THALES

Cinterion® 5G M.2 Data Card MV31-W

Hardware Interface Description

Version: 01.009a
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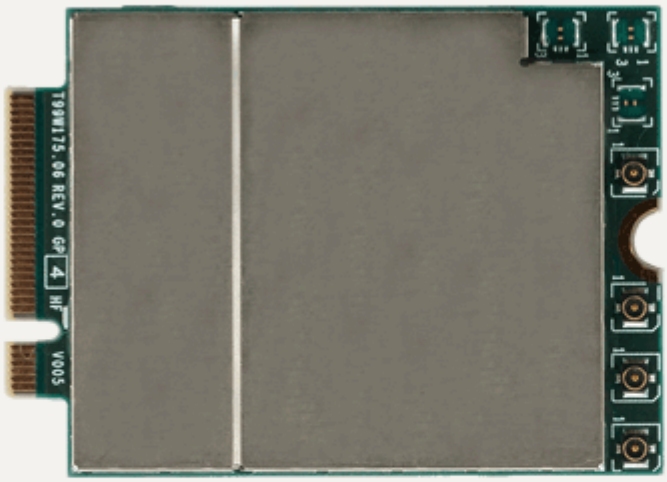

Document Name:	**5G M.2 Data Card MV31-W**
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Status	**Public / Preliminary**
Supported products:	**FR1 Sub 6 variants (See Section 1.1)**

Contents

Tables

Figures

0 Document History

Preceding document: Cinterion® MV31-W Hardware Interface Description, Version 01.009
New document: Cinterion® MV31-W Hardware Interface Description, Version **01.009a**

Chapter	What is new
2.3	Revised Figure 7 showing H2.3-S5 dimensions.
3.1	Updated electrical characteristics for FULL_CARD_POWER_OFF# (Table 3).
3.2.7	Updated Figure 13 to include second PCIe interface lane.
3.2.8.1	Revised Figure 15 to update enhanced ESD protection for SIM interface
3.2.9	New Section eUICC Interface.
4.1	Added notes regarding usage of antenna interfaces.
5.3	Revised thermal design guidelines.

Preceding document: Cinterion® MV31-W Hardware Interface Description, Version 00.058c
New document: Cinterion® MV31-W Hardware Interface Description, Version 01.009

Chapter	What is new
2.1	Revised supported 5G bands with DSS. Revised SIM feature description (DSSS -> DSSA).
2.3	Added 2.3 bottom shield dimensions.
5.2	Added thermal resistance value to Table 17.
5.9	Updated complete approval section.
6	New Appendix with label, packaging and conformance information.

Preceding document: Cinterion® MV31-W Hardware Interface Description, Version 00.058b
New document: Cinterion® MV31-W Hardware Interface Description, Version 00.058c

Chapter	What is new
2.1	Revised PCIe features. Revised 5G/4G category features.
2.2	Revised Figure 3 to add optional UIM card holder.
3.1	Updated some electrical descriptions in Table 3.
3.2.2.3	Added note recommending >30s pause between powering off and on again.
4.1	Revised Table 13, Table 14, and Table 15.
5.4	Added remark regarding recommended power reserve for peak current consumption.
6	Removed Appendix with tables showing supported CA and EN-DC configurations. These configurations are now listed in a dedicated User Guide (see [2]).

Preceding document: Cinterion® MV31-W Hardware Interface Description, Version 00.058a
New document: Cinterion® MV31-W Hardware Interface Description, Version 00.058b

Chapter	What is new
3.2.7.1	Revised description of PERST# signal
3.2.8	Added Figure 14 SIM Detection Circuit

Preceding document: Cinterion® MV31-W Hardware Interface Description, Version 00.058
New document: Cinterion® MV31-W Hardware Interface Description, Version 00.058a

Chapter	What is new
--	Removed n40
2.1	Added Data Throughput and Bands supporting DSS
4.1	Revised Table 15 regarding 5G Sub6 TX
5.2	Added Thermal Throttling Thresholds in Table 17
5.3	Added Table 18 for 3 Level Throttling Mechanism

Preceding document: Cinterion® MV31-W Hardware Interface Description, Version 00.057a
New document: Cinterion® MV31-W Hardware Interface Description, Version 00.058

Chapter	What is new
3.1	Changed Table 2 and Table 3 regarding to WAKE_ON_WWAN# signal
3.2.2.4	Revised chapter WAKE_ON_WWAN# signal is now supported

Preceding document: Cinterion® MV31-W Hardware Interface Description, Version 00.057
New document: Cinterion® MV31-W Hardware Interface Description, Version 00.057a

Chapter	What is new
1.1	Revised Table 1 regarding eSIM information
2.1	Added PCB tolerance at maximum height and revised description of SIM and SIM interface
2.2	Revised Figure 3 regarding 2nd SIM Interface
3.1	Revised Table 2 regarding UIM_1 and Table 3 regarding MIPI interface
3.2.2.1	Revised chapter regarding control circuit
3.2.3.2	Revised chapter
3.2.7	Revised Design Guidelines and Figure 13
3.2.8	Added information that 2nd interface is reserved for future use
3.2.8.1	Changed sample ESD protection component to NUP4114 and added capacitors
5.5	Replaced baseband chip name by product name
5.8	Added Chapter for Mounting Advice

Preceding document: Cinterion® MV31-W Hardware Interface Description, Version 00.050
New document: Cinterion® MV31-W Hardware Interface Description, Version 00.057

Chapter	What is new
2.1, 3.1	Changed maximum supply voltage to 4.8V.
5.7	Revised Table 27 Summary of reliability test conditions.
6.2	Revised Table 38 EN-DC Configurations.

Preceding document: Cinterion® MV31-W Hardware Interface Description, Version 00.007
New document: Cinterion® MV31-W Hardware Interface Description, Version 00.050

Chapter	What is new
Throughout document	Removed details about mmWave antenna connectors as mmWave bands are not supported with this product variant.
2	Revised Figure 1 and Figure 2 showing MV31-W top and bottom view.
3.1	Revised signal properties in Table 2.
3.2.5	Added resistor value to Figure 16.
4.1.1	Added GNSS frequencies.
5.2	Added max temperature for automatic thermal shutdown.
5.6	Revised ESD information.
6.1	Removed some comments supported CA configuration tables.

Preceding document: Cinterion® MV31-W Hardware Interface Description, Version 00.006
New document: Cinterion® MV31-W Hardware Interface Description, Version 00.007

Chapter	What is new
5.4	Revised power supply ratings.
5.5	Added timing Sequence Requirement together with its subsections.
6	New Appendix with Supported LTE CA Configurations and Supported EN-DC Configurations.

Preceding document: Cinterion® MV31-W Hardware Interface Description, Version 00.005
New document: Cinterion® MV31-W Hardware Interface Description, Version 00.006

Chapter	What is new
2.1	Revised supported Bands.
2.1, 3.1, 5.4	Changed lowest supply voltage to 3.14V (Table 3).
3.1	Revised Table 2 column Pin Type.
3.2.6	Revised USB interface description.
4	Revised notes of Table 12.

Preceding document: Cinterion® MV31-W Hardware Interface Description, Version 00.004
New document: Cinterion® MV31-W Hardware Interface Description, Version 00.005

Chapter	What is new
---	Removed information about FR2 bands.

Preceding document: Cinterion® MV31-W Hardware Interface Description, Version 00.003
New document: Cinterion® MV31-W Hardware Interface Description, Version 00.004

Chapter	What is new
---	Removed information about mmWave Variants.
2.1	Revised supported bands.

Preceding document: Cinterion® MV31-W Hardware Interface Description, Version 00.002
New document: Cinterion® MV31-W Hardware Interface Description, Version 00.003

Chapter	What is new
3	RESET# is not supported.
3.1	Added characteristics in Table 3 for mmWave_1P85.
3.2.3.1	Added Antenna Tuner example (Figure 11).
3.2.4, 3.2.5	Signal description improved.
4.1	Revised Table 13.
4.1.1	Revised Table 16.
5.3	Inserted new chapter Thermal Design Guidelines.

Preceding document: Cinterion® MV31-W Hardware Interface Description, Version 00.001
New document: Cinterion® MV31-W Hardware Interface Description, Version 00.002

Chapter	What is new
2.3	Added information about M.2 Application Connector.
2.3	Figure 7: Thermal Pad added.
3	WAKE_ON_WWAN# is not supported.
3	2nd PCI lane added for future use.
3	Change signal direction for signals mmWave_Enable_x in Table 2 and Table 3.
3.2.3	Revised signal description.

New document: Cinterion® MV31-W Hardware Interface Description, Version 00.001

Chapter	What is new
--	Initial document setup.

1 Introduction

This document[1] describes the hardware of the Cinterion® 5G M.2 Data Card MV31-W product. It helps you quickly retrieve interface specifications, electrical and mechanical details, and information on the requirements to be considered for integrating further components.

CAUTION: M.2 Add-in Card are not designed or intended to support Hot-Swap or Hot-Plug connections. Performing Hot-Swap or Hot-Plug may pose danger to the M.2 Add-in Card, to the system Platform, and to the person performing this act.

1.1 Ordering Information

Table 1: 5G Modem Card Variants

Product	Interface	Band Support	eSIM	Ordering information
MV31-W	USB 3.1 USB 2.0	FR1 (Sub 6)	Yes	Packaging unit (ordering) number: L30960-N6910-A100 Module label number[1]: S30960-S6910-A100
MV31-W	USB 3.1 USB 2.0	FR1 (Sub 6)	No	Packaging unit (ordering) number: L30960-N6910-B100 Module label number[1]: S30960-S6910-B100
MV31-W	PCIe® (2xlane) USB 2.0	FR1 (Sub 6)	Yes	Packaging unit (ordering) number: L30960-N6920-A100 Module label number[1]: S30960-S6920-A100
MV31-W	PCIe® (2xlane) USB 2.0	FR1 (Sub 6)	No	Packaging unit (ordering) number: L30960-N6920-B100 Module label number[1]: S30960-S6920-B100
Starter Kit 5G Data Card	USB	FR1 (Sub 6)		Packaging unit (ordering) number: L30960-N6901-A100 Module label number[1]: S30960-S6901-A100
Starter Kit 5G Data Card	PCIe®	FR1 (Sub 6)		Packaging unit (ordering) number: L30960-N6902-A100 Module label number[1]: S30960-S6902-A100

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.

Where necessary a note is made to differentiate between the various product variants.

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

1.2 Related Documents

[1] MV31-W Release Note
[2] MV31-W Band Combination Configuration User Guide
[3] PCI Express® M.2 Specification, Revision 4.0, November 5, 2020, PCI-SIG
[4] PCI Express® Card Electromechanical Specification, Revision 1.1, March 28, 2005
[5] Universal Serial Bus Specification[1], Revision 2.0,April 27, 2000, USB.ORG
[6] Universal Serial Bus 3.2 Specification[2] September 22, 2017, USB 3.0 Promoter Group

1.3 Terms and Abbreviations

Abbreviation	Description
3FF	Third Form Factor
3GPP	3rd Generation Partnership Project
CE	Conformité Européene (European Conformity)
CSD	Circuit Switched Data
CTM	Cellular Text Telephone Modem
DSS	Dynamic Spectrum Sharing
EN-DC	E-UTRAN New Radio Dual Connectivity
ETS	European Telecommunication Standard
FCC	Federal Communications Commission (U.S.)
GPRS	General Packet Radio Service
GSM	Global Standard for Mobile Communications
HPUE	High Power User Equipment
HSPA	High Speed Packet Access
HSDPA	High Speed Download Packet Access
I/O	Input/Output
IC	Integrated Circuit
IEC	International Electrotechnical Commission
ISO	International Standards Organization
ITU	International Telecommunications Union
LAA	Licensed Assisted Access
LED	Light Emitting Diode
Mbps	Mbits per second
MFF2	M2M UICC Form Factor 2
MMI	Man Machine Interface
MNO	Mobile Network Operator

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

Abbreviation	Description
MO	Mobile Originated
MT	Mobile Terminated
PBCCH	Packet Switched Broadcast Control Channel
PCI	Peripheral Component Interconnect (personal computer bus)
PDU	Protocol Data Unit
PIN	Personal Identification Number
PPP	Point-to-point protocol
R&TTE	Radio and Telecommunication Terminal Equipment
RF	Radio Frequency
RFFE	RF Front End
RLP	Radio Link Protocol
RoHS	Restriction of the use of certain hazardous substances in electrical and electronic equipment.
S4	Microsoft Windows power state for Hibernation.
S5	Microsoft Windows power state for Soft (power) Off.
SAR	Specific Absorption Rate
SIM	Subscriber Identification Module
SMS	Short Message Service
TTY	Text Telephone
UICC	Universal Integrated Circuit Card
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
USSD	Unstructured Supplementary Service Data

2 Product Concept

Figure 1 shows the top view and Figure 2 the bottom view of 5G M.2 Data Card MV31-W.

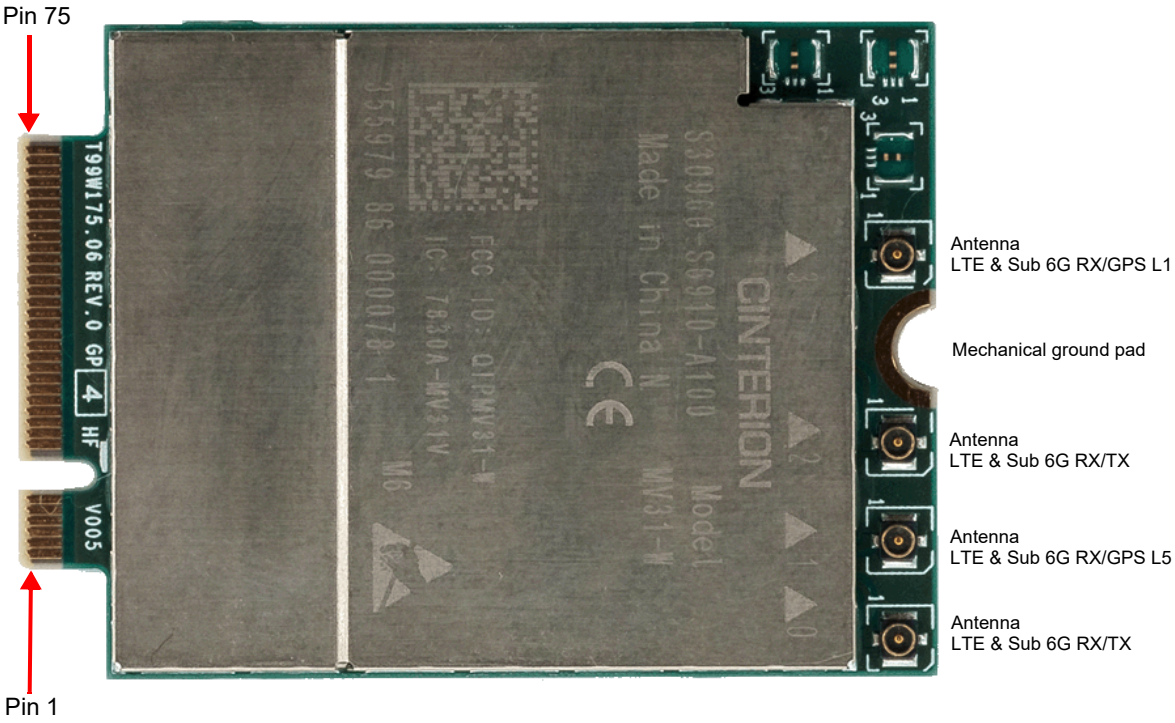

Figure 1: 5G M.2 Data Card MV31-W top view

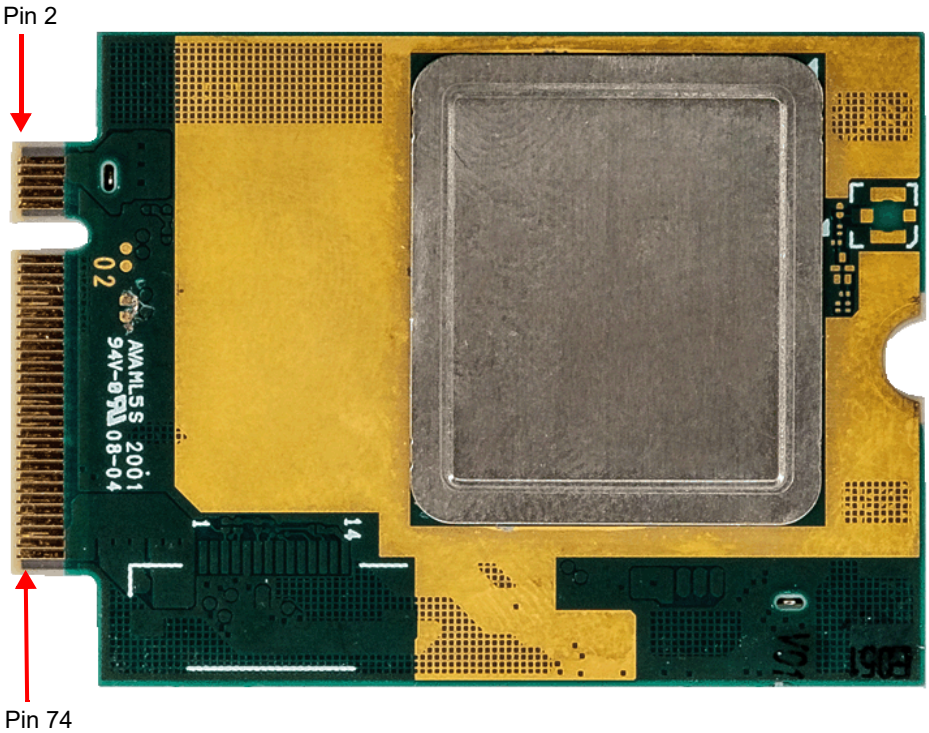

Figure 2: 5G M.2 Data Card MV31-W bottom view

2.1 Key Features at a Glance

Feature		Implementation
General		
Data throughput		DL 3.88Gbps (max. theoretical: 4.14 Gbps) at EN-DC: DC_3C-1A-7C-n78A with LTE 5CA 4x4 MIMO (20 Layers) + Sub6G 4x4 MIMO UL 632 Mbps (max theoretical: 660 Mbps) at (EN-DC: DC_7C-n78A with LTE UL CA + Sub6G SISO)
5G	Bands	FR1 (Sub 6G): FDD: n1, n2, n3, n5, n7, n8, n12, n20, n28, n66, n71 TDD: n38, n41, n77, n78, n79
	Band combinations	For supported E-UTRAN New Radio Dual Connectivity (EN-DC) see [2]
	4x4 MIMO	n1, n2, n3, n7, n66, n38, n41, n77, n78, n79
	DSS	n1, n2, n3, n5, n7, n8, n12, n20, n28, n66, n71
	Category	3GPP Rel 15 256 QAM UL/DL
	Output Power	FR1 (Sub 6G): n41, n77, n78, n79: 25.5dBm +1.5/-1dB (HPUE) All other bands: 23dBm ±1dB
4G	Bands	FDD: B1, B2, B3, B4, B5, B7, B8, B12, B13, B14, B17, B18, B19, B20, B25, B26, B28, B29, B30, B32, B66, B71 TDD: B34, B38, B39, B40, B41, B42, B48 LAA: B46 (DL only)
	Band combinations	For supported carrier aggregations (CA) see [2]
	4x4 MIMO	B1, B2, B3, B4, B7, B25, B30, B38, B39, B40, B41, B42, B48, B66
	RX Diversity	All LTE bands
	Category	UE Cat. 13 (UL: 150Mbps) + UE Cat. 20 (DL: 2Gbps); 7xDL CA, 3xUL CA (Intra-band), 5xDL CA+4X4 MIMO (Up to UE Cat20) 256 QAM UL/DL
	Output Power	B30: 22dBm ±1dBm B39: 20dBm (typical), 22.7dBm (maximum) for Japan region B41: 25.5dBm +1.5/-1.5dBm (HPUE) B42: 21 ±1dBm for US region B48: 21 +1dBm/-0.7dBm B1, B2, B3, B4, B7, B25, B34, B38, B40, B66: 23dBm ±1dBm B5, B8, B12, B13, B14, B17, B18, B19, B20, B26, B28, B71: 23.5dBm ±1dBm
3G	Bands	Bd.I, Bd.II, Bd.IV, Bd.V (Bd.VI, Bd.XIX), Bd.VIII, Bd.IX
	RX Diversity	All 3G bands
	Category	DC-HSPA+ – DL Cat. 24 (42Mbps) / UL Cat. 6 (11Mbps) HSUPA – UL 5.76Mbps Compressed mode (CM) supported according to 3GPP TS25.212
	Output Power	All bands: 23.5dBm +1/-1dB

Feature	Implementation
GNSS	Dual-Frequency GNSS: GPS: L1; L5 GLONASS: G1 Beidou: B1 Galileo E1; E5a
SIM	Dual SIM with eSIM on board, Dual SIM Single Active (DSSA)
Power supply	3.3V (typical, min. 3.14V,max. 4.8V)
Temperature	Normal operation: -30°C to +70°C Extended operation: -40°C to +85°C Storage: -40°C to +85°C
Physical	Dimensions: 42 mm × 30 mm × 2.6 mm Weight: approx. 8 g
RoHS	All hardware components fully compliant with EU RoHS Directive
Interfaces	
Form factor	M.2 3042 S3 Key B
Application connector	PCI Express® M.2 Card system connector (75 pin golden finger, Key ID B)
USB	USB 2.0
	MV31-W USB only: USB 3.1 Gen.2 SuperSpeed (10Gbps) USB configuration supported: Windows(TM)10: MBIM, GNSS Linux: DIAG, MBIM/RmNet, Modem, NMEA
PCIe®	**MV31-W PCIe®only:** Supports Endpoint and Root Complex, Gen 3, 2 lanes PCIe® configuration supported: Windows(TM)10: MBIM, GNSS Linux: DIAG, MBIM, Modem, NMEA
Driver	Windows(TM) 10 / Windows(TM) 10: Supports both PCIe® and USB interfaces Linux Kernel versions 5.13 / 5.15: MBIM on both PCIe® and USB interfaces Android 11: RIL driver SW
UICC	Supported SIM/USIM cards: 3V, 1.8V External SIM card reader has to be connected via application connector. A second SIM/USIM interface is optionally available at the application connector.
Antenna	4 MHF4 type connectors for UMTS/LTE/5G (Sub 6G) main antenna and UMTS/LTE/5G (Sub 6G) Diversity/MIMO antennas

2.2 System Overview

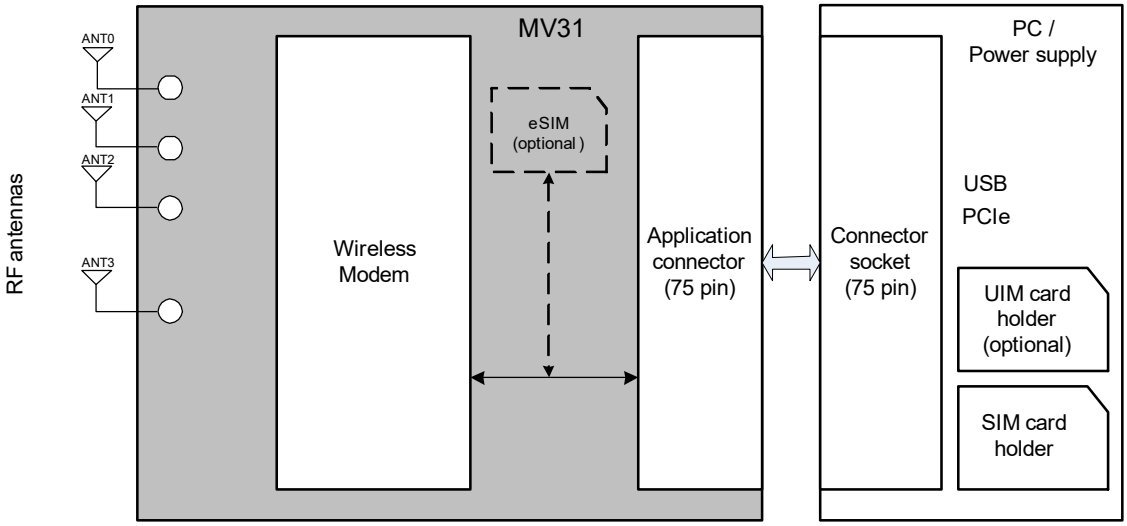

Figure 3: 5G M.2 Data Card MV31-W system overview

2.3 Mechanical Dimensions

The mechanical dimensions for PCI Express M.2 Cards with a 3042 form factor are specified in [3] and shown in Figure 4, Figure 5 and Figure 7.

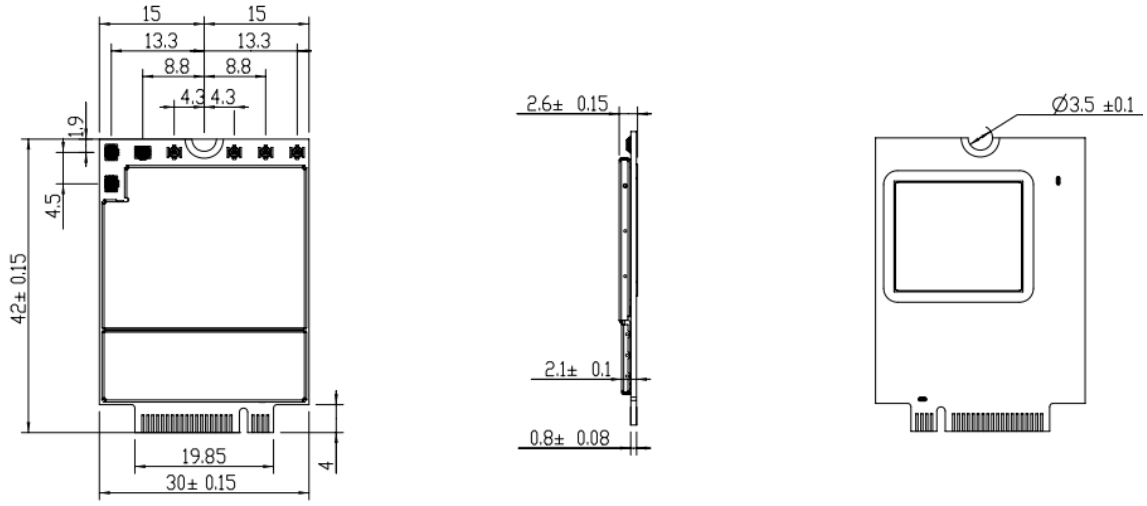

Figure 4: 5G M.2 Data Card MV31-W Dimensions

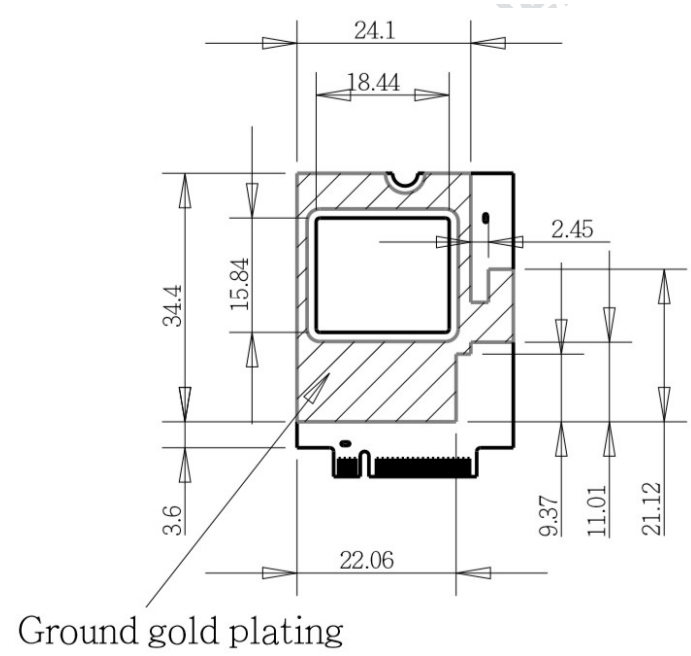

Figure 5: 5G M.2 Data Card MV31-W Ground area (with gold plating) on bottom side

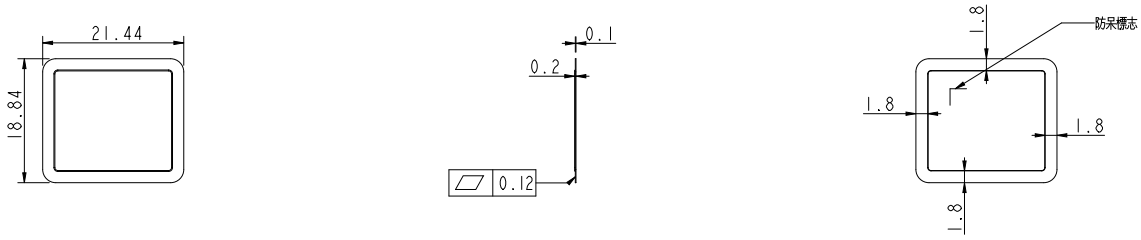

Figure 6: 5G M.2 Data Card MV31-W bottom shield dimensions

The 5G M.2 Data Card MV31-W complies with the single-sided add-in card H2.3-S5: “Stack-up Top Mount Single-sided Add-in Card for 2.00 Maximum Top-side Component Height and with Higher Clearance above Motherboard” specified in [3].

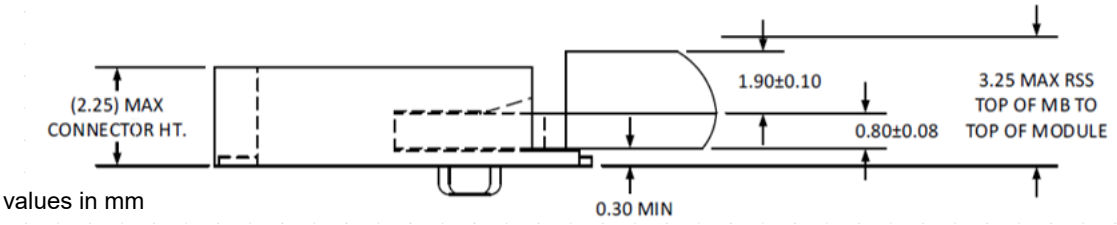

Figure 7: H2.3-S5 single-sided add-in card dimensions

The area under the 5G M.2 Data Card on the Application Board should be free of components and signals, but needs to be part of a thermal solution (see Section 5.3).

3 Application Connector Interface

3.1 Pin Assignments and Electrical Description

Table 2 matches the 5G M.2 Data Card MV31-W pin assignments at the 75-pin application connector to the pin assignments specified in [3]. Table 3 lists electrical characteristics of the assigned and available pins at the application connector interface.

Table 2: Pin assignments

Pin No.	5G M.2 Data Card MV31-W pin name[1]	Comments	PIN Type
1	CONFIG_3	Add-in Card Configuration 3, Section 3.2.12	Output
3	GND		
5	GND		
7	USB+	USB Data, Section 3.2.6.1	
9	USB-		
11	GND		
Key ID B			
21	CONFIG_0	Add-in Card Configuration 0,Section 3.2.12	Output
23	WAKE_ON_WWAN#	Wake on WWAN, Section 3.2.2.4	Output 1.8V
25	DPR_1	Dynamic Power Reduction (SAR), Section 3.2.5	Input 1.8V
27	GND		
29	USB3.1-Tx-	USB 3.1 (USB Tx-), Section 3.2.6.2	Output Usage as PCIe or USB 3.1 i/f dependent on HW variant
	PETn1	2nd PCIe® lane Tx-, Section 3.2.7	
31	USB3.1-Tx+	USB 3.1 (USB Tx+), Section 3.2.6.2	
	PETp1	2nd PCIe® lane Tx+, Section 3.2.7	
33	GND		
35	USB3.1-Rx-	USB 3.1 (USB Rx-), Section 3.2.6.2	Input Usage as PCIe or USB 3.1 i/f dependent on HW variant
	PERn1	2nd PCIe® lane Rx-, Section 3.2.7	
37	USB3.1-Rx+	USB 3.1 (USB Rx+), Section 3.2.6.2	
	PERp1	2nd PCIe® lane Rx+, Section 3.2.7	
39	GND		
41	PETn0	1st PCIe® lane Tx+/-, Section 3.2.7	Output
43	PETp0		
45	GND		

Table 2: Pin assignments

Pin No.	5G M.2 Data Card MV31-W pin name[1]	Comments	PIN Type
47	PERn0	1st PCIe® lane Rx+/-, Section 3.2.7	Input
49	PERp0		
51	GND		
53	REFCLKn	PCIe® Reference Clock, Section 3.2.7	Input
55	REFCLKp		
57	GND		
59	mmWave_Enable_1	Reserved for mmWave product variant	Output 1.8V
61	mmWave_Enable_2	Reserved for mmWave product variant	Output 1.8V
63	mmWave_Enable_3	Reserved for mmWave product variant	Output 1.8V
65	mmWave_1P85	Reserved for mmWave product variant	Output 1.9V
67	RESET#	Asynchronous RESET, Section 3.2.2.2 (not supported by MV31-W)	Input 1.8V
69	CONFIG_1	Add-in Card Configuration 1, Section 3.2.12	Output
71	GND		
73	GND		
75	CONFIG_2	Add-in Card Configuration 2, Section 3.2.12	Output
2	3V3	Power supply 3.3V, Section 3.2.1	
4	3V3		
6	FULL_CARD_POWER_OFF#	Section 3.2.2.3	Input 3.3V
8	W_DISABLE1#	Disable WWAN on the Data Card, Section 3.2.2.1	Input 3.3V
10	LED_1#	Active low signal, Section 3.2.11	Output Open drain
Key ID B			
20			internal not connected
22	ANT_TUNER_CONFIG	Antenna tuner mode control, Section 3.2.3.2	Input 1.8V
24	ANT_TUNER_POWER	Antenna tuner power	Output 1.8V
26	W_DISABLE2#	disable GNSS on Data Card, Section 3.2.2.1	Input 3.3.V
28	DPR_2	Dynamic Power Reduction (SAR), Section 3.2.5	Input 1.8V

Table 2: Pin assignments

Pin No.	5G M.2 Data Card MV31-W pin name[1]	Comments	PIN Type
30	UIM_1_RESET	UIM_1 connect to external SIM socket, Section 3.2.8	Output
32	UIM_1_CLK		Output
34	UIM_1_DATA		Input/Output
36	UIM_1_PWR		Output
38	WLAN_Tx_EN	WLAN output to WWAN, Section 3.2.4	Input 1.8V
40	SIM DETECT_2	UIM_2 optionally available, Section 3.2.8	Input 1.8V
42	UIM_2_DATA		Input/Output
44	UIM_2_CLK		Output
46	UIM_2_RESET		Output
48	UIM_2_PWR		Output
50	PERST#	PE-Reset, Section 3.2.7	Input 3.3V
52	CLKREQ#	Clock Request, Section 3.2.7	Input/Output 3.3V
54	PEWAKE#	PCIe® WAKE, Section 3.2.7	Input/Output Open Drain 3.3V
56	MIPI_DATA	For external tunable antenna (MIPI), Section 3.2.3	Input/Output 1.8V
58	MIPI_CLK		Output 1.8V
60	LAA_n79_Tx_EN	WWAN output to WLAN, Section 3.2.4	Output 1.8V
62	COEX_RXD	UART I/F for LTE / Wi-Fi coexistence, Section 3.2.4	Input 1.8V
64	COEX_TXD		Output 1.8V
66	SIM DETECT_1	SIM 1 detect, Section 3.2.8	Input 1.8V
68	GPIO	General Purpose I/O, Section 3.2.10	Input/Output 1.8V
70	3V3	Power supply 3.3V, Section 3.2.1	
72	3V3		
74	3V3		

1. Connected lines (various): ; Power Supply: ; Ground lines (GND): ;
PCIe® hardware variant only ; USB 3.1 hardware variant only
Not connected lines (nc): ; Do not connect, Reserved for future use

Table 3: Electrical description of connector interface pins

Function	Pin name	IO	Signal form and level	Comment
Power supply	3V3	I	$V_I$max = 4.8V $V_I$norm = 3.3V $V_I$min = 3.14V	
	GND		Ground	Application Ground
Control Signals	W_DISABLE1#	I	V_{IH}max = 3.36V V_{IH}min = 2.145V V_{IL}max = 1.155V	These signals disable the WWAN (W_DISABLE1#) and GNSS W_DISABLE2#) operation of the module. It is required to drive these lines low by an open drain or open collector driver connected to GND and external pull up to 3.3V with 10KΩ. Test point recommended.
	W_DISABLE2#	I		
	RESET#	I	--	Not supported.
	FULL_CARD_POWER_OFF#	I	V_{IH}max = 3.63V V_{IH}min =1.00V V_{IL}max = 0.4V	It's internally pulled down by 100kΩ resistor. 3.3V tolerant but can be driven by either 1.8V or 3.3V GPIO. Test point recommended.
	WAKE_ON_WWAN#	O	V_{IL}max = 0.8V V_{IH}min = 2.0V V_{IH}max = 3.8V V_{OL}max = 0.2V at I = 4mA	Open Drain with external pull up. The given input rating is the maximum voltage that can be applied to this pad.
Tunable Antenna	MIPI_DATA	I/O	V_{IL}max = 0.54V V_{IH}min = 1.26V V_{IH}max = 2.1V V_{OL}max = 0.45V at I = 4mA V_{OH}min = 1.35V at I = 4mA V_{OH}max = 1.8V	If unused, terminate line by 50Ω.
	MIPI_CLK	O	V_{OL}max = 0.45V at I = 4mA V_{OH}min = 1.35V at I = 4mA V_{OH}max = 1.8V	If unused, terminate line by 50Ω.
	ANT_TUNER_CONFIG	I	V_{IL}max = 0.54V V_{IH}min = 1.26V V_{IH}max = 2.1V	
	ANT_TUNER_POWER	O	V_{OL}max = 0.012V at I = 4mA V_{OH}min = 1.504V at I = 4mA V_{OH}max = 2.0V.	

Table 3: Electrical description of connector interface pins

Function	Pin name	IO	Signal form and level	Comment
WWAN/ WiFi Coexis-tence Con-trol	LAA_n79_Tx_EN	O	V_{OL}max = 0.45V at I = TBD. V_{OH}min = 1.35V at I = TBD. V_{OH}max = 1.8V	
	COEX_RXD	I	V_{IL}max = 0.54V V_{IH}min = 1.26V V_{IH}max = 2.1V	For future use.
	COEX_TXD	O	V_{OL}max = 0.45V at I = TBD. V_{OH}min = 1.35V at I = TBD. V_{OH}max = 1.8V	For future use.
	WLAN_Tx_EN	I	V_{IL}max = 0.54V V_{IH}min = 1.26V V_{IH}max = 2.1V	
Dynamic Power Reduction	DPR_1 DPR_2	I	DPR_1: V_{IH}max = 1.89V V_{IH}min = 1.17V V_{IL}max = 0.63V DPR_2: V_{IL}max = 0.54V V_{IH}min = 1.26V V_{IH}max = 2.1V	It is required to drive this line low by an open drain or open collector driver connected to GND. If unused keep line open.
USB 2.0	USB_D-	I/O	Full and High speed differential lines according to USB 2.0 (refer to [5]).	Test point recommended. USB High Speed mode operation requires a differential impedance of 90Ω.
	USB_D+	I/O		
USB 3.1 (USB 3.1 HW variant only)	USB3.1-Rx+ USB3.1-Rx-	I	SuperSpeed differential lines according to USB3.1 Gen2, 10Gbps (refer to [6])	USB SuperSpeed mode operation requires a differential impedance of 72Ω to 120Ω.
	USB3.1-Tx+ USB3.1-Tx-	O		

Table 3: Electrical description of connector interface pins

Function	Pin name	IO	Signal form and level	Comment
PCIe® (PCIe HW variant only)	PERST#	I	RPU: 10K ohm V_{OH}max = NA V_{IH}max = 3.8V V_{IH}min = 2.0V V_{IL}max = 0.8V A Low will immediately reset the PCIe interface of the data card.	This line must be driven low by an open drain or open collector driver connected to GND as long as the module turns off. If unused keep line open. Test point recommended.
	CLKREQ#	I/O	V_{IL}max = 0.8V V_{IH}min = 2.0V V_{IH}max = 3.8V V_{OL}max = 0.2V at I = 4mA	Open Drain with external pull up. The given input rating is the maximum voltage that can be applied to this pad.
	PEWAKE#	I/O	V_{IL}max = 0.8V V_{IH}min = 2.0V V_{IH}max = 3.8V V_{OL}max = 0.2V at I = 4mA	Open Drain with external pull up. The given input rating is the maximum voltage that can be applied to this pad.
	PERp0, PERp1, PERn0, PERn1	I	PCIe® differential lines according to PCI Express® Card Electromechanical Specification	
	PETp0, PETp1, PETn0, PETn1	O	PCIe® differential lines according to PCI Express® Card Electromechanical Specification	
	REFCLKp/ REFCLKn	I	PCIe® differential lines according to PCI Express® Card Electromechanical Specification	
3V SIM card interfaces (2x)	UIM_1_RESET UIM_2_RESET	O	V_{OL}max = 0.59V at I = 1mA V_{OH}min = 2.36V at I = 1mA V_{OH}max = 2.95V	Maximum cable length or copper track should be not longer than 100mm to SIM card holder. If 2nd SIM interface not used, keep line open.
	UIM_1_DATA UIM_2_DATA	I/O	V_{IL}max = 0.59V V_{IL}min = -0.3V V_{IH}min = 2.065V V_{IH}max = 3.25V V_{OL}max = 0.4V. at I = 1mA V_{OH}min = 2.065V at I = 1mA V_{OH}max = 2.95V	
	UIM_1_CLK UIM_2_CLK	O	V_{OL}max = 0.59V at I = 1mA V_{OH}min = 2.065V at I = 1mA V_{OH}max = 2.95V	
	UIM_1_PWR UIM_2_PWR	O	$V_O$min = 2.7V $V_O$typ =2.95V $V_O$max = 3.05V $I_O$max = 200mA	

Table 3: Electrical description of connector interface pins

Function	Pin name	IO	Signal form and level	Comment
1.8V SIM card interface (2x)	UIM_1_RESET UIM_2_RESET	O	V_{OL}max = 0.36V at I = 1mA V_{OH}min = 1.44V at I = 1mA V_{OH}max = 1.8V	Maximum cable length or copper track should be not longer than 100mm to SIM card holder. If 2nd SIM interface not used, keep line open.
	UIM_1_DATA UIM_2_DATA	I/O	V_{IL}max = 0.36V V_{IL}min = -0.3V V_{IH}min = 1.26V V_{IH}max = 2.1V V_{OL}max = 0.3V at I = 1mA V_{OH}min = 1.26V at I = 1mA V_{OH}max = 1.8V	
	UIM_1_CLK UIM_2_CLK	O	V_{OL}max = 0.36V at I = 1mA V_{OH}min = 1.26V at I = 1mA V_{OH}max = 1.8V	
	UIM_1_PWR UIM_2_PWR	O	$V_O$min = 1.65V $V_O$typ =1.8V $V_O$max = 1.95V $I_O$max = 200mA	
SIM Detection	SIM_DETECT_1 SIM_DETECT_2	I	V_{IL}max = 0.54V V_{IH}min = 1.26V V_{IH}max = 2.1V	internal pull-up resistor
GPIO interface	GPIO	I/O	V_{IL}max = 0.54V V_{IH}min = 1.26V V_{IH}max = 2.1V I_{IH}PD = 1uA I_{IL}PU = -1uA I_{High-Z} = 1uA V_{OL}max = 0.45V at I = TBD. V_{OH}min = 1.35V at I = TBD. V_{OH}max = 1.8V	GPIO is reserved for future use. If unused keep lines open.
Status	LED_1#	O	V_{OL}max = 0.66V. at I = TBD. V_{OH}min = 2.64V. at I = 9~12 (sink current) V_{OH}max = 3.3V	Open Drain output
Add-in Card configuration pins	CONFIG_0..3		GND or NC (Not Connected/Floating) I = 0mA	The host must provide a pull up resistor for each of these signals to either 1.8 V or 3.3 V.

3.2 Characteristics

3.2.1 Power Supply and Ground

The 5G M.2 Data Card MV31-W uses the five 3V3 pins and 11 GND pins listed in Section 3.1. All pins have to be used in parallel.

3.2.2 Control Signals

3.2.2.1 W_DISABLE1#, W_DISABLE2# Signals

W_DISABLE1# controls the WWAN part of the data card. When this signal is driven low, the WWAN part is disabled.

W_DISABLE2# controls the GNSS part of the data card. When this signal is driven low, the GNSS part is disabled.

It is recommended to control W_DISABLE1# and W_DISABLE2# lines with an open collector transistor.

3.2.2.2 RESET#

Asynchronous RESET# pin (active low) is not supported by MV31-W.

3.2.2.3 FULL_CARD_POWER_OFF#

The MV31-W can be controlled to power on/off by the FULL_CARD_POWER_OFF# pin.

Table 4: FULL_CARD_POWER_OFF# States

Signal State	Data Card State
Low	Powers off
High	Powers on

Note: Once FULL_CARD_POWER_OFF# is pulled low, MV31-W detaches from the network, shuts down its internal interfaces, and then power off automatically. After power off, it is recommended to pause for >30s before powering MV31-W on again by pulling the pin high.

3.2.2.4 WAKE_ON_WWAN#

The WAKE_ON_WWAN# signal is for power saving:
1. MV31-W always listening at very low power in idle mode
2. MV31-W will wake up mother board via WAKE_ON_WWAN# signal, when this feature is enabled by AT+WOWWAN_ENABLE=1 and the receiving SMS contains the password <pw>, which is set by AT+WOWWAN_PASSWORD=<pw>. For details refer to [3].
3. The platform will power on when triggered by the MV31-W.

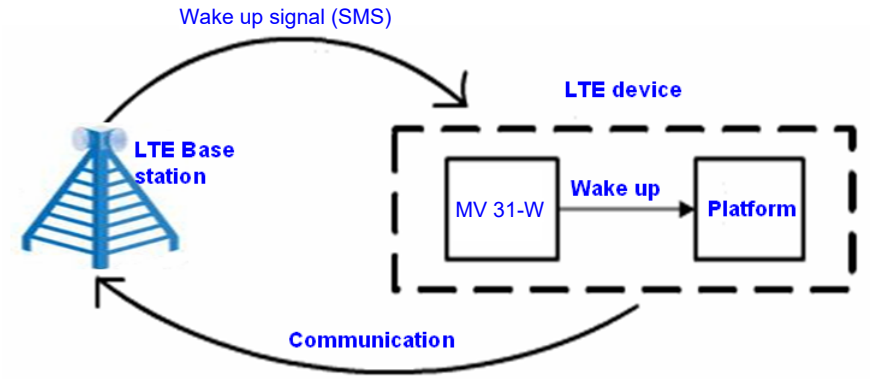

Figure 8: Wake-up scenario

The WAKE_ON_WWAN# signal is used to wake up the host. It is open drain and should be pulled up at the host side. When MV31-W needs to wake up the host, it will output a one second low pulse, shown in Figure 9.

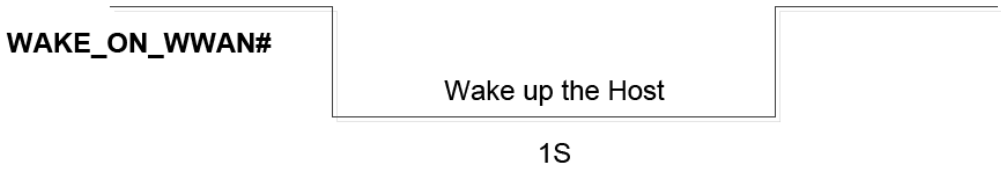

Figure 9: Wake-up signal

A typical connection in Platform/System shows Figure 10.

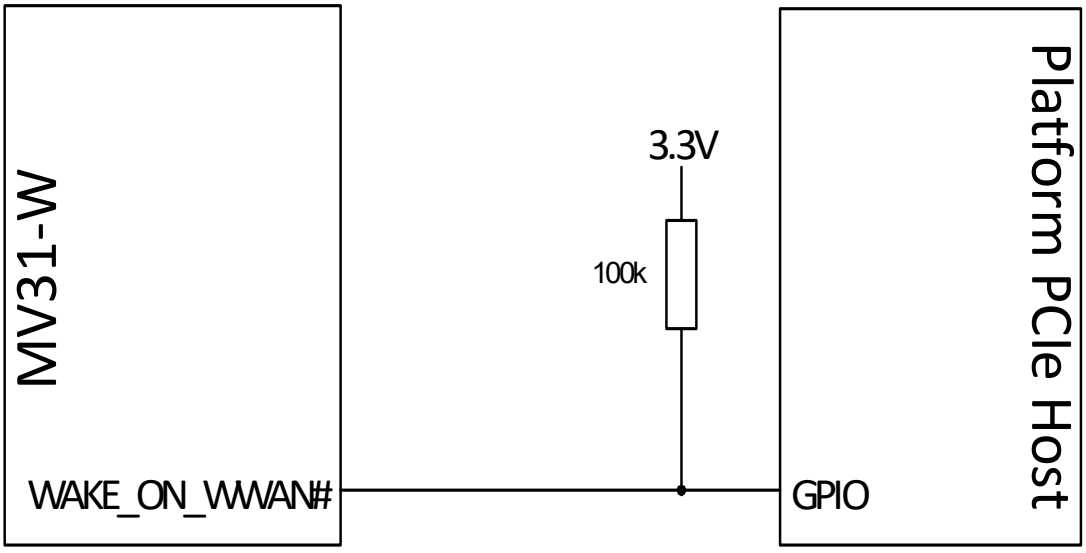

Figure 10: Typical Wake up schematic

3.2.3 Tunable Antenna Interface

3.2.3.1 Antenna Control

MV31-W provides a MIPI interface (MIPI_DATA/RFFE2_DATA and MIPI_CLK/RFFE2_CLK) for external antenna tuner application to allow the implementation of antenna tuner solutions, e.g. with QAT3555 antenna impedance tuner (see Figure 11).

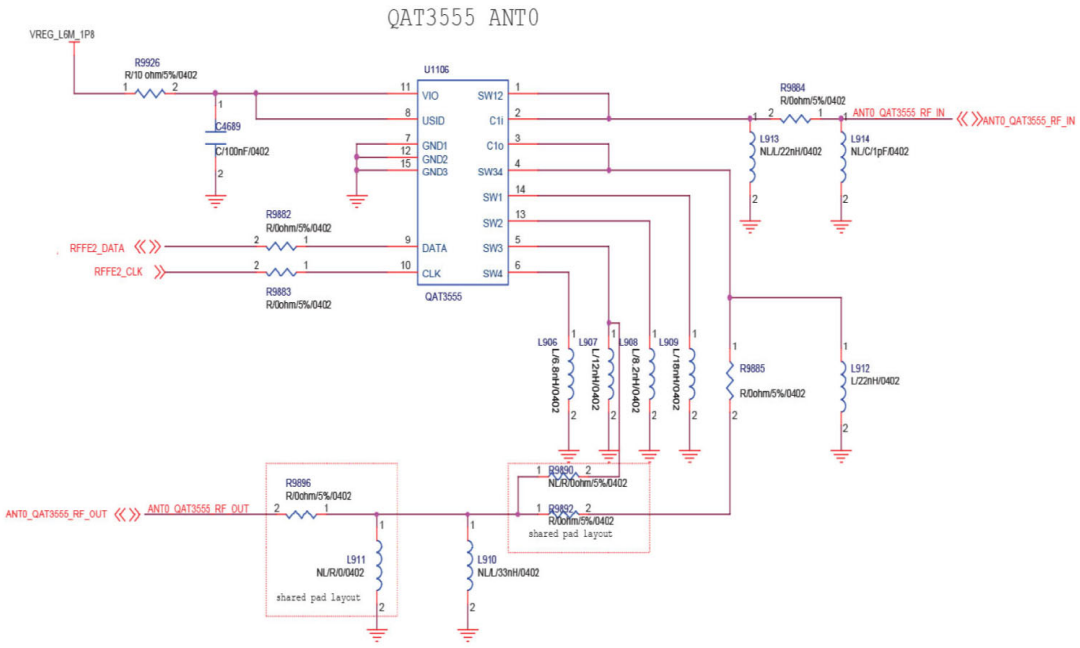

Figure 11: Sample Antenna Tuner with QAT3555 for one antenna path

3.2.3.2 ANT_TUNER_CONFIG

The ANT_TUNER_CONFIG pin of the MV31-W has the possibility to optimize the FR1 low band performance. The configuration is mainly for mobile devices with integrated antennas. Depending on the handling of the device the host controller can use this pin to trigger the 2 pre configuired modes.
Factors as the antennas, housing, size of the device, material and mobile handling e.g. tablet or notebook are influencing the performance.

Table 5: ANT_TUNER_CONFIG States

Signal State	Scenario
Low	For notebooks (Tuner Mode 0)
High	For tablets (Tuner Mode 1)

3.2.4 WWAN/WiFi Coexistence Control

The signals COEX_RXD, COEX_TXD, LAA_n79_Tx_EN and WLAN_Tx_EN are provided to allow the implementation of wireless coexistence solutions between the radio(s) on the M.2 Data Card and other off-card radio(s). These other radios can be located on another M.2 Card located in the same host platform or as alternate radio implementations.

Table 6: Coexistence Control between LAA and n79 with WiFi 5GHZ

Signal	Direction	Description
LAA_n79_Tx_EN	MV31-W to WLAN	Avoid n79 Tx impact 5GHz Wi-Fi Rx (While n79/LAA is in Tx mode, the WiFi 5G Rx mode is not working.)
WLAN_Tx_EN	WLAN to MV31-W	Avoid WLAN Tx impact n79/LAA Rx (While WiFi 5G is in Tx mode, the n79/LAA Rx mode is not working.)

The signals COEX_RXD, COEX_TXD are reserved for future use.

3.2.5 Dynamic Power Reduction

The optional DPR signals are used by M.2 Data Card to assist in meeting regulatory SAR (Specific Absorption Rate) requirements for RF exposure. The signal is provided by a host system proximity sensors to the M.2 Data Card to provide an input trigger causing a reduction in the radio transmit output power.

The required value of the power reduction will vary between different host systems and is left to the host platform OEM and card vendor to determine, along with the specific implementation details. The assertion and de-assertion of DPR is asynchronous to any system clock. All transients resulting from the proximity sensor need to be de-bounced by system circuitry.

Table 7: Dynamic Power Reduction States

Signal	Signal State	Definition
DPR_1	Low	Enable the SAR power back off
	High	Disable the SAR power back off
DPR_2	Low	Reserved for EN-DC multiple Tx requirement
	High	

DPR_1 can be implemented for 3G/4G/5G ANT Tx. DPR_2 can be implemented for 5G FR1 ANT Tx only in case DPR_1 is for 3G/4G ANT Tx.

It is recommended to control DPR_1 and DPR_2 lines with an open collector transistor or an open drain field-effect transistor.

3.2.6 USB Interface

The 5G M.2 Data Card MV31-W has 6 interface lines for USB (see Figure 12) and is acting as peripheral.

USB Design General Guidelines:
- Reserve choke on all the USB signals in platform for noise debug.
- Reserve 0.1uF capacitor on USB3.1 TX/Rx paths.
- Co-layout USB3 choke and 0.1uF capacitor on module side for noise debug

Notes: All the above components should be covered by shielding cover.

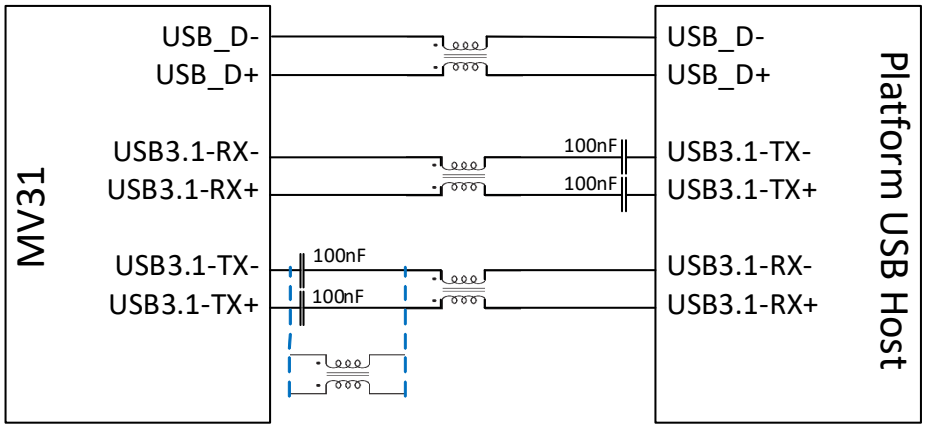

Figure 12: USB Interface

3.2.6.1 USB 2.0 Interface

The 5G M.2 Data Card MV31-W's USB interface (USB_D+, USB_D-) as part of the 75-pin application connector supports a USB 2.0 High Speed (480Mbit/s) device interface that is Full Speed (12Mbit/s) compliant. Because there is no separate voltage detection line available on the application connector, the 5G M.2 Data Card MV31-W reports as a self-powered device compliant with the [5].

3.2.6.2 USB 3.1 Gen 2 Interface

The USB 3.1 Gen 2 Interface is compliant to [6] and supports up to 10Gbit/s.

Please note that with the data card's PCIe hardware variant the USB 3.1 interface pins are used as PCIe 2nd lane pins.

3.2.7 PCI Express® Interface

The PCI Express® Interface with a 1st and 2nd lane is compliant to [4]. Please note that with the data card's USB 3.1 hardware variant the PCIe's 2nd lane pins are used as USB 3.1 interface pins.

PCIe® Design General Guidelines:

- All sensitive/high high-speed signals and circuits must be protected from PCIe® corruption, e.g. noisy signal, crosstalk and RF.
- Pay extra attention to crosstalk, ISI, and intra-lane skew and impedance discontinuities.
- Each trace needs to be adjacent to a ground plane.
- PCIe® PERx0/1, PETx0/1, REFCLK: 90 Ohm differential, +/ -10% trace impedance.
- AC coupling capacitor should be added in an application board: 220nF
  - Place 220nF capacitors on PCIe® PETx0/1 paths at module side (already included in MV31-W)
  - Place 220nF capacitors on PCIe® PETx0/1 paths at platform side.
- Reserve choke on all the PCIe® signals in platform for noise reduction
- Tx differential pair length matching < 0.5mm.
- Rx differential pair length matching < 0.5mm.

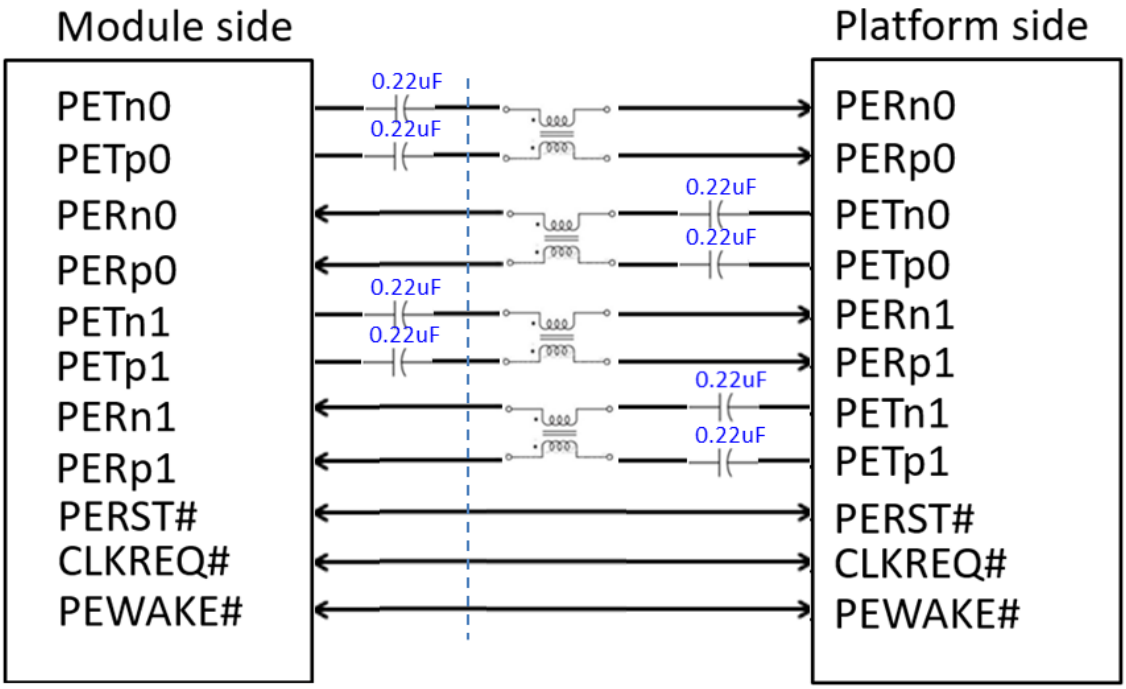

Figure 13: PCIe® Interface

3.2.7.1 PERST# Signal

The PERST# signal resets the PCIe Interface of the 5G M.2 Data Card MV31-W. After releasing the PERST# line, i.e., with a change of the signal level from low to high, the interface restarts.

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

3.2.8 SIM/UICC Interface

The 5G M.2 Data Card MV31-W provides a SIM/UICC interface at the 75-pin application connector compliant to the ISO/IEC 7816-3 specification. The SIM interface is intended for 1.8V and 3V SIM cards in accordance with GSM 11.12 Phase 2.

The following table lists the pins available for the SIM/UICC interface. A second SIM interface is optionally available. With the embedded SIM (eUICC) hardware variant, the lines for the second SIM interface are internally connected to the eUICC (see Section 3.2.9).

Table 8: Signals of the SIM interface

Signal	Description
UIM_1_CLK UIM_2_CLK	SIM clock
UIM_1_PWR UIM_2_PWR	SIM supply voltage.
UIM_1_DATA UIM_2_DATA	Serial data line, input and output.
UIM_1_RESET UIM_2_RESET	SIM reset
SIM_DETECT_1 SIM_DETECT_2	SIM insertion detection (Low = no SIM inserted, see Figure 14)

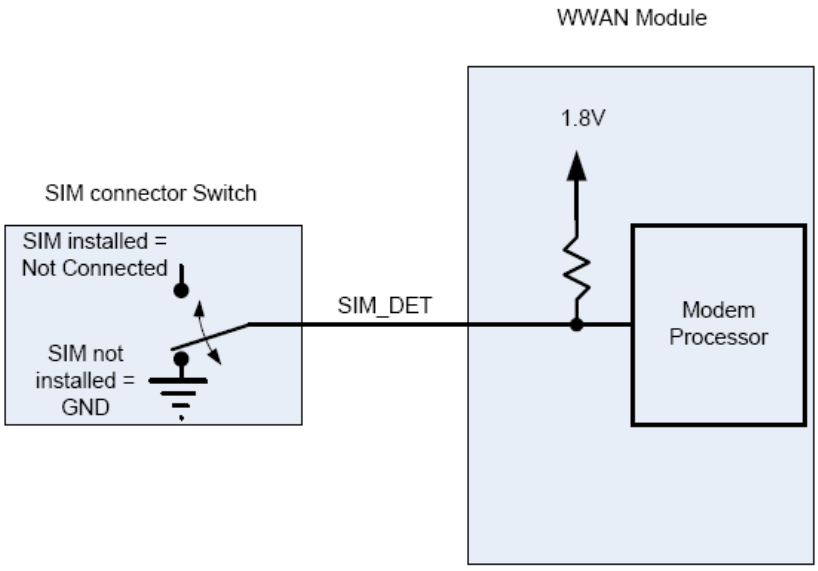

Figure 14: SIM Detection Circuit

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 5G M.2 Data Card MV31-W must be restarted.

The total cable length between the 5G M.2 Data Card MV31-W socket pads and the pads of an 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 (see Figure 3.2.8.1).

To avoid possible cross-talk from the UIM_1_CLK signal to the UIM_1_DATA 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 UIM_1_DATA line from the UIM_1_CLK line.

3.2.8.1 ESD Protection for SIM Interfaces

For ESD protection of the SIM interfaces it is required to add ESD diodes to the interface lines of the first and second SIM interface as shown in the example given in Figure 15.

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

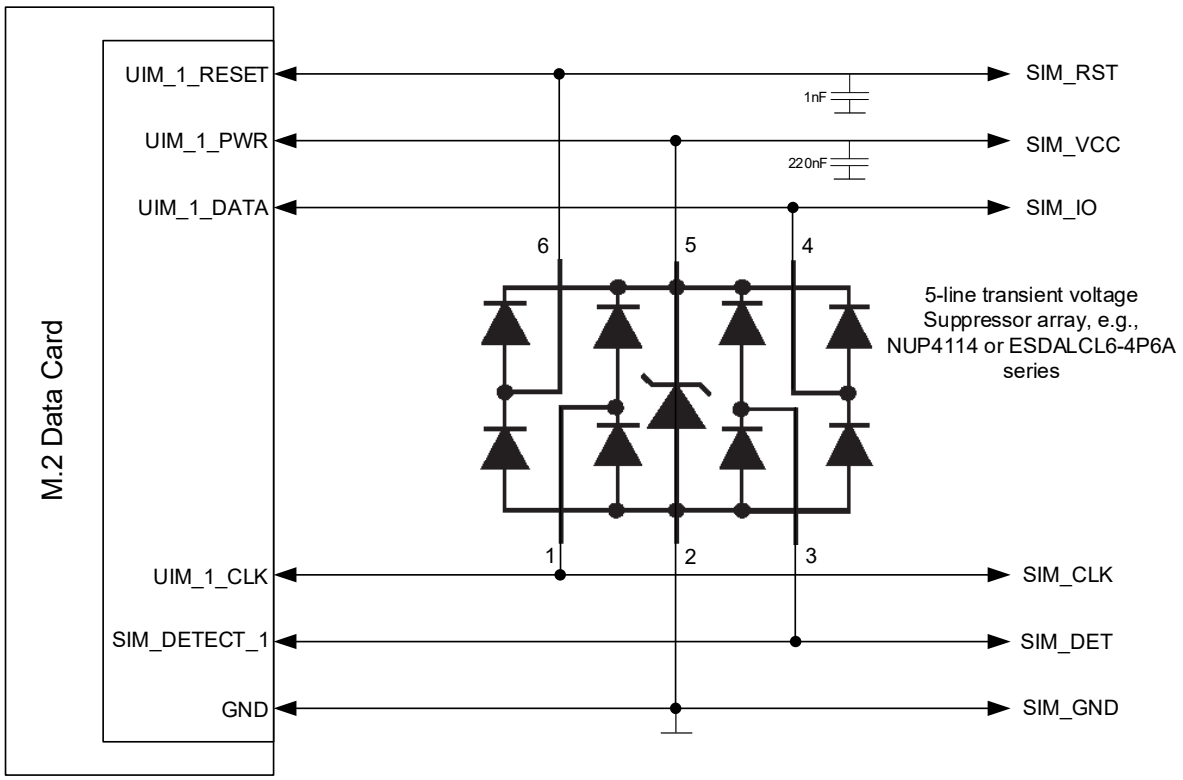

Figure 15: SIM interfaces - enhanced ESD protection

3.2.9 eUICC Interface

A dedicated 5G M.2 Data Card MV31-W hardware variant supports an eUICC in MFF-XS format. This MFF-XS eUICC is located under the shielding, and is internally connected to the specific module pads that are alternatively available as an optional second SIM interface. It has no physical connections with other circuits inside the module. To be continued...

3.2.10 GPIO Interface

The GPIO is reserved for future use.

3.2.11 Status

The LED_1# signal is provided to enable wireless communication add-in cards to provide status indications to users via system provided indicators.

Table 9: Status States

Signal State	LED	Interpretation
Low	ON	Radio is capable of transmitting.
High	OFF	Radio is incapable of transmitting.

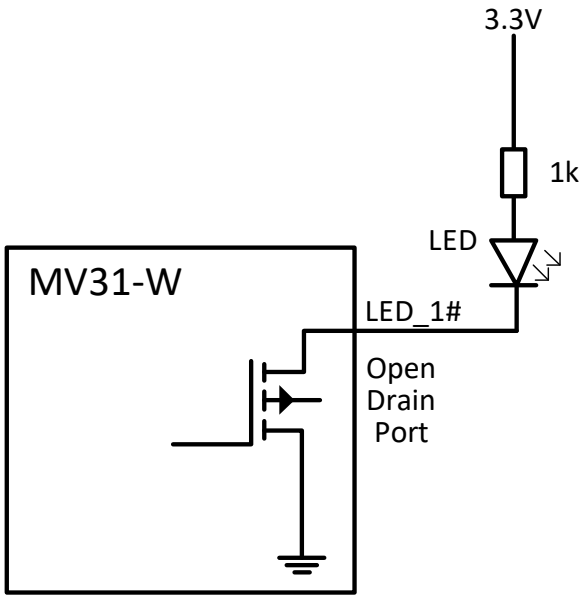

Figure 16: Sample Circuit for Status LED

Figure 16 show a sample circuit for the Status LED.

3.2.12 Add-in Card Configuration Pins

The CONFIG_x signals reports to the Host the communication interface (PCIe® or USB 3.1 Gen2) and the Port Configuration according to [3].

Table 10: Add-in Card Configuration

	Module configuration				Module Type	Port Configuration
Config	CONFIG_0	CONFIG_1	CONFIG_2	CONFIG_3		
State	NC	GND	GND	NC	WWAN PCIe®	2
	GND	GND	NC	NC	WWAN USB3.1 Gen1	2

The Port Configuration defines the signals on the GPIO0 to GPIO11 and provides the following signals in Port Configuration 2:

Table 11: GPIO Signals Mapping for Port Configuration 2

GPIO	PIN	Signal
GPIO_0	40	SIM_DETECT_2
GPIO_1	42	UIM_2_DATA
GPIO_2	44	UIM_2_CLK
GPIO_3	46	UIM_2_RESET
GPIO_4	48	UIM_2_PWR
GPIO_5	20	no connected (RFU according to [3])
GPIO_6	22	ANT_TUNER_CONFIG (RFU according to [3])
GPIO_7	24	ANT_TUNER_POWER (RFU according to [3])
GPIO_8	28	DPR_2 (RFU according to [3])
GPIO_9	10	LED_1#
GPIO_10	26	W_DISABLE2#
GPIO_11	23	WAKE_ON_WWAN# (not supported by MV31-W)

4 Antenna Interface

MV31-W also provides connectivity for off board antennas. The antennas and their connection interface for this device satisfy the requirements specified in [3]. The antenna elements are typically integrated into the notebook/ultra book /tablet and connected to MV31-W via flexible RF coaxial cables. MV31-W provides four RF connectors (MHF4 type). The four RF connectors include for 5GNR Sub 6G & UMTS/LTE primary transmitter/receiver port, diversity receiver and 4x4 MIMO receiver port. For the location of the antenna connectors see Figure 1.

For LTE and 5GNR Sub 6G to ensure stable RF performance, customer must assemble adequate antenna according to the antenna specification.

Table 12: LTE& 5GNR Sub 6G antenna specifications

Parameter	Min.	Typ.	Max.	Unit	Notes
Cable loss			0.5	dB	Maximum loss to antenna
Impedance		50		Ohm	Antenna load impedance
VSWR			3:1		Maximum allowed VSWR of antenna
Isolation	20			dB	For all antenna each other

Note:
- Antenna peak gain limit as 2.5dBi for frequency <1.5GHz and 4dBi for frequency >1.5GHz of module level certification
- For Japan regional peak gain should be limited as 2.5dBi for frequency <1.5GHz and 3dBi for frequency >1.5GHz
- For Band 30 peak gain limit as 2.99dBi (meet FCC requirement)
- For Band 48 peak gain limit as 0.92dBi (meet FCC requirement)

4.1 Antenna Interface Specification

The below Table 13 and Table 14 list RF minimum Rx sensitivity specifications.

Measurement conditions: T_{amb}= 25°C, V_{3V3} = 3.3V.

Table 13: RF antenna interface LTE: Conductive minimum receiver input sensitivity (dBm)

LTE band (BW: 10MHz	ANT0	ANT1	ANT2	ANT3	MIMO Combined
1	-96	-97	-96	-96	-102.5
2	-96	-97	-95.5	-96	-102
3	-96	-96	-95.5	-96	-102.5
4	-96	-97	-96	-96	-103
5	-99	NA	NA	-99	-102
7	-96	-96	-95.5	-96	-102.5
8	-99	NA	NA	-99	-102
12	-98.5	NA	NA	-99	-101.5
13	-98.5	NA	NA	-99	-101.5
14	-98	NA	NA	-99	-101
17	-98.5	NA	NA	-99	-101.5
18	-98.5	NA	NA	-99	-101.5
19	-98.5	NA	NA	-99	-101.5
20	-99	NA	NA	-99	-102
25	-96	-96	-95.5	-96	-102
26	-98.5	NA	NA	-99	-101.5
28	-98.5	NA	NA	-99	-101.5
29	-98.5	NA	NA	-99	-101.5
30	-95.5	-96	-96	-96	-101
32	-96	NA	NA	-96.5	-99
34	-97	NA	NA	-97	-100
38	-96.5	-96.5	-96	-96.5	-102.5
39	-97	NA	NA	-97	-100
40	-96	-97	-96	-96.5	-103
41	-96	-96	-95.5	-96	-102
42	-96.5	-97	-97	-96.5	-103
46	-96	NA	NA	-95	-98
48	-96.5	-97	-97	-96.5	-103
66	-96	-97	-97	-97	-103
71	-99	NA	NA	-99	-102

Table 14: RF antenna interface FR1 (Sub 6G): Conductive minimum receiver input sensitivity (dBm)

5G band[1]	ANT0	ANT1	ANT2	ANT3	MIMO Combined
n1	-92	-91.5	-91.5	-92	-97
n2	-91.5	-91.5	-91.5	-91.5	-97
n3	-91.5	-91	-91	-91.5	-96.5
n5	-91.5	NA	NA	-91.5	-94
n7	-90.5	-90	-90	-90.5	-95.5
n8	-92.5	NA	NA	-92.5	-95.5
n12	-90	NA	NA	-90	-93
n20	-92.5	NA	NA	-92.5	-95.5
n28	-92	NA	NA	-92	-95
n38	-91.5	-91.5	-91.5	-91.5	-97.5
n41	-91.5	-91.5	-91.5	-91.5	-97
n66	-91.5	-91.5	-91	-91.5	-97
n71	-92	NA	NA	-92	-95
n77	-91.5	-92	-91.5	-92	-97.5
n78	-92	-92	-92	-92.5	-98
n79	-89	-90	-89	-90	-95

1. Notes:
   1. n1/ n2/ n3/ n5/ n7/ n8/ n20/ n28/ n66/ n71: SCS=15KHZ; BW=20MHZ;
   2. n41/ n77/ n78: SCS=30KHZ; BW=20MHZ;
   3. n79: SCS=30KHZ; BW=40MHZ
   4. n12: SCS=15KHZ; BW=15MHZ

Table 15 lists the frequency bands as well as the direction (TX/RX) supported by the four antenna interfaces.

Table 15: Antenna interfaces[1]

Antenna interface	TX.	RX.
ANT0	WCDMA: B1/2/4/5/6/8/9/19 LTE: LB:B5,8,12,13,14,17,18,19,20,26,28,71 MHB:B1,2,3,4,7,25,30,34,38,39,40,41,66 5G Sub6G: LB:n5,8,12,20,28,71 MHB:n2,66	WCDMA: B1/2/4/5/6/8/9/19 LTE: LB:B5,8,12,13,14,17,18,19,20,26,28,29,71 MHB:B1,2,3,4,7,25,30,32,34,38,39,40,41,66 UHB:B42,48; LAA: B46 5G Sub6G: LB:n5,8,12,20,28,71 MHB:n1,2,3,7,38,41,66 UHB:n77,78,79
ANT1		LTE: MHB:B1,2,3,4,7,25,30,38,40,41,66 UHB:B42,48 5G Sub6G: MHB:n1,2,3,7,38,41,66 UHB:n77,78,79 GNSS: L5
ANT2	LTE: MHB:B1,2,3,7,66 UHB:B42,48 5G Sub6G: MHB:n1,2,3,7,38,41,66 UHB:n77,78,79	LTE: MHB:B1,2,3,4,7,25,30,38,40,41,66 UHB:B42,48 5G Sub6G: MHB:n1,2,3,7,38,41,66 UHB:n77,78,79
ANT3		WCDMA:B1/2/4/5/6/8/9/19 LTE: LB:B5,8,12,13,14,17,18,19,20,26,28,29,71 MHB:B1,2,3,4,7,25,30,32,34,38,39,40,41,66 UHB:B42,48; LAA: B46 5G Sub6G: LB:n5,8,12,20,28,71 MHB:n1,2,3,7,38,41,66 UHB:n77,78,79 GNSS: L1
ANT4	mmWave Antenna (not supported by MV31-W)	
ANT5		
ANT6		

1. LB = Low Band, MHB = Medium/High Band, UHB = Ultra High Band

Notes:
The supported RF antenna directions and bands shown in the above Table 15 apply to the following scenarios, i.e., RF antenna vs band configurations:

- LTE only, i.e., if using LTE bands only
- 5G (FR1 (Sub 6G)) only, i.e., if using 5G bands only
- EN-DC (1), if using any of the following EN-DC combinations:
  - LB (LTE) + UHB (5G)
  - LB (LTE) + MHB (5G)
  - LB (LTE) + n41 (5G)
  - MHB (LTE) + UHB (5G)
  - MHB (LTE) + n41 (5G)
  - UHB (LTE) + LB (5G)

For the following scenarios however, there are exceptions:

- EN-DC (2), if using the below EN-DC combination:
  - MHB (LTE) + LB (5G). In this case the usage of ANT0 for MHB (LTE) TX/RX is switched to ANT2.
- EN-DC (3), if using the below EN-DC combination:
  - UHB(LTE) + MHB (5G). In this case the usage of ANT2 for MHB (5G) TX/RX is swotched to ANT0.

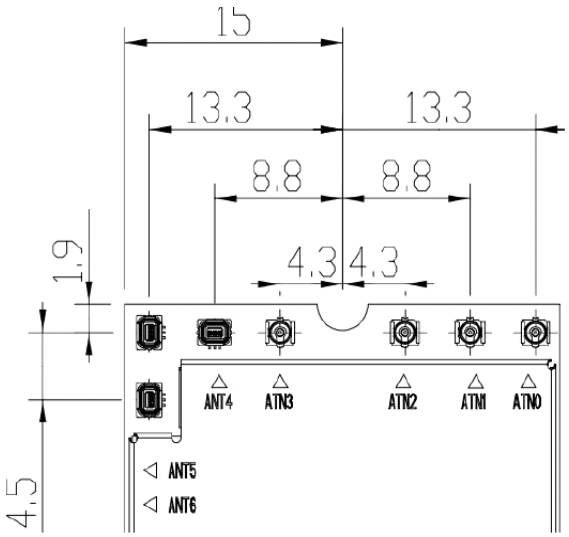

Figure 17: Antenna Interfaces

4.1.1 GNSS Interface Characteristics

Table 16: GNSS properties

Parameter	Conditions	Min.	Typical	Max.	Unit
Frequency	GPS L1 L5	 1574.4 1166.22	 1575.42 1176.45	 1576.4 1186.68	MHz
	GLONASS (G1)	1597.5	1601.7	1605.9	
	Beidou (B1)	1559.1	1561	1563.1	
	Galileo E1 E5a	 1573.4 1166.22	 1575.42 1176.45	 1577.5 11.86.68	
Horizontal accuracy	50% CEP, open sky		1.7	2	m
	90% CEP, open sky		1.9	5	m
Tracking Sensitivity	Open sky (passive antenna):		-159		dBm
Acquisition Sensitivity	Open sky (passive antenna):		-156		dBm
Time-to-First-Fix (TTFF) (indoor TTFF@-145dbm)	Hot		1.06	2	s
	Warm		23	20	s
	Cold		29	35	s

4.2 Antenna Interface Connector

4.2.1 UMTS/LTE & Sub 6G Antenna Connectors

Figure 18 and Figure 19 show the MHF4 type connectors for the UMTS/LTE & Sub 6G antennas.

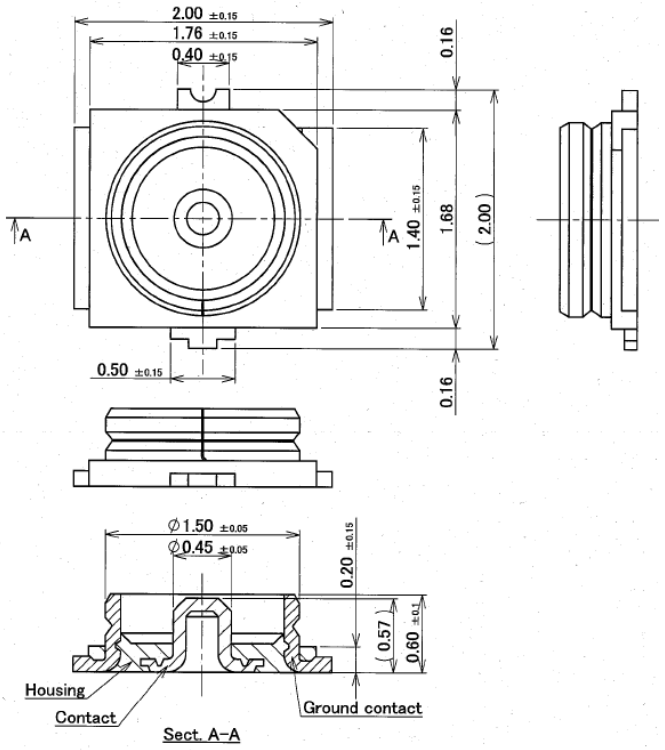

Figure 18: UMTS/LTE & Sub 6G Antenna Connector (male)

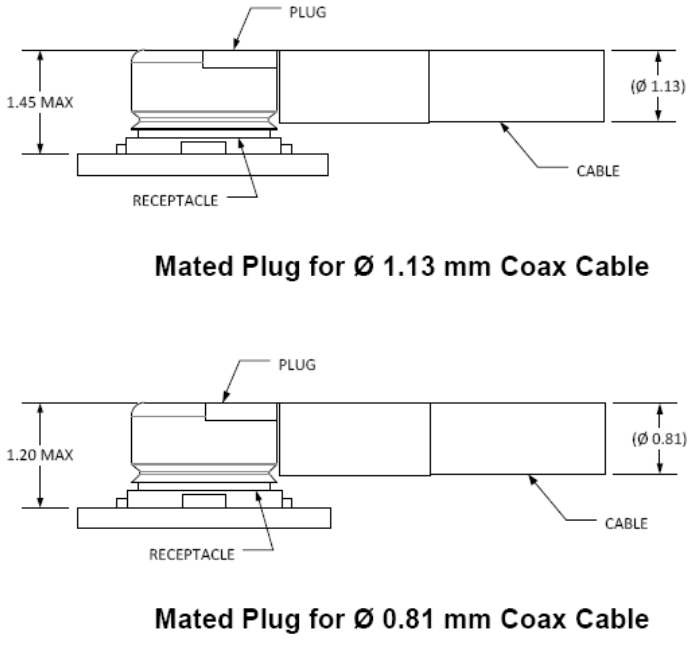

Figure 19: UMTS/LTE & Sub 6G Antenna Connector (mated plug)

5 Operation

5.1 Operating Modes

TBD.

5.2 Operating Temperatures

Table 17: Temperature characteristics

Parameter	Min	Typical	Max	Unit
Normal operation[1]	-30	25	+70	°C
Extended operation[1, 2]	-40 to -30		+70 to +85	°C
Thermal Throttling Thresholds[1, 3]:				
Level 1 PA Sensor			+80	°C
Level 1 SKIN Sensor			+85	°C
Level 2 PA Sensor			+83	°C
Level 3 PA Sensor			+89	°C
Level 3 SKIN Sensor			+89	°C
Thermal resistance (R_{th})[4]		6.67		K/W

1. Board temperature.
2. Extended operation allows normal mode data transmission for limited time until automatic thermal shutdown takes effect. Within the extended temperature range (outside the normal operating temperature range) the specified electrical characteristics may be in- or decreased.
3. Due to temperature measurement uncertainty, a tolerance of ±2°C on these switching thresholds may occur.
4. Thermal resistance (R_{th}) of the 5G M.2 Data Card MV31-W at the highest possible thermal power (P_{th}) dissipation, i.e., at the worst possible network conditions. Measured with the Starter Kit 5G Data Card in still air with an air gap of at least 100mm between the Starter Kit and other objects.

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. Note also the differences and dependencies that usually exist between board (PCB) temperature of the MV31-W and its ambient temperature.

5.3 Thermal Design Guidelines

The MV31-W m.2 card temperature rises because electrical energy is turned into heat. Depending on the application itself and housing different methods are recommend to allow the card operate under ideal conditions. The actual temperature of the board depends on different factors such as the radio technology e.g. 4G or 5G, but also on the used frequency bands with Sub6, and the output power.

The MV31-W has an optimized mechanical temperature design with a stepped EMI shielding which allows up to 19°C higher ambient temperature.

Table 18 shows the 3 level throttling mechanism based on pre-defined temperature values (Table 17), which is used by MV31-W.

Table 18: 3 Level Throttling Mechanism

Thermal Level	LTE Throttling (SKIN Sensor)	LTE Throttling (PA Sensor)	5G Sub6G Throttling (SKIN Sensor)	5G Sub6G Throttling (PA Sensor)
Level 1	4 Rx to 2 RXx fallback Drop SCells with vRLF	UL throttling	Drop SCells with vRLF Drop PSCell/disable NR in NSA	UL throttling
Level 2	N/A	Tx power back off (MTPL)	N/A	Tx power back off (MTPL) Drop PSCell/Disable NR in NSA
Level 3	Limited Service			

The stepped EMI shielding improves the time up to 42% before the MV31-W throttling levels are starting.

Section 5.3.1 illustrates a few recommended solutions that are mandatory for a full performance 5G operation of the MV31-W and the application.

5.3.1 Thermal Solutions

MV31-W requires to be thermally coupled to the application PCB as well as the stepped EMI shielding to spread and thus mitigate the heat.

To ensure an optimum heat spreading on the application PCB, the PCB should have a copper GND plane in each layer, and each layer should be thermally coupled by a large amount of vias.

The thermal conductivity of the thermal interface material (TIM) used with the various thermal solutions should be at least 6w/m*k. Depending on the mechanical setup the TIM thickness may have to be adjusted.

The below figures exemplify five thermal solutions. Figure 20, Figure 21, and Figure 22 show solutions with a heat sink, whereas options Figure 23 and Figure 24 show solutions with a heat pipe connected to the application housing.

Depending on the external application and the used housing either a heat sink or a heat pipe may be employed. For operation in high ambient temperatures or with high temperatures within the application housing a heat pipe is recommended.

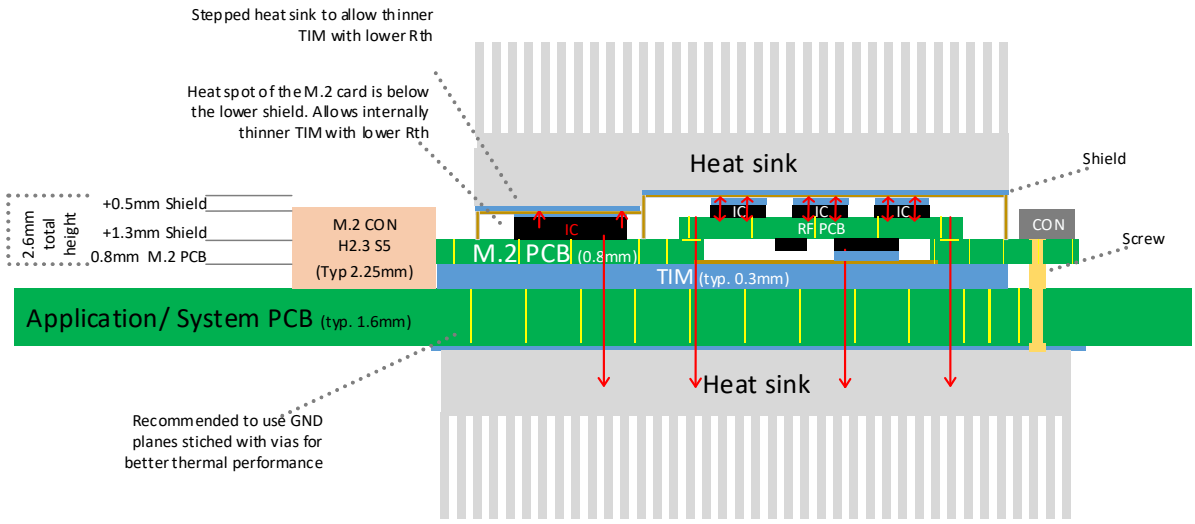

Figure 20: Option 1 - Heat sink on top of stepped shielding and bottom of application PCB

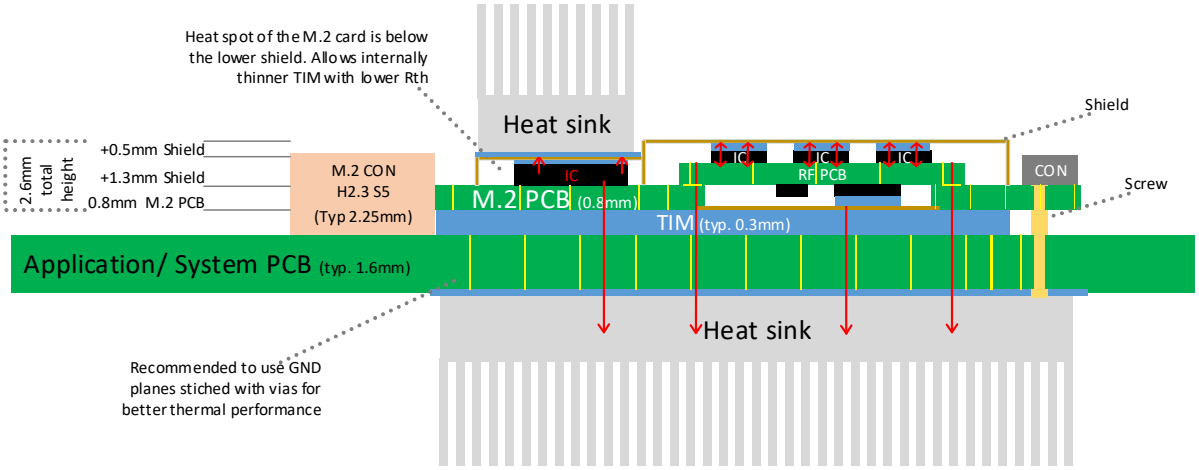

Figure 21: Option 2 - Heat sink only on heat spot of stepped shielding and bottom of application PCB

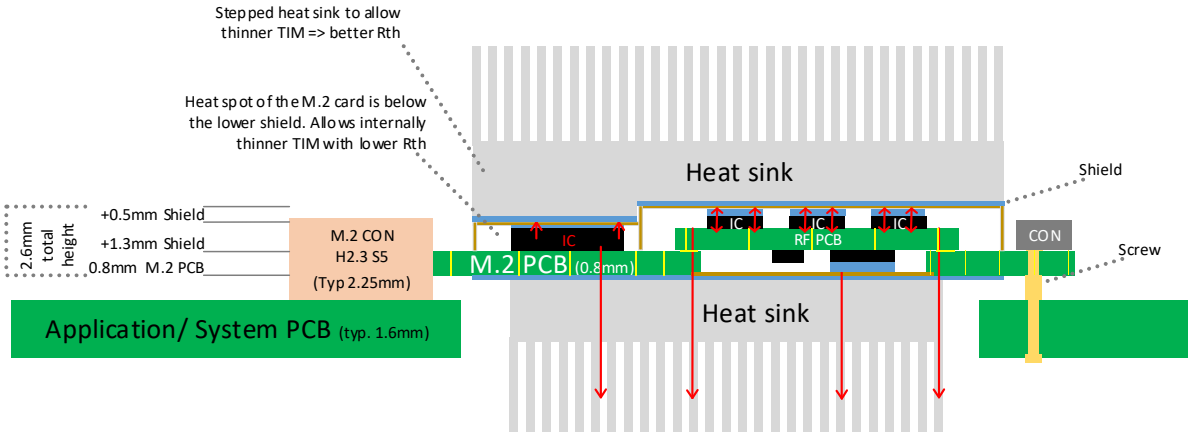

Figure 22: Option 3 - Heat sink on top of stepped shielding and directly on bottom of M.2 card PCB

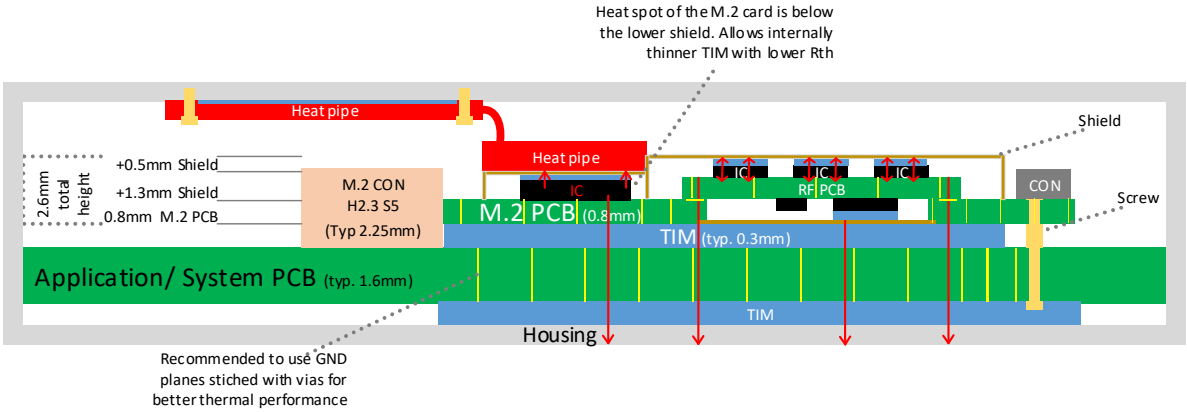

Figure 23: Option 4 - Heat pipe and small application housing

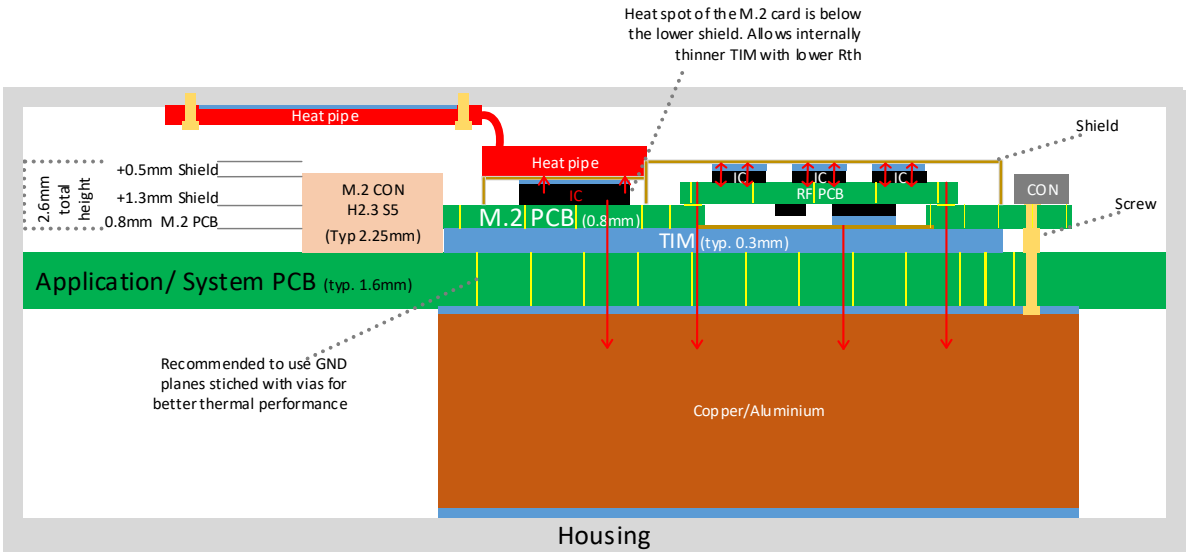

Figure 24: Option 5 - Heat pipe and big application housing

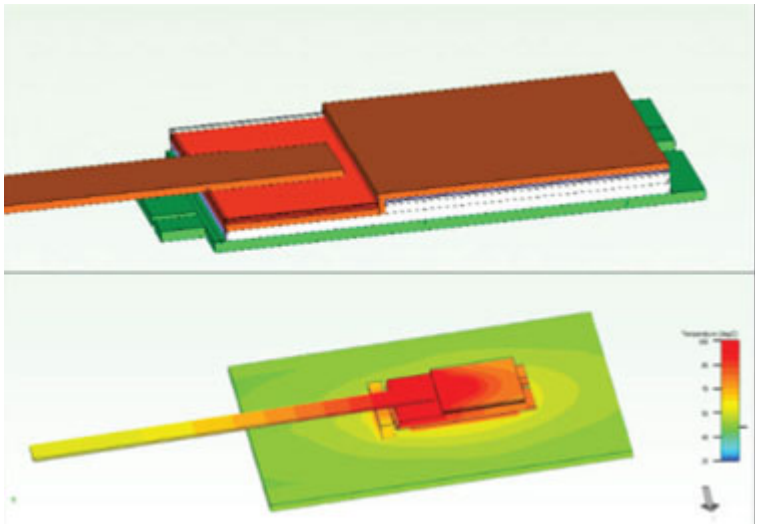

Figure 25: Thermal distribution with a heat pipe

5.4 Power Supply Ratings

The following tables provide sample power supply ratings for selected 4G/5G technologies including carrier aggregations (CA). As a general rule it is recommended to reserve at least 2500mA for the module to be able to handle peak current consumption under all conditions.

Table 19 lists selected LTE (4G) power supply ratings at various conditions.

Table 19: LTE current consumption ratings

	Description	Conditions			Typical rating	Unit
		Band	Tx power (dBm)	Channel		
I_{BATT+} [1]	Average LTE supply current Data transfer measured @minimum and @maximum Pout for low (L), mid (M) and high (H) band channels	Band 1	1dBm	18300 (M)	387	mA
			23.3dBm	18050 (L)	1079	
			23.4dBm	18300 (M)	883	
			23.1dBm	18550 (H)	1039	
		Band 2	1dBm	18900 (M)	388	mA
			23.5dBm	18650 (L)	942	
			23.3dBm	18900 (M)	949	
			23.3dBm	19150 (H)	837	
		Band 3	1dBm	19575 (M)	381	mA
			23.5dBm	19250 (L)	978	
			23.5dBm	19575 (M)	974	
			23.5dBm	19900 (H)	998	
		Band 4	1dBm	20175 (M)	380	mA
			23.3dBm	20000 (L)	991	
			23.4dBm	20175 (M)	763	
			23.4dBm	20350 (H)	1050	
		Band 5	1dBm	20525 (M)	320	mA
			23.5dBm	20450 (L)	655	
			23.6dBm	20525 (M)	635	
			23.6dBm	20600 (H)	625	
		Band 7	1dBm	21100 (M)	376	mA
			23.6dBm	20800 (L)	937	
			23.5dBm	21100 (M)	856	
			23.5dBm	21400 (H)	918	
		Band 8	1dBm	21625 (M)	320	mA
			23.7dBm	21500 (L)	720	
			23.6dBm	21625 (M)	706	
			23.6dBm	21750 (H)	699	

Table 19: LTE current consumption ratings

	Description	Conditions			Typical rating	Unit
		Band	Tx power (dBm)	Channel		
I_{BATT+}[1]	Average LTE supply current Data transfer measured @minimum and @maximum Pout for low (L), mid (M) and high (H) band channels	Band 12	1dBm	23095 (M)	314	mA
			23.4dBm	23060 (L)	581	
			23.3dBm	23095 (M)	591	
			23.4dBm	23130 (H)	599	
		Band 13	1dBm	23230 (M)	314	mA
			23.4dBm	23230 (M)	742	
		Band 14	1dBm	23330 (M)	311	mA
			23.4dBm	23330 (M)	596	
		Band 17	1dBm	23790 (M)	308	mA
			23.4dBm	23780 (L)	613	
			23.3dBm	23790 (M)	599	
			23.3dBm	23800 (H)	593	
		Band 18	1dBm	23925 (M)	337	mA
			23.4dBm	23900 (L)	670	
			23.4dBm	23925 (M)	648	
			23.4dBm	23950 (H)	652	
		Band 19	1dBm	24075 (M)	316	mA
			23.5dBm	24050 (L)	641	
			23.5dBm	24075 (M)	634	
			23.6 dBm	24100 (H)	613	
		Band 20	1dBm	24300 (M)	315	mA
			23.6dBm	24200 (L)	635	
			23.5dBm	24300 (M)	587	
			23.6dBm	24400 (H)	663	
		Band 25	1dBm	26365 (M)	376	mA
			23.4dBm	26090 (L)	1007	
			23.3dBm	26365 (M)	1007	
			23.3dBm	26640 (H)	938	
		Band 26	1dBm	26865 (M)	321	mA
			23.5dBm	26750 (L)	658	
			23.5dBm	26865 (M)	612	
			23.6dBm	26990 (H)	595	

Table 19: LTE current consumption ratings

	Description	Conditions			Typical rating	Unit
		Band	Tx power (dBm)	Channel		
I_{BATT+}[1]	Average LTE supply current Data transfer measured @minimum and @maximum Pout for low (L), mid (M) and high (H) band channels	Band 28	1dBm	27410 (M)	316	mA
			23.5dBm	27260 (L)	656	
			23.4dBm	27410 (M)	575	
			23.4dBm	27610 (H)	544	
		Band 30	1dBm	27710 (M)	397	mA
			22.2dBm	27710 (M)	953	
		Band 34	1dBm	36275 (M)	297	mA
			23.3dBm	36250 (L)	379	
			23.3dBm	36275 (M)	377	
			23.3dBm	36300 (H)	374	
		Band 38	1dBm	38000 (M)	347	mA
			23.7dBm	37800 (L)	495	
			23.6dBm	38000 (M)	499	
			23.7dBm	38200 (H)	535	
		Band 39	1dBm	38450 (M)	292	mA
			23.6dBm	38300 (L)	463	
			23.5dBm	38450 (M)	435	
			23.5dBm	38600 (H)	451	
		Band 41	1dBm	40620 (M)	342	mA
			23.6dBm	39700 (L)	519	
			23.6dBm	40620 (M)	469	
			23.7dBm	41540 (H)	494	
		Band 42	1dBm	42590 (M)	310	mA
			23.2dBm	41640 (L)	551	
			23.3dBm	42590 (M)	535	
			23.1dBm	43540 (H)	509	
		Band 48	1dBm	55990 (M)	312	mA
			21dBm	55290 (L)	452	
			21dBm	55990 (M)	442	
			21dBm	56690 (H)	440	

Table 19: LTE current consumption ratings

	Description	Conditions			Typical rating	Unit
		Band	Tx power (dBm)	Channel		
I_{BATT+} [1]	Average LTE supply current Data transfer measured @minimum and @maximum Pout for low (L), mid (M) and high (H) band channels	Band 66	1dBm	132422 (M)	376	mA
			23.2dBm	132022 (L)	985	
			23.5dBm	132422 (M)	965	
			22.8dBm	132622 (H)	940	
		Band 71	1dBm	133297 (M)	321	mA
			23.4dBm	133172 (L)	620	
			23.3dBm	133297 (M)	557	
			23.2dBm	133422 (H)	596	

1. With an impedance of Z_{LOAD}=50Ω at the antenna pads. Measured at 25°C and 3.3V

Table 20 lists selected EN-DC (4G/5G) power supply ratings at various conditions.

Table 20: EN-DC current consumption ratings

	Description	Conditions			Typical rating	Unit
		EN-DC	Tx power (dBm)	Channel		
I_{BATT+} [1]	Average EN-DC (TDD) supply current Data transfer measured @minimum and @maximum Pout for mid (M) band channels and FR1 through-out=1950Mbps	DC_B3-n41	LTE=0dBm NR=0dBm	518598(M)	790	mA
			LTE=0dBm NR=22.9dBm		950	
			LTE=23dBm NR=17.3dBm		1570	
		DC_B3-n77	LTE=0dBm NR=0dBm	650000(M)	861	mA
			LTE=0dBm NR=23dBm		1017	
			LTE=23dBm NR=15.8dBm		1530	
		DC_B3-n78	LTE=0dBm NR=0dBm	636666(M)	875	mA
			LTE=0dBm NR=22.8dBm		1008	
			LTE=23dBm NR=16dBm		1550	
		DC_B3-n79	LTE=0dBm NR=0dBm	713990(M)	920	mA
			LTE=0dBm NR=23dBm		1060	
			LTE=23dBm NR=16dBm		1600	

Table 20: EN-DC current consumption ratings

	Description	Conditions			Typical rating	Unit
		EN-DC	Tx power (dBm)	Channel		
I_{BATT+} [1]	Average EN-DC (FDD) supply current Data transfer measured @minimum and @maximum Pout for mid (M) band channels and NR through-out=319Mbps	DC_B20-n3	LTE=0dBm NR=0dBm	349500(M)	410	mA
			LTE=0dBm NR=23dBm		1180	
			LTE=23dBm NR=17.5dBm		1040	
		DC_B5-n2	LTE=0dBm NR=0dBm	376000(M)	396	mA
			LTE=0dBm NR=23dBm		925	
			LTE=23dBm NR=16dBm		920	
		DC_B12-n7	LTE=0dBm NR=0dBm	507000(M)	418	mA
			LTE=0dBm NR=22dBm		830	
			LTE=23dBm NR=17.5dBm		980	
		DC_B12-n66	LTE=0dBm NR=0dBm	349000(M)	400	mA
			LTE=0dBm NR=23dBm		790	
			LTE=23dBm NR=16dBm		923	

1. With an impedance of Z_{LOAD}=50Ω at the antenna pads. Measured at 25°C and 3.3V

Table 21 lists selected LTE CA power supply ratings at various conditions.

Table 21: LTE CA current consumption ratings

	Description	Conditions				Typical rating	Unit
		CA combinations	Tx power (dBm)	Throughput			
				DL (Mbps)	UL (Mbps)		
I_{BATT+} [1]	2CA (4x4)	1A+3A	0	780	85	550	mA
			23			950	
	3CA (4x4)	1A+3A+7A	0	1170	85	713	mA
			23			1145	
	4CA (4x4)	1A+3C+7A	0	1560	85	740	mA
			23			1150	
	5CA (2x2)	1A+3A+7C+ 28A	0	965	85	658	mA
			23			1012	

1. With an impedance of Z_{LOAD}=50Ω at the antenna pads. Measured at 25°C and 3.3V

5.5 Timing Sequence Requirement

5.5.1 Power On Timing Requirement

- Requirements:
  - +3.3V power should be stable earlier than Full_Card_Power_Off
  - Compliance with PCI Express® Card Electromechanical Specification

Figure below shows the M.2 adapter power-up sequence for an adapter from the system power rail.

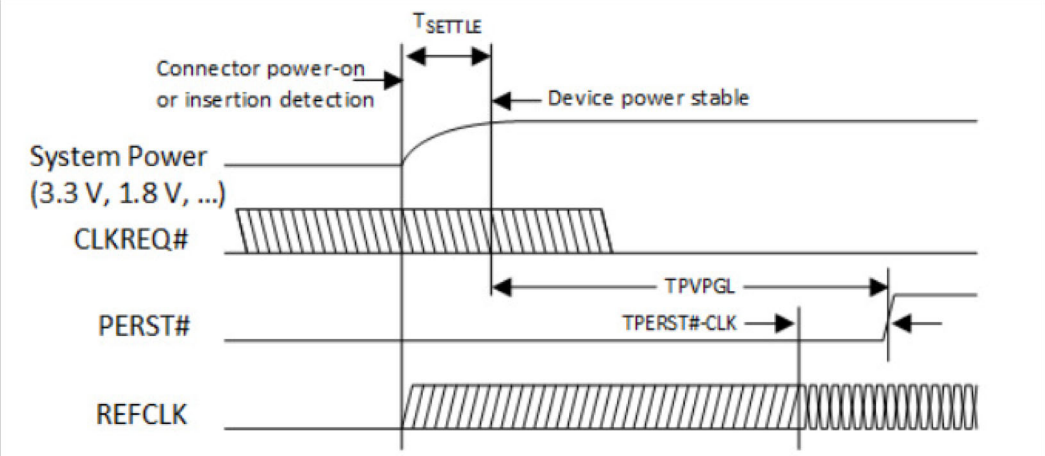

Figure 26: Power-up timing sequence

Tsettle is the time it takes all Power Rails to reach their minimum operating voltage (depending on System power rails). Power Valid is when all voltage supply rails have reached their respective Vmin.

Table 22: Power up timing information

Symbol	Parameter	Min	Max	Units
T_{PVPGL}	Power Valid to PERST# input inactive	Implementation specific: 50ms recommended		ms
$T_{PERS\#CLK}$	REFCLK stable before PERST# inactive	100		µs

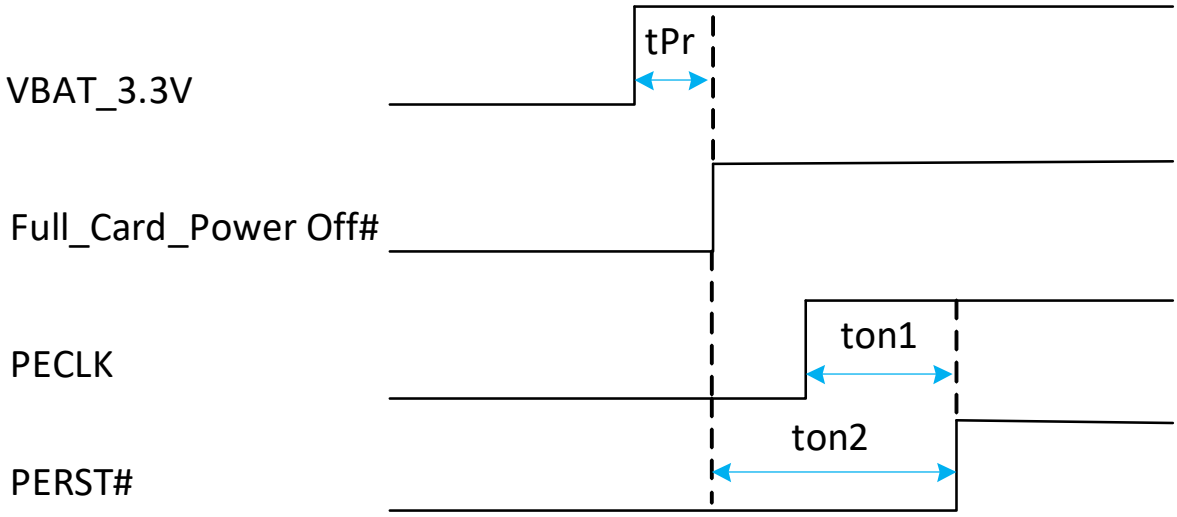

Figure 27: Power on timing diagram

Table 23: Power On information

Symbol	Minimum value	Note
tPr	10ms	Keep 3.3V power supply before Full_Card_Power_Off# assert. There is no tPr if the power supply is always ready.
ton1	150µs	Keep PCIe_CLK stable before PERST# is inactive.
ton2	150ms	PERST# should be deasserted after a Full_Card_Power_Off#

5.5.2 Power Off Timing Requirement

- The platform should follow the requirement when the device power is Off by **M.2 PIN#6** and when Windows enters S4 and S5.
- Device Power Off by M.2 PIN#6 (Full_Card_Power_Off):
  - For Windows10: Platform performs M.2 PIN#6 power off after sending CID_MBIM_MSHOSTSHUTDOWN to MV31-W and receiving CID_MBIM_MSHOSTSHUTDOWN MBIM_COMMAND_DONE from MV31-W

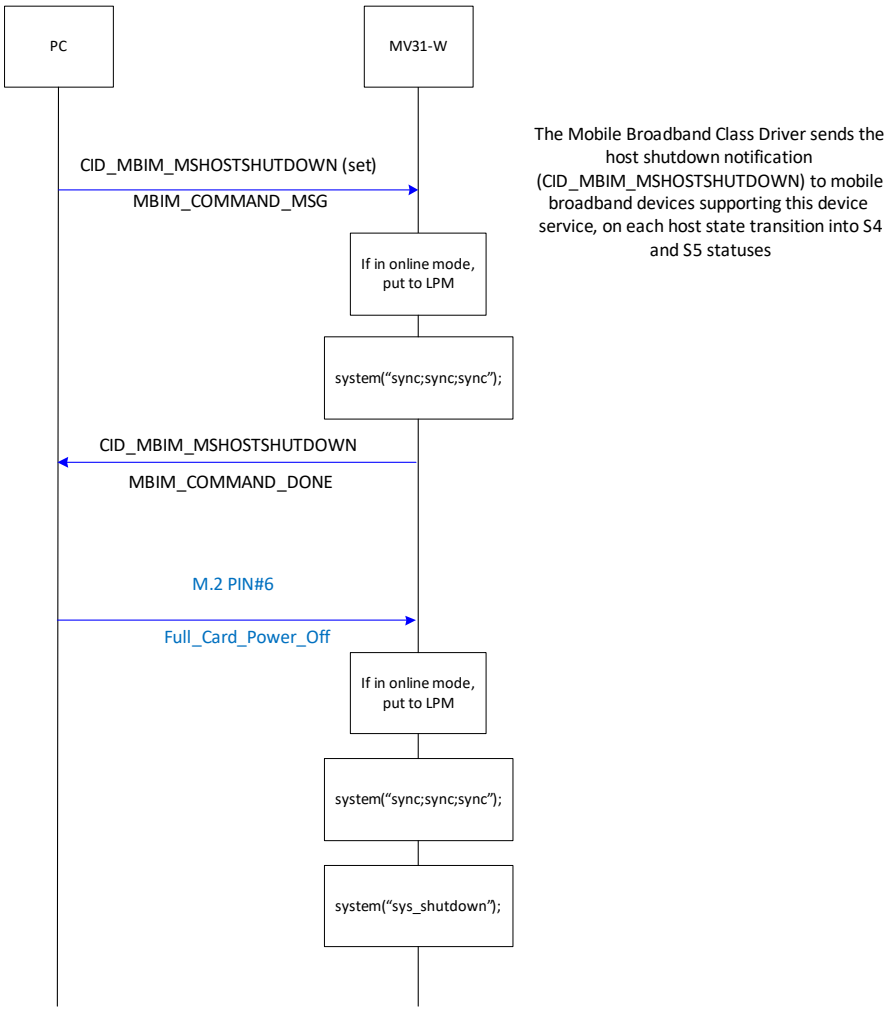

Figure 28: Device power off behavior for Windows 10

- For Linux: Estimate Software optimization with a minimum power off period.

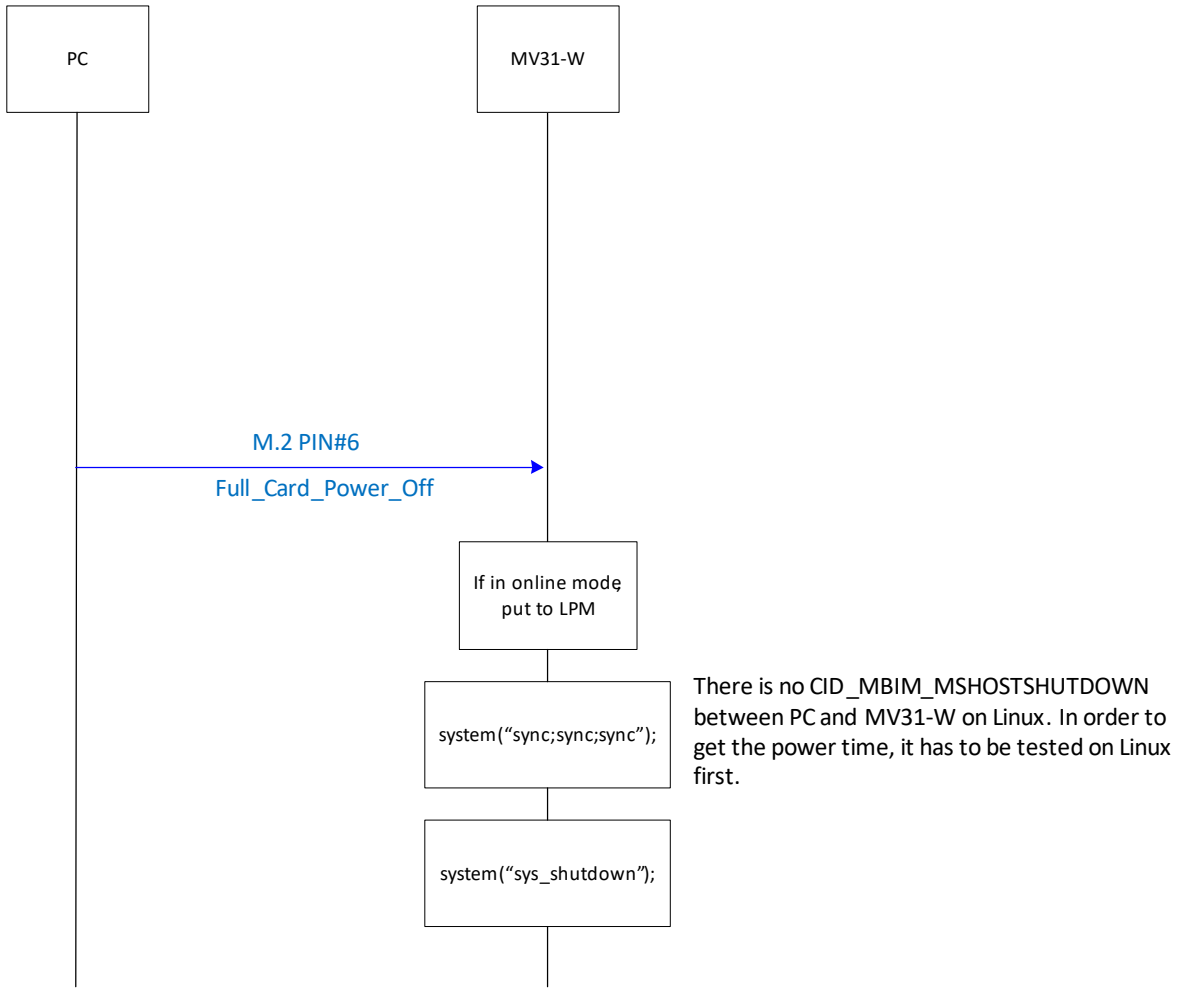

Figure 29: Device power off behavior for Linux

5.5.3 Power Off Timing

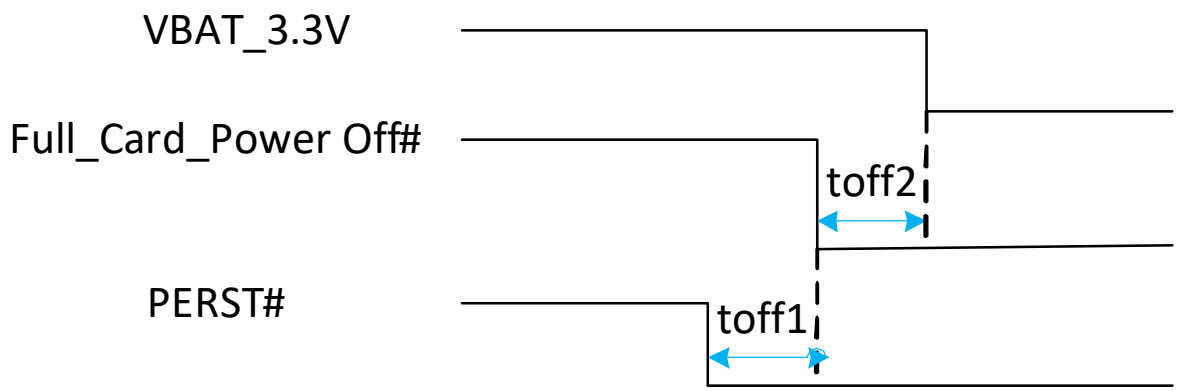

Figure 30: Power off diagram

Table 24: Power Off information

Symbol	Minimum value	Note
toff1	400ms	PERST# should deasserted before Full_Card_Power_Off#
toff2	200ms	With MBIM driver installed, Full_Card_Power_Off# deasserted hold time
	3s	Without MBIM driver installed, Full_Card_Power_Off# deasserted hold time

5.5.4 Warm Boot Restart Timing

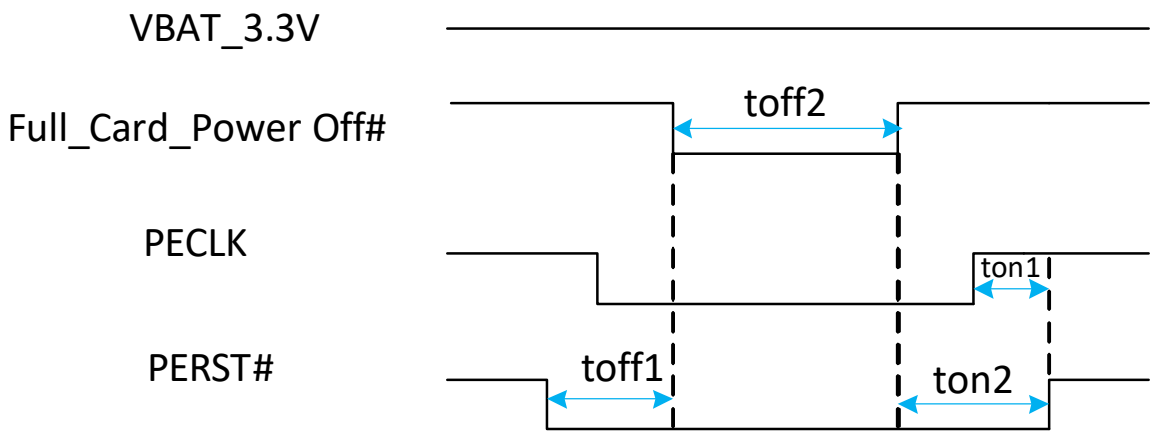

Figure 31: Warm boot restart diagram

Table 25: Warm boot restart information

Symbol	Minimum value	Note
toff1	400ms	PERST# should deasserted before Full_Card_Power_Off#
toff2	500ms	With MBIM driver installed, Full_Card_Power_Off# deasserted hold time
	3s	Without MBIM driver installed, Full_Card_Power_Off# deasserted hold time
ton1	150µs	Keep PCIe_CLK stable before PERST# is inactive.
ton2	150ms	PERST# should be deasserted after a Full_Card_Power_Off#

5.5.5 Modem Standby Requirement

In order to perform a Modem Standby, the device MHI driver will query PCIe® root port capability via Microsoft(TM) API.

Currently, the 5G M.2 Data Card MV31-W's device profile supports D0+, D3hot+, and D3cold+, whereas D1 and D2 are not supported. If the D3cold capability is not enabled on the host BIOS, there will be three messages from the "PCIE root port" (Root port is controlled by BIOS, RC configuration register) as shown below:

```
[MhiHost] [PciSetPowerPolicy]W - Device DOESN'T support D3cold
[MhiHost] [PciSetPowerPolicy]W - GetIdleWakeInfo-Hibernate, status: 0xc0000002(STATUS_NOT_IMPLEMENTED)
[MhiHost] [PciSetPowerPolicy]Bus Driver DOES support D3cold
```

A corresponding BIOS is required that has an "PCIe enable/disable D3cold" item. If this item is not enabled on the standard BIOS, the user may have to modify the BIOS.

BIOS is needed to enable the PCIe® root port D3cold capability.

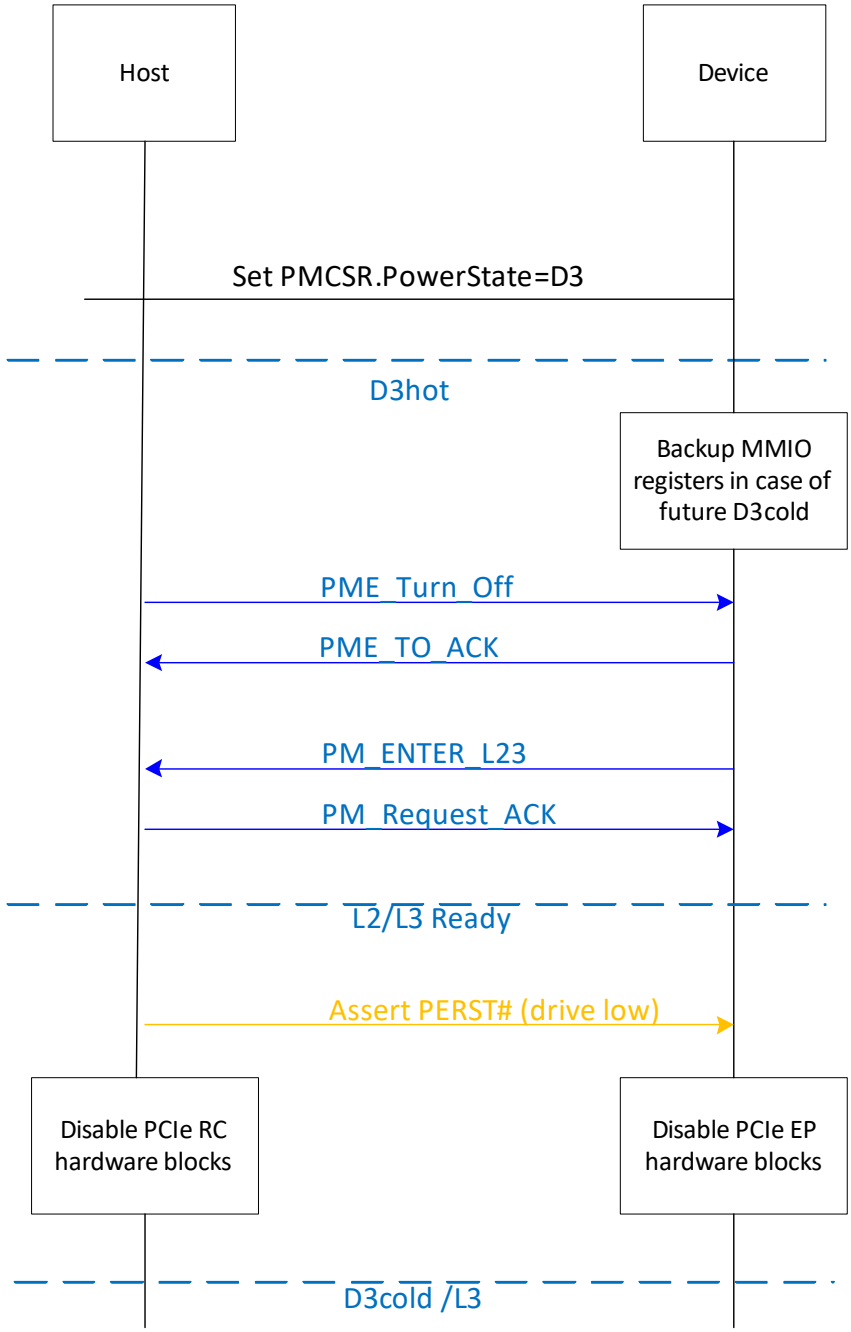

Figure 32: Modern Standby-D3cold Entry Flow

- The Host sets PMCSR in order to put device into D3hot state.
- The Host turns off PME.
- Device PM enters L2/L3
- The Host asserts PERST# (drive low)

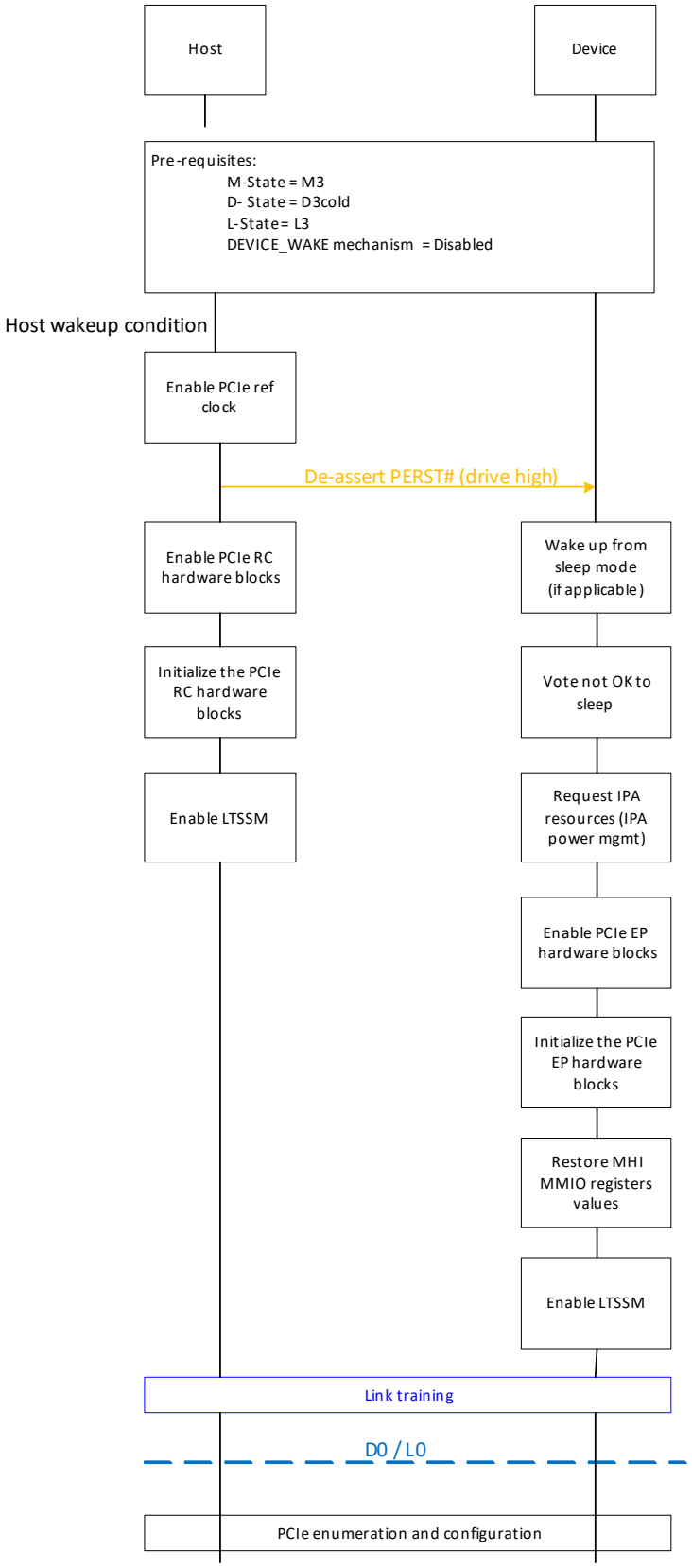

Figure 33: Modern Standby D3cold

- The Host enabled PCIe® reference clock and deasserts PERST# (drive high).

5.6 Electrostatic Discharge

The 5G M.2 Data Card MV31-W 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 5G M.2 Data Card MV31-W module.

The 5G M.2 Data Card's MV31-W module has been tested according to the following standards. Electrostatic values can be gathered from the following table.

Table 26: Electrostatic values

Specification/Requirements	Contact discharge	Air discharge
ETSI EN 301 489-1/7		
Application connector signals Antenna interface	± 4kV	± 8kV

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.

5.7 Reliability Characteristics

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

Table 27: Summary of reliability test conditions

Type of test	Conditions	Standard
Shock Test (Non-operating)	Amplitude: 400G, Waveform: 1/2 sine, 2 msec duration, Repetition: 6 times / each axis	DIN IEC 60068-2-27
Vibration (Non Operating) Sinusoidal	Amplitude: 3.0G peak to peak, Frequency: 5hz - 500hHz, Freq Sweep rate : 0.5 Octave/min,linear, Duration: 2hr/each axis	DIN IEC 68-2-36
Vibration (Non Operating) Random	3.0 G rms, Frequency Range: 10hz to 500hz, Duration: 1hr / each axis	DIN IEC 68-2-36
Damp Cycle	High Temp:70°C, Low Temp = 25°C, Humidity: 95%, Duration: 12H+12H, Repetition: 6 times	DIN IEC 60068-2-30 Db
Thermal Shock	-40°C/85°C, 500 cycles Function check point interval 200, 500 cycles	DIN IEC 60068-2-14 Na
Drop Test	Height: 100cm, concrete or steel 6 drops (all surfaces)	DIN IEC 60068-2-31

5.8 Mounting Advice

Maximum force to the top shielding: 30 N
Maximum bending: 0,315 mm (0,75% of 42 mm)

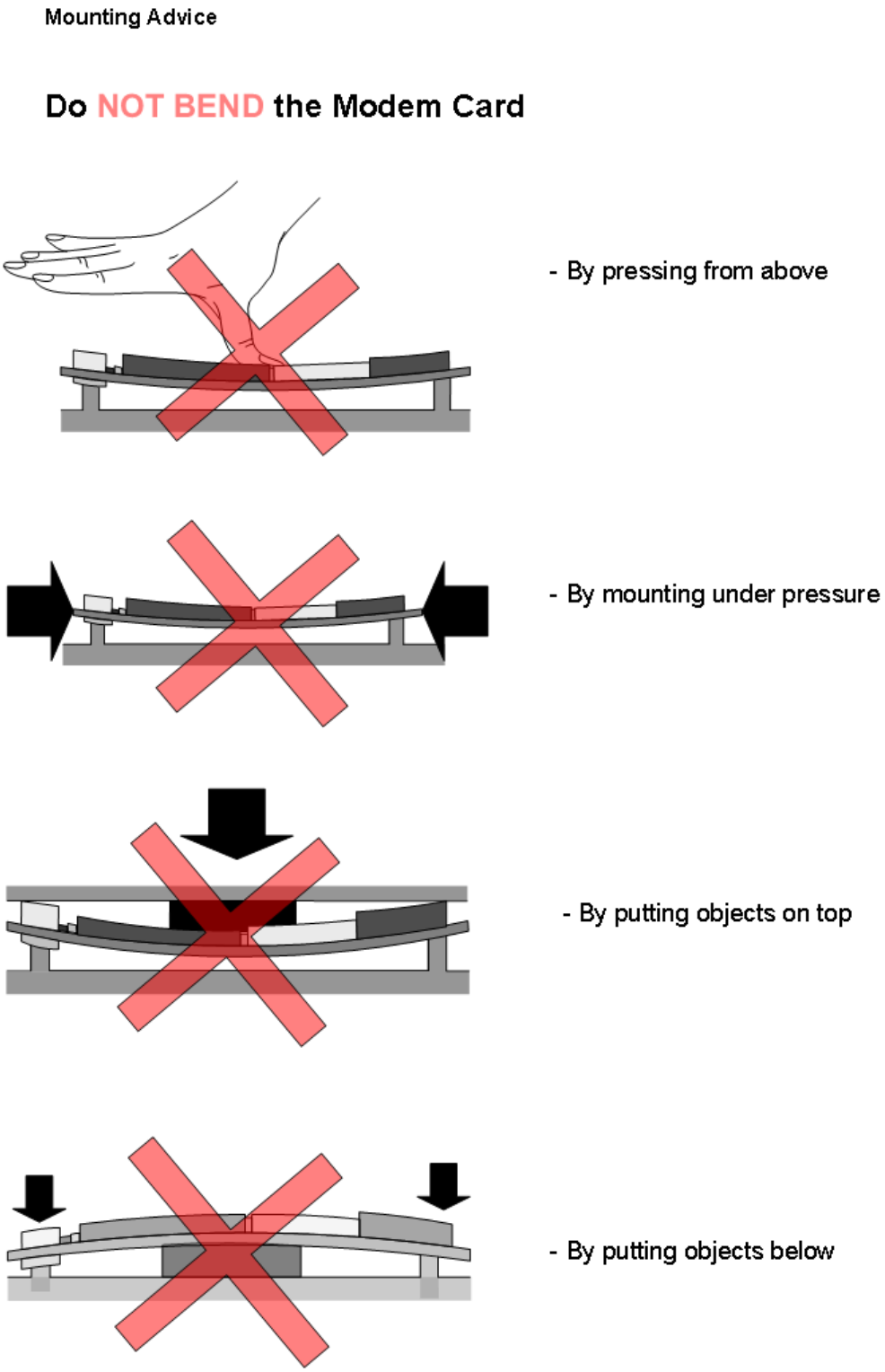

Figure 34: Mounting Advice

5.9 Approval Information

The 5G M.2 Data Card MV31-W has been type approved. The reference setup submitted to type approve the MV31-W consisted of the following components: MV31-W, PC as MMI, Power Supply.

Approval of mobile computing platforms containing 5G M.2 Data Card MV31-W can therefore be based on the existing module approval together with this document as appropriate technical documentation.

5.9.1 Directives and Standards

The 5G M.2 Data Card MV31-W is designed to comply with the directives and standards listed below.

Table 28: Directives

2014/53/EU	Directive of the European Parliament and of the council of 16 April 2014 on the harmonization of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/05/EC. The product is labeled with the CE conformity mark.
2002/95/EC (RoHS 1) 2011/65/EC (RoHS 2) 2015/863/EC (RoHS 3)	Directive of the European Parliament and of the Council of 27 January 2003 (and revised on 8 June 2011 and 31 March 2015) on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)

Table 29: Standards of North American type approval

CFR Title 47	Code of Federal Regulations, Part 22, Part 24, Part 27, Part 90 and Part 96; US Equipment Authorization FCC
OET Bulletin 65 (Edition 97-01)	Evaluating Compliance with FCC Guidelines for Human Exposure to Radio frequency Electromagnetic Fields
KDB 447498 D01	General RF Exposure Guidance v06
NAPRD.03 V6.5	Overview of PCS Type certification review board Mobile Equipment Type Certification and IMEI control PCS Type Certification Review board (PTCRB)
RSS Gen, RSS-102, RSS-130, RSS-132, RSS-133, RSS-139, RSS-195, RSS-199	Canadian Standard

Table 30: Standards of European type approval

3GPP TS 51.010-1	Digital cellular telecommunications system (Release 7); Mobile Station (MS) conformance specification;
GCF-CC V3.83.0	Global Certification Forum - Certification Criteria
Draft ETSI EN 301 489-01 V2.2.3	Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU and the essential requirements of article 6 of Directive 2014/30/EU

Table 30: Standards of European type approval

Draft ETSI EN 301 489-17 V3.2.3	ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 17: Specific conditions for Broadband Data Transmission Systems; Harmonised Standard for ElectroMagnetic Compatibility
Draft EN 301 489-19 V2.2.0	ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 19: Specific conditions for Receive Only Mobile Earth Stations (ROMES) operating in the 1,5 GHz band providing data communications and GNSS receivers operating in the RNSS band providing positioning, navigation, and timing data; Harmonised Standard for ElectroMagnetic Compatibility
Draft ETSI EN 301 489-52 V1.1.0	Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 52: Specific conditions for Cellular Communication Mobile and portable (UE) radio and ancillary equipment; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU
ETSI EN 301 908-01 V13.1.1	IMT cellular networks; Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 1: Introduction and common requirements
ETSI EN 301 908-02 V13.1.1	IMT cellular networks; Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 2: CDMA Direct Spread (UTRA FDD) User Equipment (UE)
ETSI EN 301 908-13 V13.1.1	IMT cellular networks; Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 13: Evolved Universal Terrestrial Radio Access (E-UTRA) User Equipment (UE)
EN 62368-1:2014 +A11:2017	Audio/video, information and communication technology equipment - Part 1: Safety requirements

Table 31: Standards (Statutory Instruments) for UK

S.I. 2019/696 Part 3 Regulation 32 Schedule 29	The Product Safety and Metrology etc. (Amendment etc.) (EU Exit) Regulations 2019, Amendment of the Radio Equipment Regulations 2017 and related amendments. The product is labeled with the UK conformity mark UKCA
S.I. 2012/3032	Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012
S.I. 2016 No. 1101 Chapter 1, clause 6-1 a	Electrical Equipment (Safety) Regulations 2016
S.I. 2016 No. 1091 Chapter 1, clause 6-1 b	The Electromagnetic Compatibility Regulations 2016
S.I. 2017 No. 1206 Chapter 1, clause 6-2	The Radio Equipment Regulations 2017

Table 32: Requirements of quality

IEC 60068	Environmental testing
DIN EN 60529	IP codes

Table 33: Standards of the Ministry of Information Industry of the People's Republic of China

SJ/T 11363-2006	"Requirements for Concentration Limits for Certain Hazardous Substances in Electronic Information Products" (2006-06).
SJ/T 11364-2006	"Marking for Control of Pollution Caused by Electronic Information Products" (2006-06).  According to the "Chinese Administration on the Control of Pollution caused by Electronic Information Products" (ACPEIP) the EPUP, i.e., Environmental Protection Use Period, of this product is 20 years as per the symbol shown here, unless otherwise marked. The EPUP is valid only as long as the product is operated within the operating limits described in the Thales Hardware Interface Description. Please see Table 34 for an overview of toxic or hazardous substances or elements that might be contained in product parts in concentrations above the limits defined by SJ/T 11363-2006.

Table 34: Toxic or hazardous substances or elements with defined concentration limits

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

O:
表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T11363-2006 标准规定的限量要求以下。
Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in SJ/T11363-2006.

X:
表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T11363-2006标准规定的限量要求。
Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part *might exceed* the limit requirement in SJ/T11363-2006.

5.9.2 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**) - 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) 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 35: 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)	Built-in equipment, it shall be evaluated in the end product	
Hazardous Substances, Chemical reaction		
Kinetic / mechanical energy source		
Thermal energy source		
Radiated energy source		

5.9.3 SAR requirements specific to portable mobiles

Mobile phones, PDAs or other portable transmitters and receivers incorporating a GSM module must be in accordance with the guidelines for human exposure to radio frequency energy. This requires the Specific Absorption Rate (SAR) of portable 5G M.2 Data Card MV31-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

IEEE 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.

5.9.4 Reference Equipment for Type Approval

The Thales reference setup submitted to type approve 5G M.2 Data Card MV31-W is shown in the following figure[1]:

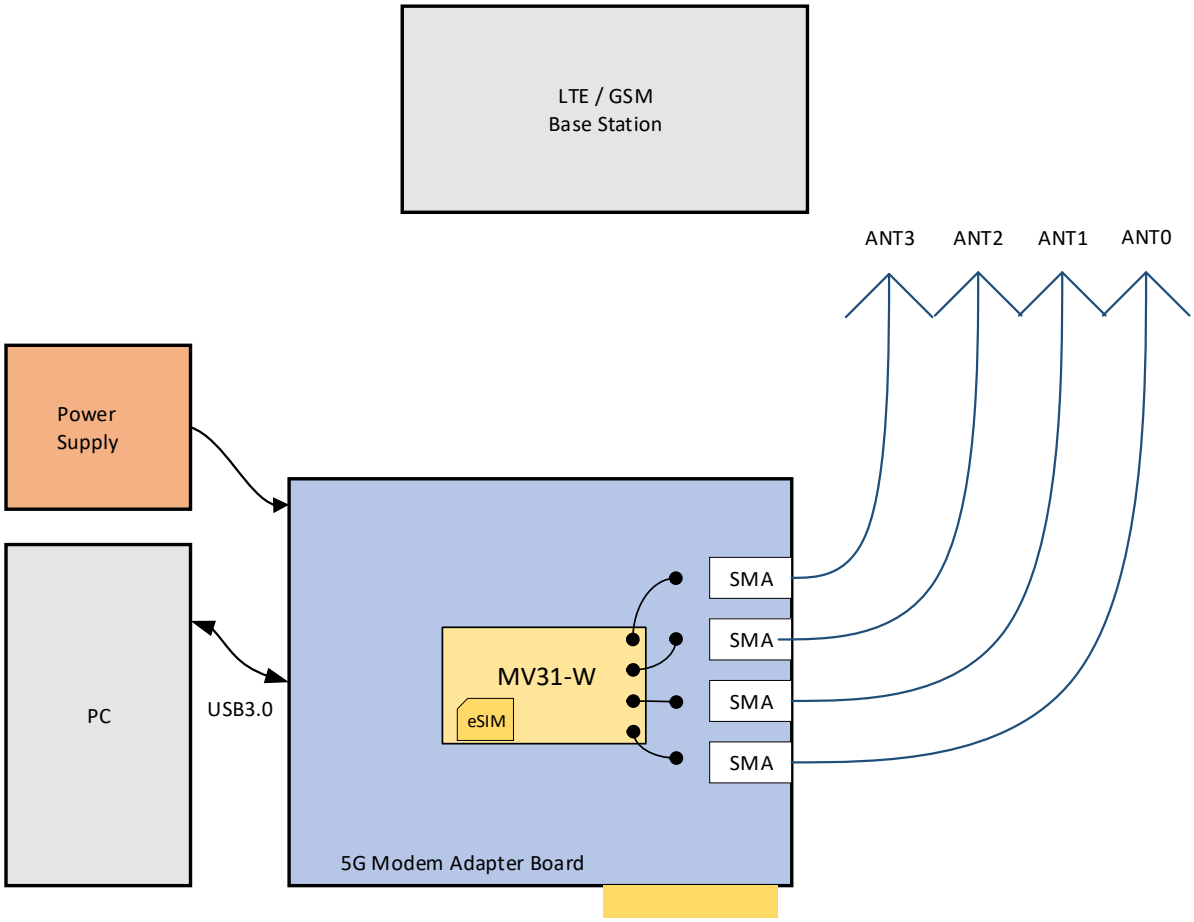

Figure 35: Reference equipment for type approval

1. For RF performance tests an MHF4 adapter is needed to connect the MV31-W directly to the UMTS/ LTE/GNSS test equipment instead of employing the SMA antenna connectors on the 4G Modem Adapter Board as shown in Figure 35.

5.9.5 Compliance with FCC and ISED Rules and Regulations

The Equipment Authorization Certification for the Thales reference application described in Section 5.9.4 will be registered under the following identifiers:

FCC Identifier: QIPMV31-W
ISED Certification Number: 7830A-MV31W
Granted to THALES DIS AIS Deutschland GmbH

Manufacturers of mobile or fixed devices incorporating MV31-W modules are authorized to use the FCC Grants and ISED Certificates of the MV31-W modules for their own final products according to the conditions referenced in these documents. In this case, an FCC/ IC label of the module shall be visible from the outside, or the host device shall bear a second label stating "Contains FCC ID: QIPMV31-W" , and accordingly “Contains IC: 7830A-MV31W“. 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 TBD.

IMPORTANT:
Manufacturers of portable applications incorporating MV31-W modules are required to have their final product certified and apply for their own FCC Grant and ISED Certificate related to the specific portable mobile. This is mandatory to meet the SAR requirements for portable mobiles (see Section 5.9.3 for detail).

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

5.9.6 Compliance with Japanese Rules and Regulations

The 5G M.2 Data Card MV31-W reference application described in Section 5.9.4 complies with the requirements of the Japanese "Telecommunications Business Law" and "Ordinance Concerning Technical Regulations Conformity Certification of Specified Radio Equipment" as well as with the requirements of the Japanese "Radio Law" and "Ordinance Concerning Technical Conditions Compliance Approval and Certification of the Type for Terminal Equipment".

- The certificates granted in accordance with the "Telecommunications Business Law" have the identifiers:
  MV31-W: TBD.

- The certificates granted in accordance with the "Radio Law" have the identifiers:
  MV31-W: TBD.

5.10 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 5G M.2 Data Card MV31-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.

6 Appendix

6.1 Product Label Information

The label engraved[1] on the top of MV31-W comprises the following information.

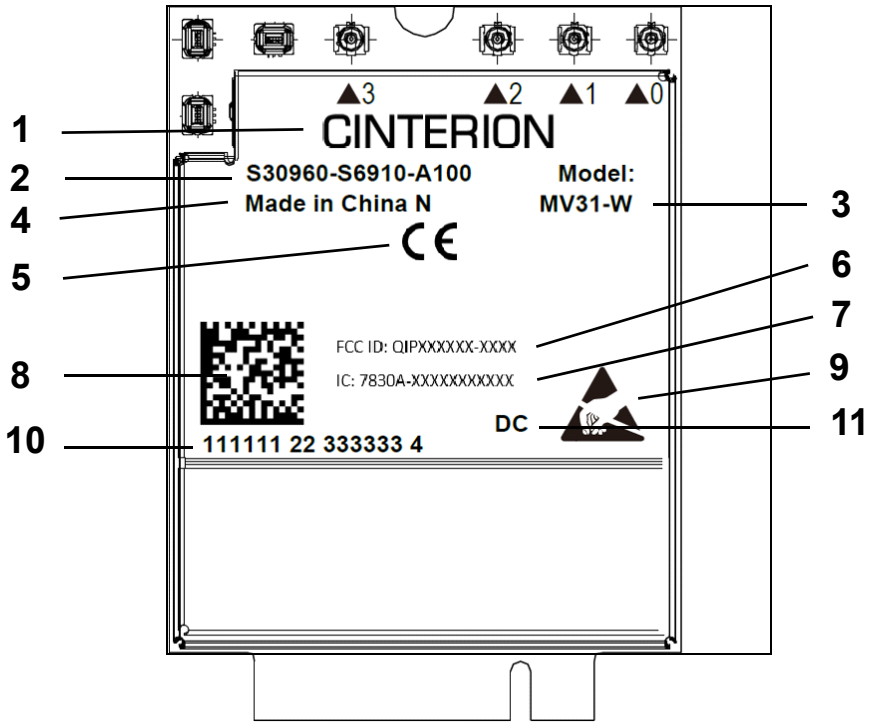

Figure 36: Sample Label of MV31-W

Table 36: 5G M.2 Data Card MV31-W label information

No.	Information
1	Cinterion Logo (trademark)
2	Product ordering number
3	Product name
4	Marking "Made in China"
5	CE logo
6	FCC ID
7	IC ID
8	Product IMEI code (2D)
9	ESD warning sign
10	Product IMEI
11	Date code

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.

6.2 Packaging

6.2.1 Trays

MV31-W is shipped in 5 x 2 ESD trays (dimensions: 229 x 152 x 15mm), pictured in Figure 37. Module orientation can be seen in Figure 37. All modules shall follow the same orientation in the tray.

Figure 37: 5x2 Tray

6.3 Declaration of Conformity

TBD.

THALES DIS AIS Deutschland GmbH
Werinherstrasse 81
81541 Munich
Germany