation, Lucent Technologies Inc, Microsoft Corporation, NEC Corporation, Koninklijke Philips Electronics N.V. All rights reserved.

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[17] MBIM v1.0 specification,
http://www.usb.org/developers/devclass_docs/MBIM10.zip

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3/198 10-FAF 901 658/1 Ericsson AB

13 Annex

13.1 Test Setup for Measuring Host-Generated Noise

For a module integrated in host the total noise density level (N_{tot}) seen at the GPS receiver can be expressed as the sum of different contributions.

- Thermal Noise – Generated within the GPS receiver
- External Noise – Generated by the laptop
- WWAN Noise – Generated by the WWAN transmitter

All of these noise sources are uncorrelated and will add up to a total noise density N_{tot} at the auxiliary Antenna Reference Port (ARP), according to Equation 1.

Equation 1 Total noise level [W/Hz]

$$N_{tot} = N_t + N_{ext} + N_{wwan}$$

The thermal noise density generated by the GPS receiver itself is equal to $N_t = kTF$, where kT is -174 dBm/Hz at room temperature and F is the noise figure, typically 3.5 dB. The noise density generated by the GPS receiver is then calculated to -170.5 dBm/Hz=-116.5 dBm/MHz.

The thermal noise is the critical contribution and will set the limit for the GPS performance.

Assume that the WWAN radio is disabled, then N_{wwan} can be set to zero and therefore neglected in the further analysis.

To minimize the impact of the noise generated outside the GPS receiver a noise margin M is introduced, according to Figure 30.

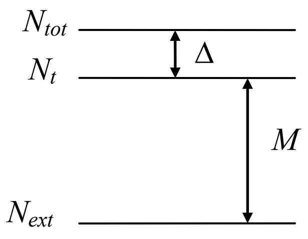

Figure 30, Definition of Noise Margin

The external noise must be lower than the thermal noise to conserve the GPS performance. The main question is how much lower?

The noise margin can be expressed as a function of the noise degradation as in Equation 2.

Equation 2 Noise Margin [dB]

$$M = 10\log\left(\frac{1}{10^{\frac{\Delta}{10}} - 1}\right)$$

Equation 2 then plotted in Figure 31   Noise Margin as a function of degradation

as function of the degradation.

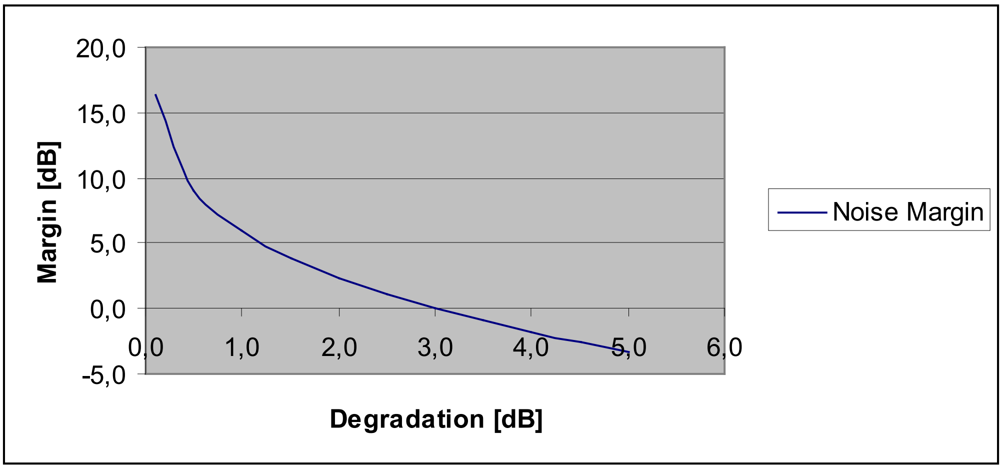

Figure 31   Noise Margin as a function of degradation

It can be seen that if the margin is set to zero, then the degradation is 3 dB. A consequence of this is that the noise generated by the host device must be substantially lower than the internal noise generated by the receiver it self.

So if the overall performance shall be conserved we can assume that the total noise level shall be degraded only 1 dB. This assumption gives, according to Figure 31   Noise Margin as a function of degradation

, that the margin must be 6 dB and therefore the noise generated by the host device at ARP must be less than -176.5 dBm/Hz=-116.5 dBm/MHz.

13.1.1 Test Setup

The test setup for measuring host-generated noise at ARP consists of two host devices:

- Host Device 1 (HD1) is used to control the GPS and measure the C/N_0 value.
- Host Device 2 (HD2) is the host device to be investigated, also known as the Device Under Test (DUT). A coaxial cable is connected from HD2 auxiliary antenna to HD1 auxiliary antenna reference port (ARP).

The test is made in two steps:

1. A reference measurement is done with HD2 turned OFF. The signal strength from all satellites is documented.
2. Then HD2 is turned ON, and a second measurement is performed. The signal strength from all satellites is documented.

The C/N_0 difference for each satellite is caused by noise added by HD2.

This measurement gives valid estimates if the signal strength from the satellites can be assumed to be constant.

Equation 3 Relation between C/N_0 and P_{rx}

$$\frac{C}{N_0} = P_{rx} - N_{tot}$$

Assume that P_{rx} is constant during the measurement period, then C/N_o is only dependent of N_{tot}, according to Equation 3.

Doing this test with open sky and good signal conditions makes it possible to estimate the increased noise density caused by HD2.