NAD SAMSUNG S5123
Model SA-N9001 CUSTOMER D

Hardware Guide

Version 1.3(2020.12.03)

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REVISION HISTORY

Version	Date	Description	Written by	Reviewed by
0.1	2019.08.02	C2 customer draft release	Yoongoo Nam	
0.2	2019.10.11	RF support band update	Yoongoo Nam	
0.3	2019.11.07	Pin map update	Yoongoo Nam	
0.4	2019.11.14	CA update	Yoongoo Nam	
0.5	2019.12.05	RF Support band & Pinmap update	Yoongoo Nam	
0.6	2020.01.07	RF Support band update	Yoongoo Nam	
0.7	2020.02.24	Pinmap update for TCAM2	Yoongoo Nam	
0.8	2020.03.10	Support band update	Yoongoo Nam	
0.9	2020.04.13	USB add, CA update	Yoongoo Nam	
1.0	2020.05.06	Global sku support band update	Yoongoo Nam	
1.1	2020.10.16	LTE CA support band update	Yoongoo Nam	
1.2	2020.12.01	LTE CA support band update	Yoongoo Nam	
1.3	2020.12.03	FCC warning update	Yoongoo Nam	

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1 General

1.1 Document purposes

WAVE is a 5G module, which supports 3GPP Release 15 NR features including Sub-6 GHz. It also supports all legacy modem features, including 4G LTE, 3G FDD, 3G TDD, 2G GSM. This document describes the module information about WAVE module.

This document helps hardware engineers to understand the interface specifications, electrical features and related product guidelines of the SAMSUNG WAVE Network Access Device module.

1.2 Function overview

1.2.1 Support Band

Products	Bands
Global	**LTE FDD:** B1,B2,B3,B4,B5,B7,B8,B9,B10,B12,B13,B17,B18,B19,B20,B21,B25,B26,B28,B29(Rx), B30(Rx),B32,B66,B71 **LTE TDD:** B34,B38,B39,B40,B41,B42 **WCDMA/HSPA+:** B1,B2,B3,B4,B5,B8,B19 **GSM/GPRS/EDGE:** 850MHz,900MHz,1800MHz,1900MHz **5G:** n1, n2, n3, n5, n7, n8, n20, n25, n28, n38, n41, n66, n71, n77(n78)

NOTE

4x4 support band : LTE B1/B2/B3/B4/B7/B30/B34/B38/B39/B40/B41/B42/B66
NR n77(n78)

SKU	CA Combination
Global	(Downlink) - 2CA 1A-1A, 1C, 1A-3A, 1A-5A, 5A-1A, 1A-7A, 7A-1A, 1A-8A, 8A-1A, 1A-18A, 18A-1A, 1A-19A, 19A-1A, 1A-20A, 20A-1A, 1A-26A, 26A-1A, 1A-28A, 28A-1A, 1A-32A, 1A-38A, 1A-40A, 2A-2A, 2C, 2A-4A, 4A-2A, 2A-5A, 5A-2A, 2A-12A, 12A-2A, 2A-13A, 13A-2A, 2A-17A, 17A-2A, 2A-28A, 2A-29A, 2A-30A, 2A-66A, 2A-71A, 71A-2A, 3A-3A, 3B, 3C, 3A-5A, 5A-3A, 3A-7A, 7A-3A, 3A-8A, 8A-3A, 3A-18A, 18A-3A, 3A-19A, 19A-3A, 3A-20A, 20A-3A, 3A-26A, 26A-3A, 3A-28A, 28A-3A, 3A-32A, 3A-38A, 3A-40A, 4A-4A, 4A-5A, 5A-4A, 4A-12A, 12A-4A, 4A-13A, 13A-4A, 4A-17A, 17A-4A, 4A-28A, 4A-29A, 4A-30A, 4A-71A, 5A-5A, 5B, 5A-7A, 7A-5A, 5A-25A, 25A-5A, 5A-30A, 5A-38A, 5A-40A, 5A-41A, 5A-66A, 66A-5A, 7A-7A, 7B, 7C, 7A-8A, 8A-7A, 7A-12A, 12A-7A, 7A-20A, 20A-7A, 20A-42A, 7A-26A, 26A-7A, 7A-28A, 28A-7A, 7A-32A, 7A-42A, 7A-66A(B66 SCC only), 8B, 8A-32A, 8A-38A, 8A-39A, 8A-40A, 8A-41A, 8A-42A, 12A-25A, 25A-12A, 12A-12A, 12B, 12A-30A, 12A-66A, 13A-66A, 66A-13A, 19A-42A, 20A-32A, 20A-38A, 20A-40A, 21A-28A, 28A-21A, 21A-42A, 25A-25A, 25A-26A, 26A-25A, 26A-41A, 28C, 28A-38A, 28A-40A, 28A-41A, 28A-42A, 32A-42A, 38C, 39C, 39A-41A, 39A-42A, 39C-42A, 40A-40A, 40C, 40A-42A, 42A-40A, 41A-41A, 41C, 41A-42A, 42A-41A, 42A-42A, 42C, 66A-29A, 66A-30A, 66A-66A, 66B, 66C, 66A-71A, 71A-66A - 3CA 1A-1A-3A, 1A-1A-5A, 1C-5A, 1A-1A-7A, 1A-3A-3A, 1C-3A, 1A-1A-28A, 28A-1A-1A, 1A-3C, 1A-3A-5A, 1A-3A-7A, 1A-3A-8A, 1A-3A-18A, 1A-3A-19A, 1A-3A-20A, 1A-3A-26A, 1A-3A-28A, 1A-3A-32A, 1A-3A-38A, 1A-3A-40A, 1A-5A-7A, 1A-5A-40A, 1A-7A-7A, 1A-7C, 1A-7A-8A, 1A-7A-20A, 1A-7A-26A, 1A-7A-28A, 1A-7A-32A, 1A-8A-38A, 1A-8A-40A, 1A-20A-32A, 1A-40C, 2A-2A-4A, 2A-2A-5A, 2C-5A, 2A-2A-12A, 2C-12A, 2A-2A-13A, 2A-2A-29A, 2C-29A, 2A-2A-30A, 2C-30A, 2A-4A-4A, 2A-4A-5A, 2A-4A-12A, 2A-4A-13A, 2A-4A-28A, 2A-4A-29A, 2A-4A-30A, 2A-4A-71A, 2A-5B, 2A-5A-30A, 2A-5A-66A, 2A-12A-12A, 2A-12B, 2A-12A-30A, 2A-12A-66A, 2A-13A-66A, 2A-29A-30A, 2A-29A-66A, 2A-30A-66A, 2A-66A-71A, 2A-66A-66A, 2A-66B, 2A-66C, 2A-2A-66A, 2C-66A, 2A-2A-71A, 3C-5A, 3A-3A-7A, 3A-7A-7A, 3A-7B, 3A-7C, 3C-7A, 3A-3A-8A, 3C-8A, 3A-3A-19A, 3A-3A-20A, 3C-20A, 3A-3A-28A, 3C-28A, 3C-32A, 3C-38A, 3A-5A-7A, 3A-5A-40A, 3A-7A-8A, 3A-7A-20A, 3A-7A-26A, 3A-7A-28A, 3A-7A-32A, 3A-7A-42A, 3A-8A-32A, 3A-8A-38A, 3A-8A-40A, 3A-19A-42A , 3A-20A-32A, 3A-28A-38A, 3A-28A-40A, 3A-28A-42A, 3A-40A-40A, 3A-40C, 3C-40A, 4A-4A-5A, 4A-5B, 4A-4A-12A, 4A-4A-13A, 4A-4A-29A, 4A-4A-30A, 4A-4A-71A, 4A-5A-30A, 4A-12A-12A, 4A-12B, 4A-12A-30A, 4A-29A-30A, 5B-30A, 5A-5A-40A, 5A-5A-66A, 5A-7A-7A, 5A-7C, 5A-30A-66A, 5A-40A-40A, 5A-40C, 5A-66A-66A, 5A-66B, 5A-66C, 5B-66A, 7A-7A-8A, 7C-20A, 7A-7A-26A, 7B-28A, 7C-28A, 7A-7A-66A(B66 SCC only), 7C-66A(B66 SCC only), 7A-12B, 7A-12A-66A(B66 SCC only), 7A-20A-32A, 7A-42A-42A, 7A-66A-66A(B66 SCC only), 8A-39C, 8B-39A, 8A-40C, 8A-41C, 8B-41A, 8A-42C, 8A-39A-41A, 12A-30A-66A, 12A-66A-66A, 12A-66C, 12B-66A, 13A-66A-66A, 13A-66B, 13A-66C, 19A-42C, 20A-38C, 20A-40A-40A, 20A-40C, 20A-42A-42A, 21A-28A-42A, 21A-42C, 25A-25A-25A, 25A-25A-26A, 26A-41C, 28A-40C, 28A-41C, 28A-41A-42A, 28A-42C, 39A-41C, 39C-41A, 39A-42C, 40A-40C, 40D, 40A-42C, 40C-42A, 41A-41C, 41D, 41A-41A-41A, 41A-42C, 42A-42C, 42D, 66A-66B, 66A-66C, 66A-66A-66A, 66D, 66A-29A-30A, 66A-66A-29A, 66C-29A, 66A-66A-30A, 66A-66A-71A, 66C-71A - 4CA 1A-1A-3C, 3C-1A-1A, 1A-1A-3A-5A, 3A-1A-1A-5A, 5A-1A-1A-3A, 1C-3A-5A, 3A-1C-5A, 5A-1C-3A, 1A-1A-3A-7A, 3A-1A-1A-7A, 7A-1A-1A-3A, 1A-1A-3A-28A, 3A-1A-1A-28A, 28A-1A-1A-3A, 1A-3C-5A, 3C-1A-5A, 5A-1A-3C, 1A-3A-3A-7A, 3A-3A-1A-7A, 7A-1A-3A-3A, 1A-3C-7A, 3C-1A-7A, 7A-1A-3C, 1A-3A-3A-8A, 3A-3A-1A-8A, 8A-1A-3A-3A, 1A-3C-8A, 3C-1A-8A, 8A-1A-3C, 1A-3A-3A-19A, 3A-3A-1A-19A, 19A-1A-3A-3A, 1A-3A-3A-20A, 3A-3A-1A-20A, 20A-1A-3A-3A, 1A-3C-20A, 3C-1A-

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1.2.2 Function overview

Feature	Description
Physical Dimensions	Dimensions (L × W × H): 34 mm × 38 mm × 3.4 mm Weight: about 10 g
Operating Temperature	Normal operating temperature: -40℃ to +85℃ Extended operating temperature : -40℃ to +95℃
Storage Temperature	-40℃ to +95℃
Humidity	RH5% to RH95%
Power Voltage	DC 4.0 V to 4.4 V (typical value is 4.2 V)
Antenna Interface	antenna pad x 2

NOTE

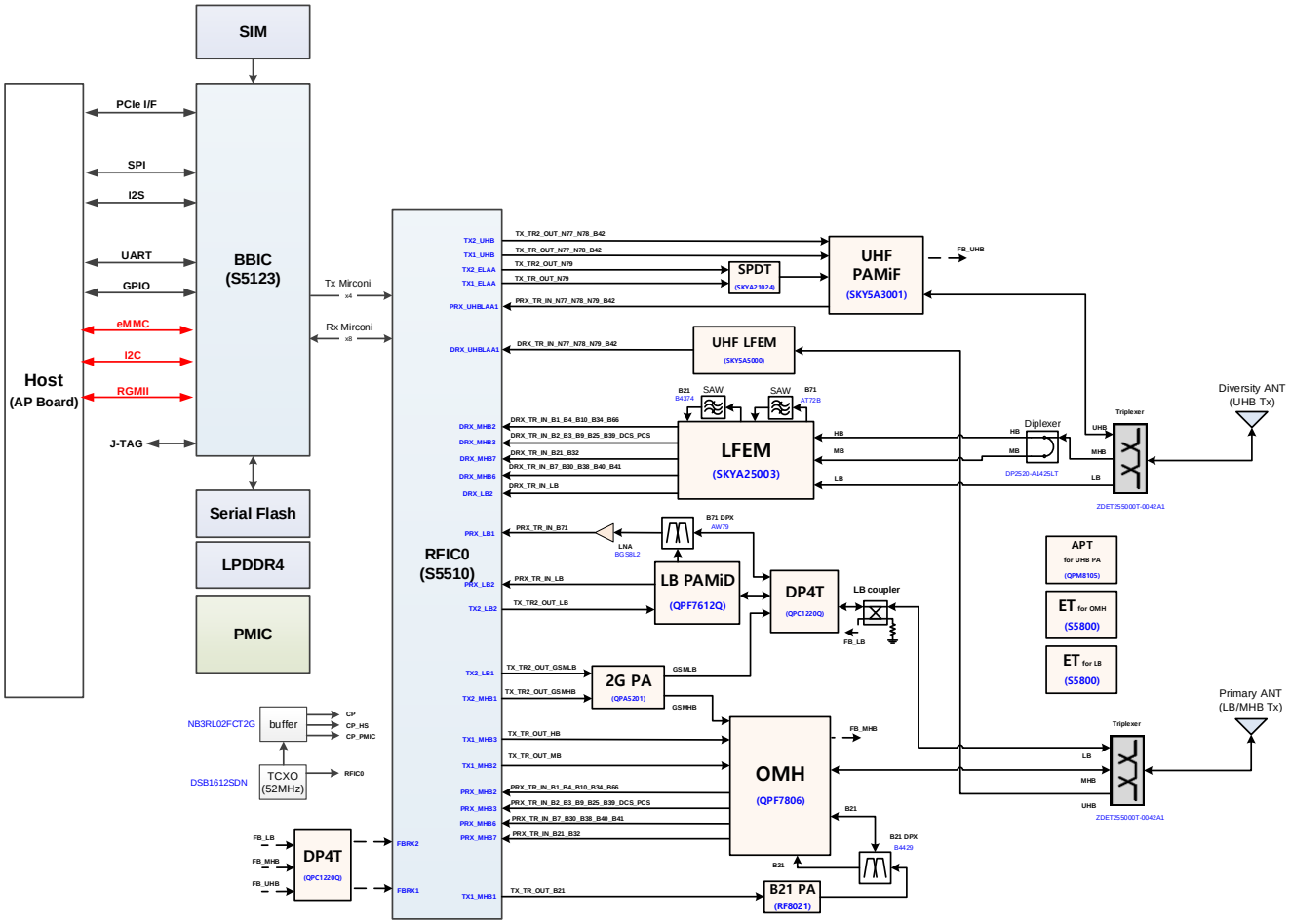
1) −10°C ~ +55°C This range is defined by 3GPP. WAVE guarantees its modules to comply with all 3GPP standard and to have full functionality of the module with in this range.
2) −40°C ~ +85°C WAVE guarantees full functionality within this range as well. However, there may possibly be some performance deviations in this extended range relative to 3GPP requirements, which means that some RF parameters may deviate from the 3GPP specification in the order of a few dB.

1.2.3 Circuit Block Diagram

The module was developed based on Samsung platform. Figure 1-1 shows the circuit block diagram. The major functional units contain the following parts:

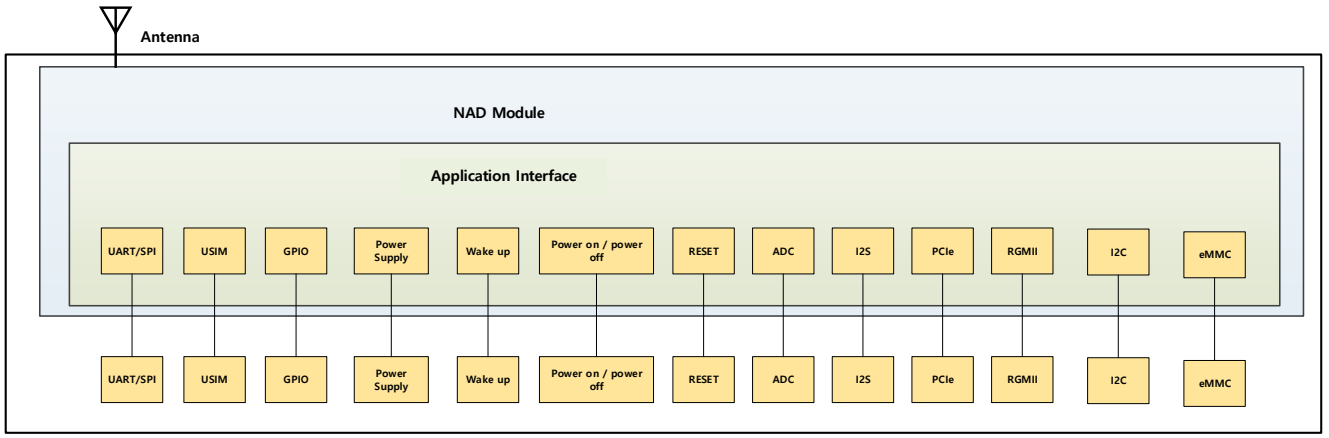
- Power Management
- Baseband Controller
- SPI NOR Flash
- RF Circuit

Figure 1-1 Circuit block diagram of the module



1.2.4 Application Block Diagram

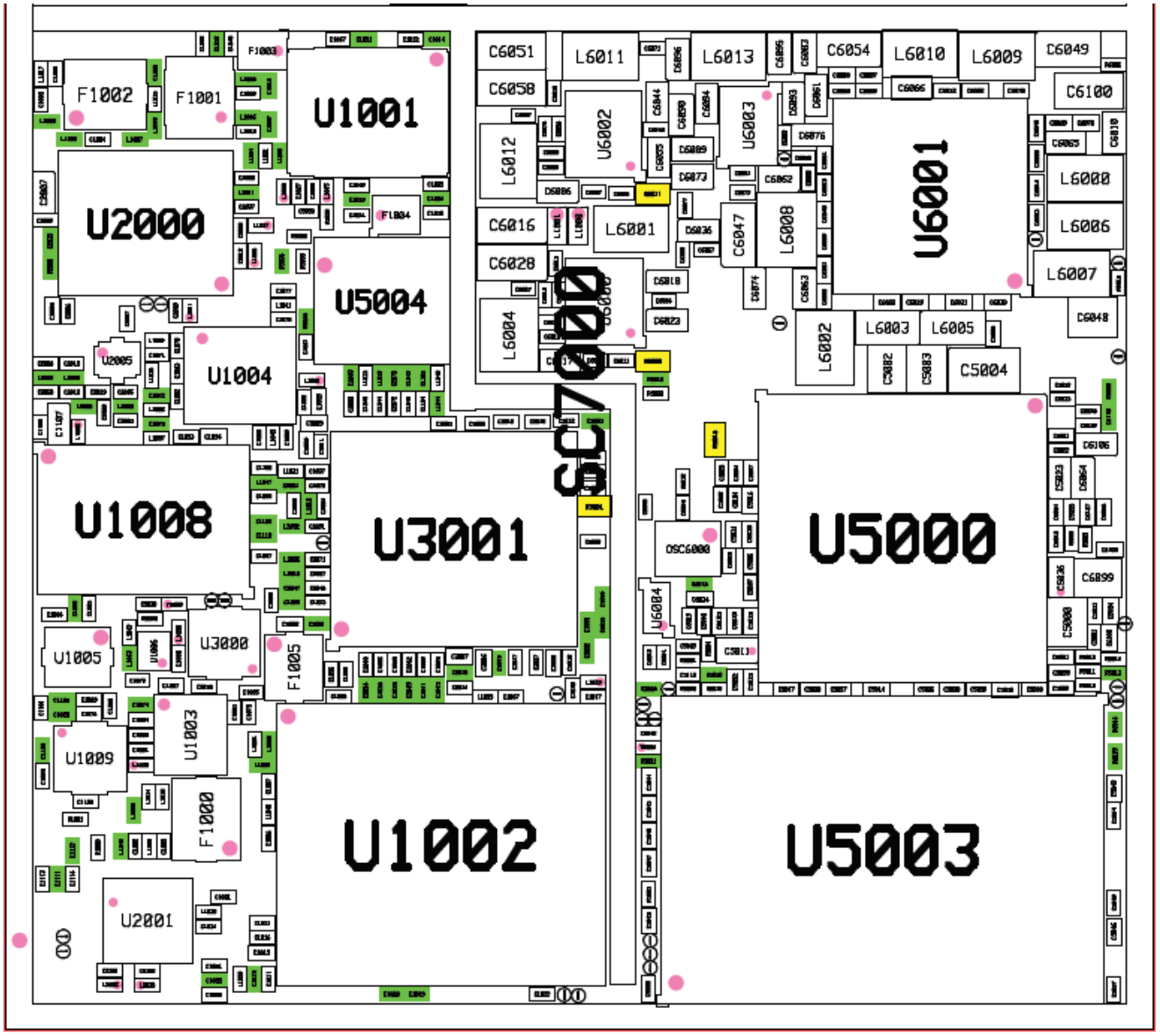
Figure 1-2 Application block diagram of the module



SPI Interface	Serial Peripheral Interface.
UART Interface	Module supports UART interfaces.
USIM Interface	USIM interface provides the interface for a USIM card.
eSIM Interface	eSIM interface support.
GPIO	General Purpose I/O pins
External Power Supply	DC 4 V is recommended.
Audio Interface	The module supports one PCM interface.
RF Pad	RF antenna interface
ADC Interface	Analog-to-Digital Converter
I2C Interface	Inter-Integrated Circuit
SDIO Interface	Secure Digital Input and Output (SD3.0)
PCIe Interface	Peripheral Component Interface Express
MII Interface	Media Independent Interface
eMMC Interface	embedded Multi Media Card Interface

1.2.5 Components Layout

Figure 1-3 Components Layout



2 Description of the Application Interfaces

2.1 LGA Interface

Figure 2-1 LGA Interface **(TOP View)**

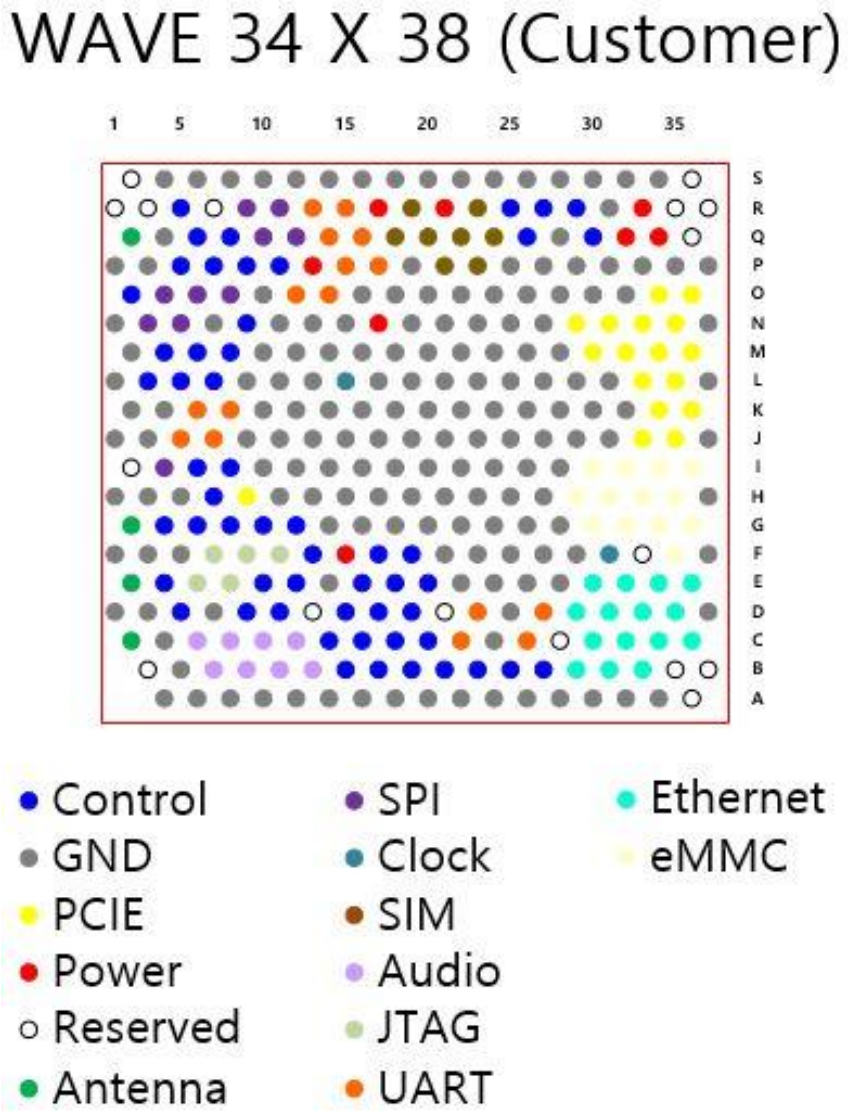
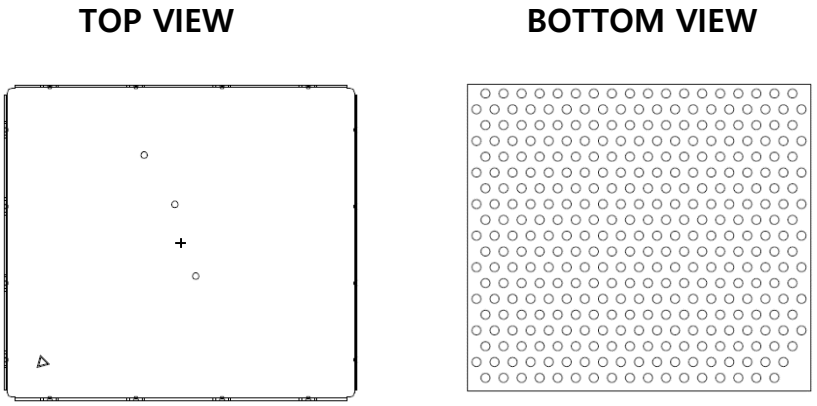


Figure 2-2 Appearance of the module (**Without Label**)



The position of the 1st pin where the triangle mark is located.

Table 2-1 Definitions of pins on the LGA interface

No	Name	Voltage Level	I/O	Internal Pull state	Description	Connection to TCU External AP (BMW WAVE)	Connection to TCU eAP (VOLVO TCAM2)
POWER							
F15	VDD_1P8_AP	1.8	Power Input	-	VDD AP Power / Input for PCIe PU	UG1V8_NAD	UG1V8_NAD
Q32	VPH_PWR	4.0 ~ 4.4	Power Input	-	NAD Main POWER (4.2V~4.5V)	UG4V2	UG4V2
Q34	VPH_PWR	4.0 ~ 4.4	Power Input	-		UG4V2	UG4V2
R33	VPH_PWR	4.0 ~ 4.4	Power Input	-		UG4V2	UG4V2
P13	VLDO2_CP_VDD180	1.8	Power Output	-	VDD CP Power / Output	NAD_ECP_1V8	NAD_ECP_1V8
R21	VLDO10_CP_USIM0	1.8	Power Output	-	USIM0 Power output	NAD_SIM0_VCC	NAD_SIM0_VCC
R17	VLDO11_CP_USIM1	1.8	Power Output	-	Reserved	Leave this pin open(floating)	NAD_SIM1_VCC
Antenna Port							
C2	MAIN_ANT	-	-	-	Prx(MiMo #1) Antenna Port	Cellular_MainAnt1	Cellular_MainAnt1
Q2	DIV_ANT	-	-	-	Drx(MiMo #2) Antenna Port	Cellular_MainAnt2	Cellular_MainAnt2
G2	GNSS_ANT_L1	-	-	-	GNSS L1 ANT	Leave this pin open(floating)	GNSS_ANT_L1
E2	GNSS_ANT_L5	-	-	-	GNSS L5 ANT	Leave this pin open(floating)	GNSS_ANT_L5
Antenna switching							
M8	RFFE_DATA	1.8	O	-	MIPI DATA for ANT switch at TCU side	Ant switch	Ant switch
N9	RFFE_CLK	1.8	O	-	MIPI CLK for ANT switch at TCU side	Ant switch	Ant switch
E12	GPADC2	1.8	I	-	Connect to GND if unused	Ant switch (ADC)	Ant switch (ADC)
PCIE Interface							

L33	PCIE1_REFCLK_N	0.85	B	-	PCIE REF CLKN	AP_PCIe0_REFCLK_N	AP_PCIe0_REFCLK_N
L35	PCIE1_REFCLK_P	0.85	B	-	PCIE REF CLKP	AP_PCIe0_REFCLK_P	AP_PCIe0_REFCLK_P
J33	PCIE1_RXD_N	0.85	O	-	PCIE TXDN at CP side	AP_PCIe0_RX_N	AP_PCIe0_RX_N
J35	PCIE1_RXD_P	0.85	O	-	PCIE TXDP at CP side	AP_PCIe0_RX_P	AP_PCIe0_RX_P
K34	PCIE1_TXD_N	0.85	I	-	PCIE RXDN at CP side	AP_PCIe0_TX_N	AP_PCIe0_TX_N
K36	PCIE1_TXD_P	0.85	I	-	PCIE RXDP at CP side	AP_PCIe0_TX_P	AP_PCIe0_TX_P
N29	PCIE1_CLK_REQ_N	1.8	B	PU	PCIE Clock Request_N	NAD_PCIe_CLK_REQn	NAD_PCIe_CLK_REQn
H9	PCIE1_RST_N_RC	1.8	O		PCIE Reset as NAD	Leave this pin open(floating)	NAD_PCIe_RSTn
O36	PCIE2_REFCLK0_N	0.85	B	-	PCIE REF CLKN	Leave this pin open(floating)	PCIE2_REFCLK0_N
O34	PCIE2_REFCLK0_P	0.85	B	-	PCIE REF CLKP	Leave this pin open(floating)	PCIE2_REFCLK0_P
M34	PCIE2_RX0_N	0.85	O	-	PCIE TXDN at CP side	Leave this pin open(floating)	PCIE2_RX0_N
M36	PCIE2_RX0_P	0.85	O	-	PCIE TXDP at CP side	Leave this pin open(floating)	PCIE2_RX0_P
N33	PCIE2_TX0_N	0.85	I	-	PCIE RXDN at CP side	Leave this pin open(floating)	PCIE2_TX0_N
N35	PCIE2_TX0_P	0.85	I	-	PCIE RXDP at CP side	Leave this pin open(floating)	PCIE2_TX0_P
N31	PCIE2_CLK_REQ_N	1.8	B	PU	PCIE Clock Request_N	Leave this pin open(floating)	PCIE2_CLK_REQ_N
M30	PCIE2_RST_N	1.8	O	-	PCIE Reset as NAD	Leave this pin open(floating)	PCIE2_RST_N
SPI Interface							
Q12	CP_SPI_CLK	1.8	I/O	-	SPI Clock	NAD_SPI_CLK	NAD_SPI_CLK
Q10	CP_SPI_CSN	1.8	I/O	-	SPI Chip Select	NAD_SPI_CSn	NAD_SPI_CSn
R11	CP_SPI_MISO	1.8	O	-	SPI TX DATA	NAD2_SPI_MISO(slave mode) NAD_SPI_MOSI(master mode)/ AP2CP_DUMP_NOTI	NAD2_SPI_MISO(slave mode) NAD_SPI_MOSI(master mode)
R9	CP_SPI_MOSI	1.8	I	-	SPI RX DATA	NAD2_SPI_MISO(slave mode) NAD_SPI_MOSI(master mode)	NAD2_SPI_MISO(slave mode) NAD_SPI_MOSI(master mode)
AP / MCU ↔ CP Interface							
Q26	CP_PMIC_PWR_EN	1.8	I	-	CP Power on input	NAD_PMIC_EN	NAD_PMIC_EN
C28	CP_RESETB	1.8	I	-	External Reset Input	NAD_RSTn	NAD_RSTn
F31	CP_CLK_32K	1.8	I	-	CP sleep clock / input	NAD_RTC	NAD_RTC
I2S Interface							
C6	SPEECH_I2S_BCK_CP	1.8	I	-	Audio I/F Clock	NAD_I2S_BCK	NAD_I2S_BCK
C8	SPEECH_I2S_D_IN_CP	1.8	I	-	Audio I/F Serial Data Input	NAD_I2S_DIN	NAD_I2S_DIN
B9	SPEECH_I2S_D_OUT_CP	1.8	O	-	Audio I/F Serial Data Output	NAD_I2S_DOUT	NAD_I2S_DOUT
B7	SPEECH_I2S_LRCK_CP	1.8	I	-	Audio I/F Left/Right Channel	NAD_I2S_LRCK	NAD_I2S_LRCK
B13	CP_I2S1_BCK_RSV	1.8	I	-	Audio I/F Clock	Leave this pin open(floating)	CP_I2S1_BCK
B11	CP_I2S1_DIN_RSV	1.8	I	-	Audio I/F Serial Data Input	Leave this pin open(floating)	CP_I2S1_DIN
C12	CP_I2S1_DOUT_RSV	1.8	O	-	Audio I/F Serial Data Output	Leave this pin open(floating)	CP_I2S1_DOUT
C10	CP_I2S1_LRCK_RSV	1.8	I	-	Audio I/F Left/Right Channel	Leave this pin open(floating)	CP_I2S1_LRCK

SIM Interface							
Q22	SIM0_CLK	1.8	O	-	USIM0 CLK	NAD_SIM0_CLK	NAD_SIM0_CLK
P23	SIM0_DATA	1.8	O	-	USIM0 DATA	NAD_SIM0_IO	NAD_SIM0_IO
Q24	SIM0_RST	1.8	O	-	USIM0 Reset	NAD_SIM0_RST	NAD_SIM0_RST
R23	TRAY_DET_SIM0	1.8	I	-	SIM Tray detect. Need external PU(47k) to NAD_ECP_1V8	SIM Tray detect	SIM Tray detect / CP_GPIO
P21	SIM1_CLK	1.8	O	-	USIM1 CLK	Leave this pin open(floating)	SIM1_CLK / CP_GPIO
Q20	SIM1_DATA	1.8	O	-	USIM1 DATA	Leave this pin open(floating)	SIM1_DATA / CP_GPIO
Q18	SIM1_RST	1.8	O	-	USIM1 Reset	Leave this pin open(floating)	SIM1_RST / CP_GPIO
R19	TRAY_DET_SIM1	1.8	I	-	SIM Tray detect. Need external PU(47k) to NAD_ECP_1V8	Leave this pin open(floating)	TRAY_DET_SIM1 / CP_GPIO
CV2X Interface							
L15	RAN_SYNC	1.8	O	-	RAN SYNC for CV2X	RAN_SYNC	RAN_SYNC
N17	GNSS_PPS	1.8	O	-	GNSS PPS for CV2X	Leave this pin open(floating)	GNSS_PPS
Debug Interface							
E8	RSV_CP_JTAG_TCK	1.8	I	-	CPU JTAG TCK	CP_JTAG_TCK	CP_JTAG_TCK
E6	RSV_CP_JTAG_TDI	1.8	I	-	CPU JTAG TDI	CP_JTAG_TDI	CP_JTAG_TDI
F11	RSV_CP_JTAG_TDO	1.8	I	-	CPU JTAG TDO	CP_JTAG_TDO	CP_JTAG_TDO
F9	RSV_CP_JTAG_TMS	1.8	I	-	CPU JTAG TMS	CP_JTAG_TMS	CP_JTAG_TMS
F7	RSV_CP_JTAG_TRST_N	1.8	I	-	CPU JTAG TRst	CP_JTAG_TRST	CP_JTAG_TRST
UART Interface							
P15	CP_UART_RXD	1.8	I	-	CP UART0 Rx Data	NAD_Debug_UART_RX	NAD_Debug_UART_RX
P17	CP_UART_TXD	1.8	O	-	CP UART0 Tx Data	NAD_Debug_UART_TX	NAD_Debug_UART_TX
R13	UART1_RXD	1.8	I	-	CP UART1 Rx Data	Leave this pin open(floating)	UART1_RXD
R15	UART1_TXD	1.8	O	-	CP UART1 Tx Data	Leave this pin open(floating)	UART1_TXD
J5	UART1_CTSB_N	1.8	I	-	CP UART1 CTS Data	Leave this pin open(floating)	UART1_CTS
J7	UART1_RTSB_N	1.8	O	-	CP UART1 RTS Data	Leave this pin open(floating)	UART1_RTS
Q14	UART2_RXD	1.8	I	-	CP UART2 Rx Data	Leave this pin open(floating)	UART2_RXD
Q16	UART2_TXD	1.8	O	-	CP UART2 Tx Data	Leave this pin open(floating)	UART2_TXD
K6	UART2_CTSB_N	1.8	I	-	CP UART2 CTS Data	Leave this pin open(floating)	UART2_CTS
K8	UART_RTSB_N	1.8	O	-	CP UART2 RTS Data	Leave this pin open(floating)	UART2_RTS
O12	UART3_RXD	1.8	I	-	CP UART3 Rx Data	Leave this pin open(floating)	UART3_RXD
O14	UART3_TXD	1.8	O	-	CP UART3 Tx Data	Leave this pin open(floating)	UART3_TXD
TCU thermal detection							
D11	CP_THM	1.8	O	-	Thermistor on NAD module (Max 1.8V)	CP_THM	CP_THM
EMMC Interface							
F35	EMMC_CLK	1.8	O	-	EMMC_CLK	Leave this pin open(floating)	EMMC_CLK

G34	EMMC_CMD	1.8	O	-	EMMC_CMD	Leave this pin open(floating)	EMMC_CMD
H33	EMMC_D(0)	1.8	B	-	EMMC_D(0)	Leave this pin open(floating)	EMMC_D(0)
I36	EMMC_D(1)	1.8	B	-	EMMC_D(1)	Leave this pin open(floating)	EMMC_D(1)
G32	EMMC_D(2)	1.8	B	-	EMMC_D(2)	Leave this pin open(floating)	EMMC_D(2)
I32	EMMC_D(3)	1.8	B	-	EMMC_D(3)	Leave this pin open(floating)	EMMC_D(3)
G36	EMMC_D(4)	1.8	B	-	EMMC_D(4)	Leave this pin open(floating)	EMMC_D(4)
H31	EMMC_D(5)	1.8	B	-	EMMC_D(5)	Leave this pin open(floating)	EMMC_D(5)
H35	EMMC_D(6)	1.8	B	-	EMMC_D(6)	Leave this pin open(floating)	EMMC_D(6)
I34	EMMC_D(7)	1.8	B	-	EMMC_D(7)	Leave this pin open(floating)	EMMC_D(7)
G30	EMMC_NRESET	1.8	O	-	EMMC_NRESET	Leave this pin open(floating)	EMMC_NRESET
H29	EMMC_PWREN	1.8	O	-	EMMC_PWREN	Leave this pin open(floating)	EMMC_PWREN
I30	EMMC_RDQS	1.8	I	-	EMMC_RDQS	Leave this pin open(floating)	EMMC_RDQS
Ethernet Interface (RGMII)							
E32	XETH0_INTR	1.8	I	-	XETH0_INTR	Leave this pin open(floating)	XETH0_INTR
B29	XETH0_MDC	1.8	O	-	XETH0_MDC	Leave this pin open(floating)	XETH0_MDC
B31	XETH0_MDIO	1.8	B	-	XETH0_MDIO	Leave this pin open(floating)	XETH0_MDIO
C30	XETH0_RXC	1.8	I	-	XETH0_RXC	Leave this pin open(floating)	XETH0_RXC
D29	XETH0_RXCTL	1.8	I	-	XETH0_RXCTL	Leave this pin open(floating)	XETH0_RXCTL
B33	XETH0_RXD0	1.8	I	-	XETH0_RXD0	Leave this pin open(floating)	XETH0_RXD0
C32	XETH0_RXD1	1.8	I	-	XETH0_RXD1	Leave this pin open(floating)	XETH0_RXD1
C34	XETH0_RXD2	1.8	I	-	XETH0_RXD2	Leave this pin open(floating)	XETH0_RXD2
C36	XETH0_RXD3	1.8	I	-	XETH0_RXD3	Leave this pin open(floating)	XETH0_RXD3
E30	XETH0_TXC	1.8	O	-	XETH0_TXC	Leave this pin open(floating)	XETH0_TXC
D31	XETH0_TXCTL	1.8	O	-	XETH0_TXCTL	Leave this pin open(floating)	XETH0_TXCTL
D33	XETH0_TXD0	1.8	O	-	XETH0_TXD0	Leave this pin open(floating)	XETH0_TXD0
E34	XETH0_TXD1	1.8	O	-	XETH0_TXD1	Leave this pin open(floating)	XETH0_TXD1
D35	XETH0_TXD2	1.8	O	-	XETH0_TXD2	Leave this pin open(floating)	XETH0_TXD2
E36	XETH0_TXD3	1.8	O	-	XETH0_TXD3	Leave this pin open(floating)	XETH0_TXD3
GNSS Control & Debug Pins							
G4	GNSS_LNA_EN_L1	1.8	O	-	GNSS_LNA_Control	Leave this pin open(floating)	GNSS_LNA_EN_L1

E4	GNSS_LNA_EN_L5	1.8	O	-	GNSS_LNA_Control	Leave this pin open(floating)	GNSS_LNA_EN_L5
C26	GNSS_UART_TX	1.8	O	-	GNSS_UART_TX	Leave this pin open(floating)	GNSS_UART_TX
D27	GNSS_UART_RX	1.8	I	-	GNSS_UART_RX	Leave this pin open(floating)	GNSS_UART_RX
D23	GNSS_UART_CTS	1.8	I	-	GNSS_UART_CTS	Leave this pin open(floating)	GNSS_UART_CTS
C22	GNSS_UART_RTS	1.8	O	-	GNSS_UART_RTS	Leave this pin open(floating)	GNSS_UART_RTS
D5	GNSS_CHUB_INT	1.8	I	-	GNSS_CHUB_INT	Leave this pin open(floating)	GNSS_CHUB_INT
F13	GNSS_BLANK_RFIC	1.8	O	-	GNSS_BLANK_RFIC	Leave this pin open(floating)	GNSS_BLANK_RFIC
I2C Interface							
I6	XUSI00_I2C_SDA	1.8	B	-	I2C_SDA	Leave this pin open(floating)	XUSI00_I2C_SDA / EXTCLK0 (APGS)
I4	XUSI00_I2C_SCL	1.8	B	-	I2C_SCL	Leave this pin open(floating)	XUSI00_I2C_SCL
Q30	XUSI01_I2C_SDA	1.8	B	-	I2C_SDA	Leave this pin open(floating)	XUSI01_I2C_SDA
R29	XUSI01_I2C_SCL	1.8	B	-	I2C_SCL	Leave this pin open(floating)	XUSI01_I2C_SCL
O2	I2C1_SDA	1.8	B	-	I2C1_SDA	Leave this pin open(floating)	I2C1_SDA
P11	I2C1_SCL	1.8	B	-	I2C1_SCL	Leave this pin open(floating)	I2C1_SCL
CP GPIO							
F17	XCP_GPIO3_CPALV	1.8	B	-	CP_GPIO	CP2AP_NOTIFY_ACTIVE (CP sends an interrupt to notify active status to AP. Need external PD(47k) to GND)	CP_GPIO / (CP sends an interrupt to notify active status to MCU. Need external PD(47k) to GND)
F19	XCP_GPIO4_CPALV	1.8	B	-	CP_GPIO	CP2AP_WAKEUP (CP sends an interrupt signal to wake up AP)	CP_GPIO
R5	XCP_GPIO_23	1.8	B	-	CP_GPIO	CP2WUC_WAKEUP (CP sends an interrupt signal to wake up MCU)	CP_GPIO
E10	I3C_CP_SCL	1.8	B	-	I3C_CP_SCL	Leave this pin open(floating)	CP_GPIO
D9	I3C_CP_SDA	1.8	B	-	I3C_CP_SDA	Leave this pin open(floating)	CP_GPIO
CP / AP GPIO (These pins can be used as CP GPIO for BMW WAVE Project or AP GPIO for VOLVO TCAM2 project)							
H7	XCP_GPIO_46	1.8	B		AP / CP GPIO	Leave this pin open(floating)	AP_GPIO
I8	XCP_GPIO_47	1.8	B		AP / CP GPIO	Leave this pin open(floating)	AP_GPIO
B25	XCP_GPIO_57	1.8	B	-	AP / CP GPIO	Leave this pin open(floating)	AP_GPIO
B27	XCP_GPIO_60	1.8	B	-	AP / CP GPIO	Leave this pin open(floating)	AP_GPIO
P7	XCP_GPIO_48	1.8	O	-	AP / CP GPIO	GPIO_ANT_SW1	AP_GPIO
P9	XCP_GPIO_49	1.8	O	-	AP / CP GPIO	GPIO_ANT_SW2	AP_GPIO
Q6	XCP_GPIO_54	1.8	O	-	AP / CP GPIO	GPIO_ANT_SW3	AP_GPIO
Q8	XCP_GPIO_55	1.8	O	-	AP / CP GPIO	GPIO_ANT_SW4	AP_GPIO

P5	XCP_GPIO_63	1.8	B	-	AP / CP GPIO	XCP_GPIO_RSV1	AP_GPIO
M4	XCP_GPIO_50	1.8	B	-	AP / CP GPIO	XCP_GPIO_RSV2	AP_GPIO
M6	XCP_GPIO_51	1.8	B	-	AP / CP GPIO	XCP_GPIO_RSV3	AP_GPIO
L3	XCP_GPIO_52	1.8	B	-	AP / CP GPIO	XCP_GPIO_RSV4	AP_GPIO
L5	XCP_GPIO_53	1.8	B	-	AP / CP GPIO	Leave this pin open(floating)	AP_GPIO
L7	XCP_GPIO_62	1.8	B	-	AP / CP GPIO	Leave this pin open(floating)	AP_GPIO
R25	XCP_GPIO_61	1.8	B	-	AP / CP GPIO	Leave this pin open(floating)	AP_GPIO
R27	XCP_GPIO_58	1.8	B	-	AP / CP GPIO	Leave this pin open(floating)	AP_GPIO
AP GPIO							
M32	AP_XEINT_0	1.8	I	-	AP_GPIO	NAD_PCIe_RSTn (PCIE1 reset as NAD EP)	AP_GPIO
G6	AP_XEINT_1	1.8	I	-	AP_GPIO	AP2CP_WAKEUP (External AP sends an interrupt signal to wake up CP)	AP_GPIO
G8	AP_XEINT_2	1.8	I	-	AP_GPIO	AP_CP2_ACTIVE (External AP sends an interrupt to notify AP active status to CP)	AP_GPIO
G10	AP_XEINT_3	1.8	I	-	AP_GPIO	Reserved (Not connected, leave open)	AP_GPIO
G12	AP_XEINT_4	1.8	I	-	AP_GPIO	WUC2CP_WAKEUP (MCU sends an interrupt signal to Wake up CP)	AP_GPIO GPIO / Dual image boot select (Need external PU(10k) to ECP_1V8 and De-cap (100nF) to GND)
E16	AP_GPIO_SDIO0_CLK	1.8	O	-	AP_GPIO	Leave this pin open(floating)	AP_GPIO
B19	AP_GPIO_SDIO0_CMD	1.8	B	-	AP_GPIO	Leave this pin open(floating)	AP_GPIO
C18	AP_GPIO_SDIO0_D0	1.8	B	-	AP_GPIO	Leave this pin open(floating)	AP_GPIO
E20	AP_GPIO_SDIO0_D1	1.8	B	-	AP_GPIO	Leave this pin open(floating)	AP_GPIO
C16	AP_GPIO_SDIO0_D2	1.8	B	-	AP_GPIO	Leave this pin open(floating)	AP_GPIO
C14	AP_GPIO_SDIO0_D3	1.8	B	-	AP_GPIO	Leave this pin open(floating)	AP_GPIO
B15	AP_GPIO_SDIO1_CLK	1.8	O	-	AP_GPIO	Leave this pin open(floating)	AP_GPIO
D17	AP_GPIO_SDIO1_CMD	1.8	B	-	AP_GPIO	Leave this pin open(floating)	AP_GPIO
B17	AP_GPIO_SDIO1_D0	1.8	B	-	AP_GPIO	Leave this pin open(floating)	AP_GPIO
E18	AP_GPIO_SDIO1_D1	1.8	B	-	AP_GPIO	Leave this pin open(floating)	AP_GPIO
D19	AP_GPIO_SDIO1_D2	1.8	B	-	AP_GPIO	Leave this pin open(floating)	AP_GPIO
D15	AP_GPIO_SDIO1_D3	1.8	B	-	AP_GPIO	Leave this pin open(floating)	AP_GPIO
SPI Flash (eAP emergency Boot Download. Connect to EDGE connector)							
O4	CP_SPI1_TXD_FLASH	1.8	I	-	SPI MOSI	Leave this pin open(floating)	CP_SPI1_TXD_FLASH

O6	CP_SPI1_CSN_FLASH	1.8	I	-	SPI CSN	Leave this pin open(floating)	CP_SPI1_CSN_FLASH
O8	CP_SPI1_RXD_FLASH	1.8	O	-	SPI MISO	Leave this pin open(floating)	CP_SPI1_RXD_FLASH
N3	CP_SPI1_CLK_FLASH	1.8	I	-	SPI CLK	Leave this pin open(floating)	CP_SPI1_CLK_FLASH
N5	CP_SPI1_WPN_FLASH	1.8	I	-	SPI WP	Leave this pin open(floating)	CP_SPI1_WPN_FLASH
BOOT Mode (SPI: 000 , eMMC : 101 , NAD internal PD 100k ohm)							
C20	XCP_OM0	1.8	I	-	XCP_OM0	Leave this pin open(floating)	Need external PU(1k) to NAD_ECP_1V8
B21	XCP_OM1	1.8	I	-	XCP_OM1	Leave this pin open(floating)	Leave this pin open(floating)
B23	XCP_OM2	1.8	I	-	XCP_OM2	Leave this pin open(floating)	Need external PU(1k) to NAD_ECP_1V8
Reserved Pins							
Q36	Reserved	-	-	-	Reserved	Leave this pin open(floating)	Leave this pin open(floating)
D21	Reserved	-	-	-	Reserved	Leave this pin open(floating)	Leave this pin open(floating)
V33	Reserved	-	-	-	Reserved	Leave this pin open(floating)	Leave this pin open(floating)
D13	Reserved	-	-	-	Reserved	Leave this pin open(floating)	Leave this pin open(floating
I2	Reserved	-	-	-	Reserved	Leave this pin open(floating)	Leave this pin open(floating)
R7	Reserved	-	-	-	Reserved	Leave this pin open(floating)	Leave this pin open(floating)
F33	Reserved	-	-	-	Reserved	Leave this pin open(floating)	Leave this pin open(floating)
GND							
A4	GND	-	-	-	GND	GND	GND
A6	GND	-	-	-	GND	GND	GND
A8	GND	-	-	-	GND	GND	GND
A10	GND	-	-	-	GND	GND	GND
A12	GND	-	-	-	GND	GND	GND
A14	GND	-	-	-	GND	GND	GND
A16	GND	-	-	-	GND	GND	GND
A18	GND	-	-	-	GND	GND	GND
A20	GND	-	-	-	GND	GND	GND
A22	GND	-	-	-	GND	GND	GND
A24	GND	-	-	-	GND	GND	GND
A26	GND	-	-	-	GND	GND	GND
A28	GND	-	-	-	GND	GND	GND
A30	GND	-	-	-	GND	GND	GND
A32	GND	-	-	-	GND	GND	GND
A34	GND	-	-	-	GND	GND	GND
B5	GND	-	-	-	GND	GND	GND
C4	GND	-	-	-	GND	GND	GND
C24	GND	-	-	-	GND	GND	GND
D1	GND	-	-	-	GND	GND	GND
D3	GND	-	-	-	GND	GND	GND
D7	GND	-	-	-	GND	GND	GND
D25	GND	-	-	-	GND	GND	GND
D37	GND	-	-	-	GND	GND	GND
E14	GND	-	-	-	GND	GND	GND
E22	GND	-	-	-	GND	GND	GND

E24	GND	-	-	-	GND	GND	GND
E26	GND	-	-	-	GND	GND	GND
E28	GND	-	-	-	GND	GND	GND
F1	GND	-	-	-	GND	GND	GND
F3	GND	-	-	-	GND	GND	GND
F5	GND	-	-	-	GND	GND	GND
F21	GND	-	-	-	GND	GND	GND
F23	GND	-	-	-	GND	GND	GND
F25	GND	-	-	-	GND	GND	GND
F27	GND	-	-	-	GND	GND	GND
F29	GND	-	-	-	GND	GND	GND
F37	GND	-	-	-	GND	GND	GND
G14	GND	-	-	-	GND	GND	GND
G16	GND	-	-	-	GND	GND	GND
G18	GND	-	-	-	GND	GND	GND
G20	GND	-	-	-	GND	GND	GND
G22	GND	-	-	-	GND	GND	GND
G24	GND	-	-	-	GND	GND	GND
G26	GND	-	-	-	GND	GND	GND
G28	GND	-	-	-	GND	GND	GND
H1	GND	-	-	-	GND	GND	GND
H3	GND	-	-	-	GND	GND	GND
H5	GND	-	-	-	GND	GND	GND
H11	GND	-	-	-	GND	GND	GND
H13	GND	-	-	-	GND	GND	GND
H15	GND	-	-	-	GND	GND	GND
H17	GND	-	-	-	GND	GND	GND
H19	GND	-	-	-	GND	GND	GND
H21	GND	-	-	-	GND	GND	GND
H23	GND	-	-	-	GND	GND	GND
H25	GND	-	-	-	GND	GND	GND
H27	GND	-	-	-	GND	GND	GND
H37	GND	-	-	-	GND	GND	GND
I10	GND	-	-	-	GND	GND	GND
I12	GND	-	-	-	GND	GND	GND
I14	GND	-	-	-	GND	GND	GND
I16	GND	-	-	-	GND	GND	GND
I18	GND	-	-	-	GND	GND	GND
I20	GND	-	-	-	GND	GND	GND
I22	GND	-	-	-	GND	GND	GND
I24	GND	-	-	-	GND	GND	GND
I26	GND	-	-	-	GND	GND	GND
I28	GND	-	-	-	GND	GND	GND
J1	GND	-	-	-	GND	GND	GND
J3	GND	-	-	-	GND	GND	GND
J9	GND	-	-	-	GND	GND	GND
J11	GND	-	-	-	GND	GND	GND
J13	GND	-	-	-	GND	GND	GND
J15	GND	-	-	-	GND	GND	GND
J17	GND	-	-	-	GND	GND	GND
J19	GND	-	-	-	GND	GND	GND
J21	GND	-	-	-	GND	GND	GND
J23	GND	-	-	-	GND	GND	GND
J25	GND	-	-	-	GND	GND	GND
J27	GND	-	-	-	GND	GND	GND
J29	GND	-	-	-	GND	GND	GND

J31	GND	-	-	-	GND	GND	GND
J37	GND	-	-	-	GND	GND	GND
K2	GND	-	-	-	GND	GND	GND
K4	GND	-	-	-	GND	GND	GND
K10	GND	-	-	-	GND	GND	GND
K12	GND	-	-	-	GND	GND	GND
K14	GND	-	-	-	GND	GND	GND
K16	GND	-	-	-	GND	GND	GND
K18	GND	-	-	-	GND	GND	GND
K20	GND	-	-	-	GND	GND	GND
K22	GND	-	-	-	GND	GND	GND
K24	GND	-	-	-	GND	GND	GND
K26	GND	-	-	-	GND	GND	GND
K28	GND	-	-	-	GND	GND	GND
K30	GND	-	-	-	GND	GND	GND
K32	GND	-	-	-	GND	GND	GND
L1	GND	-	-	-	GND	GND	GND
L9	GND	-	-	-	GND	GND	GND
L11	GND	-	-	-	GND	GND	GND
L13	GND	-	-	-	GND	GND	GND
L17	GND	-	-	-	GND	GND	GND
L19	GND	-	-	-	GND	GND	GND
L21	GND	-	-	-	GND	GND	GND
L23	GND	-	-	-	GND	GND	GND
L25	GND	-	-	-	GND	GND	GND
L27	GND	-	-	-	GND	GND	GND
L29	GND	-	-	-	GND	GND	GND
L31	GND	-	-	-	GND	GND	GND
L37	GND	-	-	-	GND	GND	GND
M2	GND	-	-	-	GND	GND	GND
M10	GND	-	-	-	GND	GND	GND
M12	GND	-	-	-	GND	GND	GND
M14	GND	-	-	-	GND	GND	GND
M16	GND	-	-	-	GND	GND	GND
M18	GND	-	-	-	GND	GND	GND
M20	GND	-	-	-	GND	GND	GND
M22	GND	-	-	-	GND	GND	GND
M24	GND	-	-	-	GND	GND	GND
M26	GND	-	-	-	GND	GND	GND
M28	GND	-	-	-	GND	GND	GND
N1	GND	-	-	-	GND	GND	GND
N7	GND	-	-	-	GND	GND	GND
N11	GND	-	-	-	GND	GND	GND
N13	GND	-	-	-	GND	GND	GND
N15	GND	-	-	-	GND	GND	GND
N19	GND	-	-	-	GND	GND	GND
N21	GND	-	-	-	GND	GND	GND
N23	GND	-	-	-	GND	GND	GND
N25	GND	-	-	-	GND	GND	GND
N27	GND	-	-	-	GND	GND	GND
N37	GND	-	-	-	GND	GND	GND
O10	GND	-	-	-	GND	GND	GND
O16	GND	-	-	-	GND	GND	GND
O18	GND	-	-	-	GND	GND	GND
O20	GND	-	-	-	GND	GND	GND
O22	GND	-	-	-	GND	GND	GND

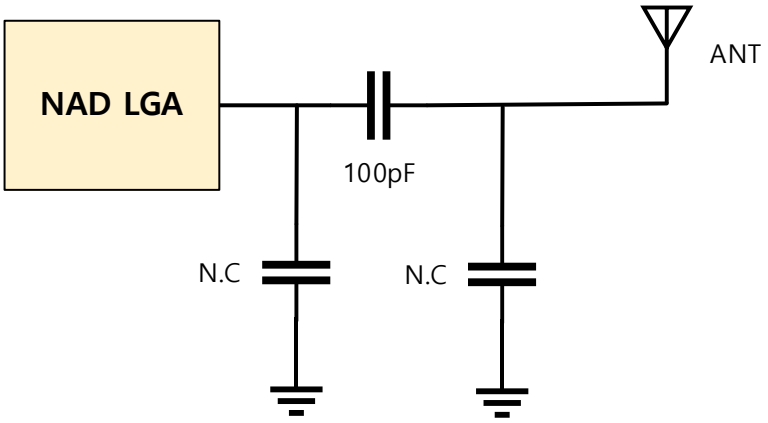
O24	GND	-	-	-	GND	GND	GND
O26	GND	-	-	-	GND	GND	GND
O28	GND	-	-	-	GND	GND	GND
O30	GND	-	-	-	GND	GND	GND
O32	GND	-	-	-	GND	GND	GND
P1	GND	-	-	-	GND	GND	GND
P3	GND	-	-	-	GND	GND	GND
P19	GND	-	-	-	GND	GND	GND
P25	GND	-	-	-	GND	GND	GND
P27	GND	-	-	-	GND	GND	GND
P29	GND	-	-	-	GND	GND	GND
P31	GND	-	-	-	GND	GND	GND
P33	GND	-	-	-	GND	GND	GND
P35	GND	-	-	-	GND	GND	GND
P37	GND	-	-	-	GND	GND	GND
Q4	GND	-	-	-	GND	GND	GND
Q28	GND	-	-	-	GND	GND	GND
R31	GND	-	-	-	GND	GND	GND
S4	GND	-	-	-	GND	GND	GND
S6	GND	-	-	-	GND	GND	GND
S8	GND	-	-	-	GND	GND	GND
S10	GND	-	-	-	GND	GND	GND
S12	GND	-	-	-	GND	GND	GND
S14	GND	-	-	-	GND	GND	GND
S16	GND	-	-	-	GND	GND	GND
S18	GND	-	-	-	GND	GND	GND
S20	GND	-	-	-	GND	GND	GND
S22	GND	-	-	-	GND	GND	GND
S24	GND	-	-	-	GND	GND	GND
S26	GND	-	-	-	GND	GND	GND
S28	GND	-	-	-	GND	GND	GND
S30	GND	-	-	-	GND	GND	GND
S32	GND	-	-	-	GND	GND	GND
S34	GND	-	-	-	GND	GND	GND
NC Pins							
A36	NC	-	-	-	NC	Leave this pin open(floating)	Leave this pin open(floating)
B3	NC	-	-	-	NC	Leave this pin open(floating)	Leave this pin open(floating)
B35	NC	-	-	-	NC	Leave this pin open(floating)	Leave this pin open(floating)
B37	NC	-	-	-	NC	Leave this pin open(floating)	Leave this pin open(floating)
R1	NC	-	-	-	NC	Leave this pin open(floating)	Leave this pin open(floating)
R3	NC	-	-	-	NC	Leave this pin open(floating)	Leave this pin open(floating)
R35	NC	-	-	-	NC	Leave this pin open(floating)	Leave this pin open(floating)
R37	NC	-	-	-	NC	Leave this pin open(floating)	Leave this pin open(floating)
S2	NC	-	-	-	NC	Leave this pin open(floating)	Leave this pin open(floating)
S36	NC	-	-	-	NC	Leave this pin open(floating)	Leave this pin open(floating)

2.2 LGA Interface guideline

2.2.1. ANT port

Place 3 matching components close to ANT port (**Figure 2-3**) to improve RF performance

Figure 2-3 Matching components at ANT port



2.2.2 MIPI

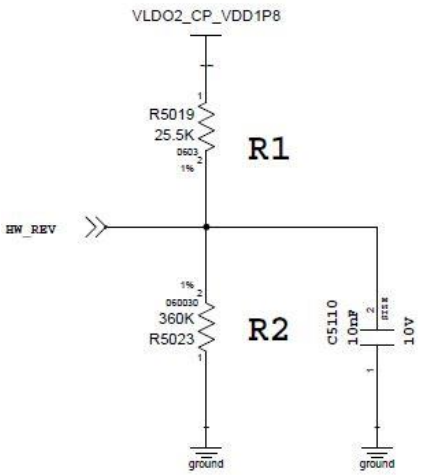
If TCU use Qorvo ANT switch, USID pin of ANT switch sholud be connected to VIO pin, to distinguish it from the ANT switch in NAD side.

2.2.3 PCIe

Place 220nF series capacitor close to MTK pin if they don't have any recommendation.

2.3 CP HW Revison

Figure 2-4 CP HW Revision



HW_REVISION (ADC)

HWID	R1	R2	LEVEL
0	OPEN	1K	0 - 0.72 V
1	100K	120K	0.96 V
2	100K	150K	1.08 V
3	100K	200K	1.20 V
4	120K	332K	1.32 V
5	91K	360K	1.44 V
6	56.2K	360K	1.56 V
7	25.5K	360K	1.68 V

2.4 USB Interface

S5123 chipset do not support USB. The USB interface cannot be used in the NAD because related functions are not supported in the S5123 chipset.

3 Power Interface

3.1 POWER Interface

3.1.1 Overview

The power supply part of the module contains:

- VPH_PWR pin for the power supply input
- VDD_1P8_AP pin is pull up for PCIe clock request signal
- VLDO2_CP_VDD180 pin for power output
- VLDO10_CP_USIM0 pin for USIM0 card power output

Table 3-1 Definitions of the pins on the power supply interface

Pin No.	Pin Name	Pad	Description	Comment
Q32, O34, R33	VPH_PWR	PI	Power supply input. The rising time of VBAT must be greater than 100 μs.	Input power is 4.0–4.4 V. The typical voltage is 4.2 V. Those power pins are used for PMIC.
F15	VDD_1P8_AP	PI	Power supply input for PCIe PU.	It's for PCIe I/F voltage level. Supply same level with AP PCIe.
P13	VLDO2_CP_VDD180	PO	Pin for external power output	Module output power is 1.8 V. This power is shared by CP GPIO.
R21	VLDO10_CP_USIM0	PO	Power supply for USIM card	Module output power of USIM
R17	VLDO11_CP_USIM1	PO	Power supply for USIM1 card	Power supply for USIM1 card
Include 284 pins	GND	-	Thermal Ground Pad	-

3.1.2 Input Power Supply Interface

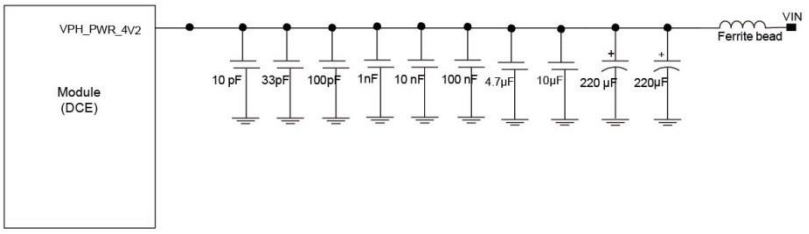
Input power supply interfaces are VPH_PWR.

When the module works normally, power is supplied through the VPH_PWR pins and the voltage ranges from 4.0 V to 4.4 V (typical value is 4.2 V).

When the module works at GSM mode and transmits signals at the maximum power, the transient peak current may reach 2.75A due to the differences in actual network environments. In this case, the input power voltage will drop. If you want good wireless performance, please make sure that the voltage does not drop below 3.8 V in any case. Otherwise, exceptions such as restart of the module may occur.

A LDO (Low Dropout Regulator) or switch power with current output of more than 3 A is recommended for external power supply. Furthermore, four 220μF or above energy storage capacitors are connected in parallel at the power interface of the module. In addition, to reduce the impact of channel impedance on voltage drop, it is recommended to try to shorten the power supply circuit of the VPH_PWR interface.

Figure 3-1 Recommended power circuit



The UVLO circuit for the NAD prevents the device from malfunctioning at low-input voltages and from excessive discharge of the power. As VPH_PWR voltage is under UVLO threshold, the NAD enters into UVLO state which forces the device to an inactive state until the VPH_PWR is high enough to allow the device to operate normal function.

The UVLO voltage level are 2.9 V rising and 2.0 V falling (hysteresis 900 mV), respectively. In case the VPH_PWR voltage rises over 2.9 V, NAD including all regulators starts to operate from lockout state and if the VPH_PWR voltage falls under 2.0 V, NAD is turned off.

3.1.3 Output Power Supply Interface

Output power supply interfaces are VLDO2_CP_VDD180 and VLDO10_CP_USIM0.

Table 3-2 Output power supply interface signals

Pin Name	Typ. (V)	Typ. (mA)
VLDO2_CP_VDD180	1.8	10
VLDO10_CP_USIM0	1.8/2.85	150
VLDO11_CP_USIM1	1.8/2.85	150

Through the VLDO2_CP_VDD180, the module can supply 1.8 V power externally with an output current of 10 mA (typical value) for external level conversion. This power is shared with CP GPIO. Be aware to affect CP stable.
Through the VLDO10_CP_USIM0, the module can supply 1.8 V or 2.85 V power for the USIM card.

3.2 UART and SPI Interface

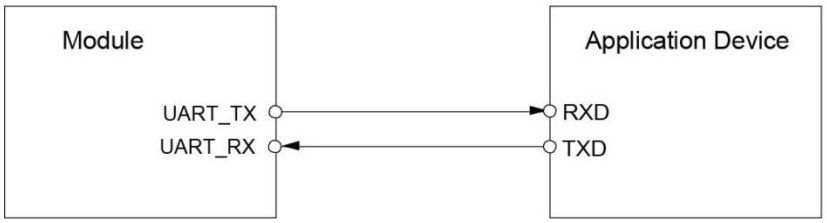
The module provides one 2-wire UART interface. As the UART interface supports signal control through standard modem handshake, Software commands are entered and serial communication is performed through the UART interface.

The baud rates supported are shown below: 300 bps, 600 bps, 1200 bps, 2400 bps, 4800 bps, 9600 bps, 19200 bps, 38400 bps, 57600 bps, 115200 bps, 230400 bps, 460800 bps, 921600 bps, 2764800 bps.

Table 3-3 UART interface signals

Pin No.	Pin Name	Pad Type	Description	Typ. (V)
P17	CP_UART_TX	O	UART transmit data output for debug	1.8
P15	CP_UART_RX	I	UART receive data input for debug	1.8

Figure 3-2 Recommended connection of the UART interface in the module with the host

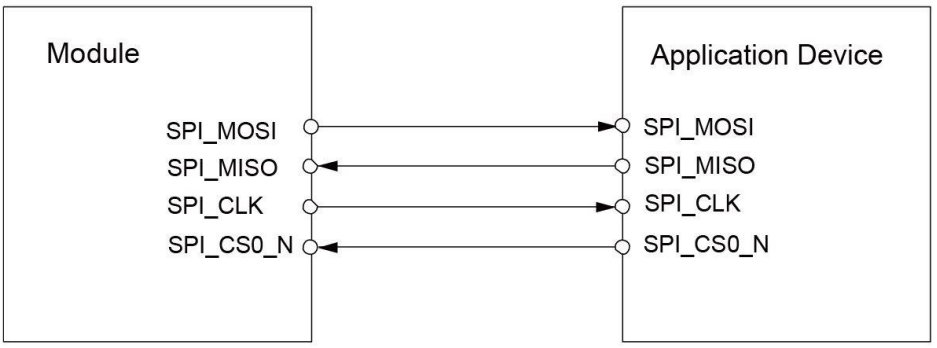


In addition, the module provides a SPI interface.

Table 3-4 SPI interface signals

Pin No.	Pin Name	Pad Type	Description	Typ. (V)
R11	CP_SPI_MISO	O	SPI interface data output	1.8
R09	CP_SPI_MOSI	I	SPI interface data input	1.8
Q12	CP_SPI_CLK	I	SPI interface clock	1.8
Q10	CP_SPI_CSN	I	SPI interface chip select	1.8

Figure 3-3 Recommended connection of the SPI interface



3.3 USIM Card Interface

The module provides a USIM card interface complying with the ISO 7816-3 standard and supports both Class B and Class C USIM cards.

Table 3-5 USIM card interface signals

Pin No.	Pin Name	Pad Type	Description	Typ. (V)
Q24	SIM0_RST	O	USIM card reset	1.8/2.85
P23	SIM0_DATA	I/O	USIM card data	1.8/2.85
Q22	SIM0_CLK	O	USIM card clock	1.8/2.85

3.4 Audio Interface

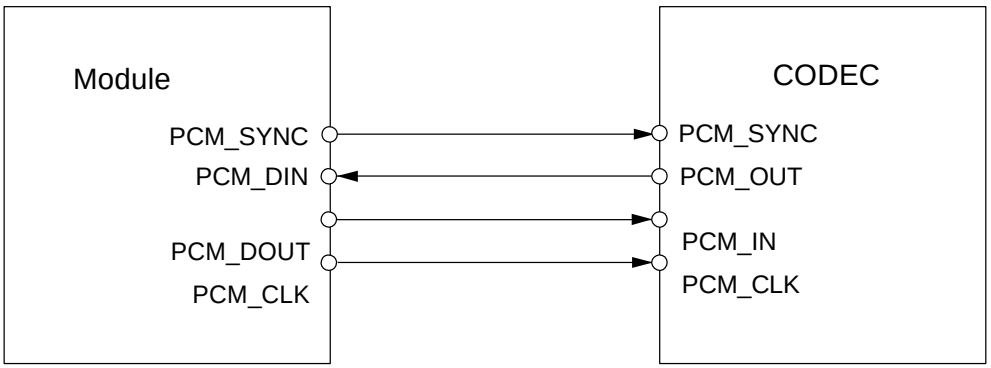
The module provides one PCM (Pulse Code Modulation) digital audio interface.

Table 3-6 Signals on the digital audio interface

Pin No.	Pin Name	Pad Type	Description	Typ. (V)	Comments
B7	SPEECH_I2S_LRCK_CP	I	PCM interface L/R Channel	1.8	The pin is output when the module is used as PCM master.
C8	SPEECH_I2S_D_IN_CP	I	PCM interface data in	1.8	-
B9	SPEECH_I2S_D_OUT_CP	O	PCM interface data out	1.8	-
C6	SPEECH_I2S_BCK_CP	I	PCM interface clock	1.8	The pin is output when the module is used as PCM master.

The module PCM interface enables communication with an external codec to support linear format.

Figure 3-4 Recommended circuit diagram of the PCM interface(The module is used as PCM master)



3.5 PCIe Interface

The module provides PCIe interface.

It is compliant to PCI Express Base 3.0 Specification, revision 1.0
It supports the Gen4 (5Gbps)
It supports each 1-lane for TX and RX.
It supports dynamic frequency configuration
It has a 16-bit PIPE width per lane.
It supports PCIe Active State Power Management (ASPM) including L1 sub state
It has a dedicated DBI Slave IF.
It supports Internal ATU (Address Translation Unit)
It supports AXI3 Bridge.
It supports Maximum of 32 outbound requests for Non-Posted (NP)

It is recommended that the differential clock output signals of PCIe interface should be connected as Figure 3-5. Two 220nF capacitors inner module are separately placed on the TX signal in series. In addition, two 220nF capacitors placed on the differential clock output signals in series are used for DC blocking.

Figure 3-5 Recommended circuit of the PCIe interface(CP only)

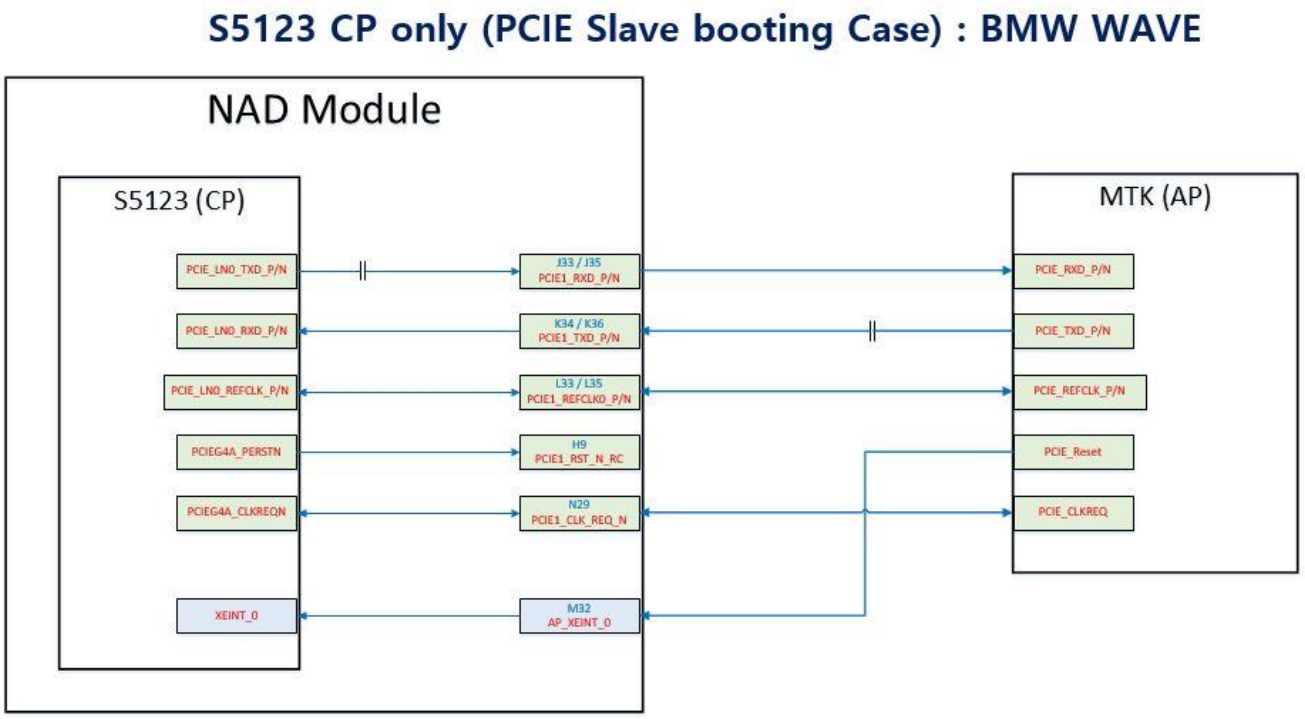


Figure 3-6 Recommended circuit of the PCIe interface(eAP)

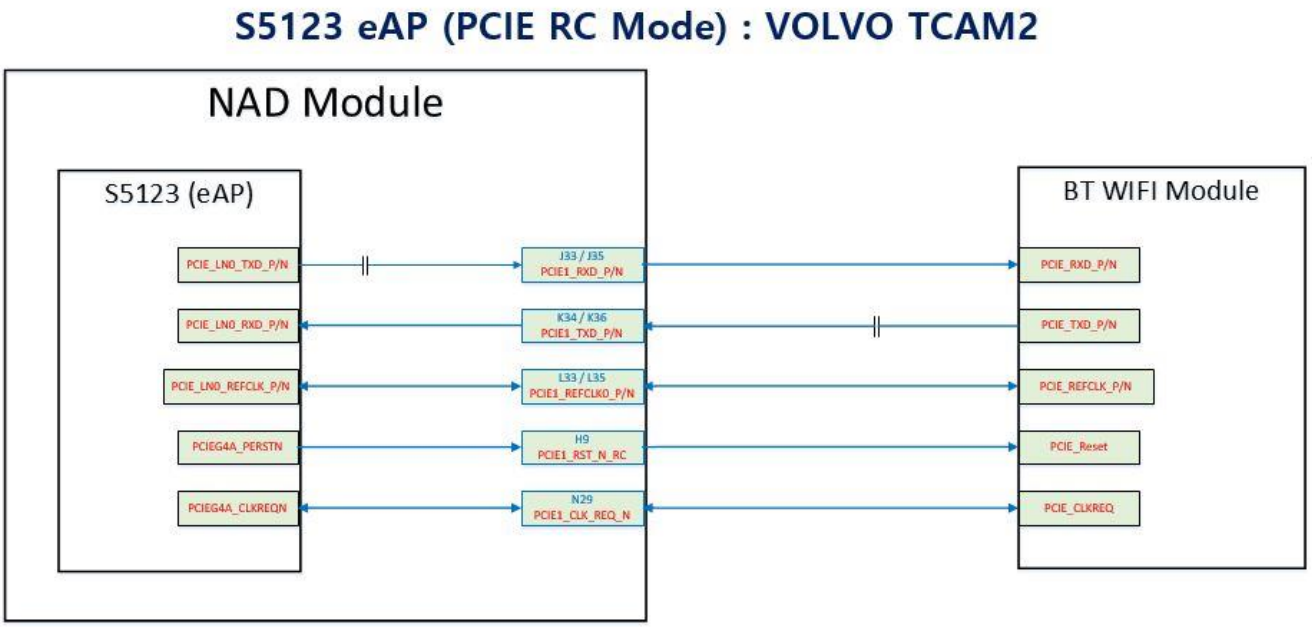
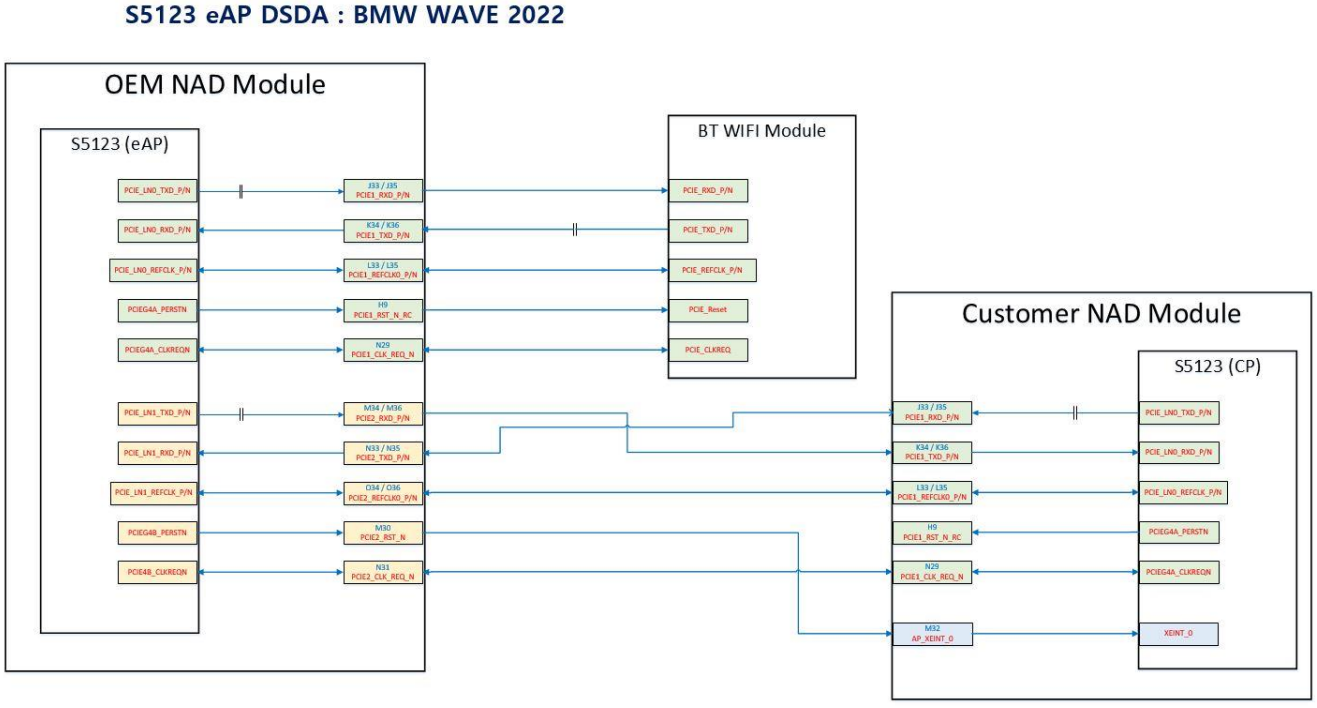


Figure 3-7 Recommended circuit of the PCIe interface(eAP DSDA)



4 RF Specification

4.1 About This Chapter

This chapter describes the RF specifications of the module, including:

- Operating Frequencies
- Conducted RF Measurement
- Conducted Rx Sensitivity and Tx Power
- Antenna Design Requirements

4.2 Operating Frequencies

Table 4-1 ~Table 4-2 show the RF bands supported.

4.2.1 Operating Frequency

Table 4-1 RF bands supported by CUSTOMER NAD

Operating Band	Tx	Rx
GSM 850	824-849 MHz	869-894 MHz
GSM 900	880–915 MHz	925–960 MHz
GSM 1800	1710–1785 MHz	1805–1880 MHz
GSM 1900	1850-1910 MHz	1930-1990 MHz
UMTS Band 1	1920–1980 MHz	2110–2170 MHz
UMTS Band 2	1850–1910 MHz	1930–1990 MHz
UMTS Band 3	1710–1785 MHz	1805–1880 MHz
UMTS Band 4	1710–1755 MHz	2110–2155 MHz
UMTS Band 5	824–849 MHz	869–894 MHz
UMTS Band 8	880–915 MHz	925–960 MHz
UMTS Band 19	830–845 MHz	875–890 MHz

Operating Band	Tx	Rx
LTE Band 1	1920–1980 MHz	2110–2170 MHz
LTE Band 2	1850–1910 MHz	1930–1990 MHz
LTE Band 3	1710–1785 MHz	1805–1880 MHz
LTE Band 4	1710–1755 MHz	2110–2155 MHz
LTE Band 5	824–849 MHz	869–894 MHz
LTE Band 7	2500–2570 MHz	2620–2690 MHz
LTE Band 8	880–915 MHz	925–960 MHz

LTE Band 9	1749.49 – 1784.9 MHz	1844.9–1879.9 MHz
LTE Band 10	1710 - 1770 MHz	2110–2170 MHz
LTE Band 12	699–716 MHz	729–746 MHz
LTE Band 13	777–787 MHz	746–756 MHz
LTE Band 17	704–716 MHz	734–746 MHz
LTE Band 18	815–830 MHz	860–875 MHz
LTE Band 19	830–845 MHz	875–890 MHz
LTE Band 20	832–862 MHz	791–821 MHz
LTE Band 21	1447.9–1462.9 MHz	1495.9–1510.9 MHz
LTE Band 25	1850–1915 MHz	1930–1995 MHz
LTE Band 26	814–849 MHz	859–894 MHz
LTE Band 28	703–748 MHz	758–803 MHz
LTE Band 29	Downlink only	717–728 MHz
LTE Band 30	Downlink only	2350–2360 MHz
LTE Band 32	Downlink only	1452–1496 MHz
LTE Band 66	1710–1780 MHz	2110–2200 MHz
LTE Band 71	663–698 MHz	617–652 MHz
LTE Band 34	2010–2025MHz	2010–2025MHz
LTE Band 38	2570-2620 MHz	2570-2620 MHz
LTE Band 39	1880–1920 MHz	1880–1920 MHz
LTE Band 40	2300–2400 MHz	2330–2400 MHz
LTE Band 41	2496–2690 MHz	2496–2690 MHz
LTE Band 42	3400–3600 MHz	3400–3600 MHz
5G n1	1920 ~ 1980 MHz	2110 ~ 2170 MHz
5G n2	1850 ~ 1910 MHz	1930 ~ 1990 MHz
5G n3	1710 ~ 1785 MHz	1805 ~ 1880 MHz
5G n5	824 ~ 849 MHz	869 ~ 894 MHz
5G n7	2500 ~ 2570 MHz	2620 ~ 2690 MHz
5G n8	880 ~ 915 MHz	925 ~ 960 MHz
5G n20	832~862 MHz	791 ~ 821 MHz
5G n25	1850–1915 MHz	1930–1995 MHz
5G n28	703 ~ 748 MHz	758 ~ 803 MHz
5G n38	2570 ~ 2620 MHz	2570 ~ 2620 MHz
5G n41	2496 - 2690 MHz	2496 - 2690 MHz

5G n66	1710 - 1780 MHz	2110 - 2200 MHz
5G n71	663-698 MHz	617-652 MHz
5G n77	3300-4200 MHz	3300-4200 MHz
5G n78	3300-3800 MHz	3300-3800 MHz

4.2.2 Data Services and Power Class

Feature	Description
Data Services	5G sub-6GHz (DL 1.8Gbps, UL 550Mbps) LTE DL Cat16, UL Cat18 (DL 0.975Gbps, UL 211Mbps) DC-HSPA+: 42 Mbps/5.76 Mbps HSPA+: 21 Mbps/5.76 Mbps EDGE: DL:236.8 kbps/UL: 236.8 kbps (Multi-slot Class 12) GPRS: DL: 85.6 kbps/UL: 85.6 kbps (Multi-slot Class 12) GSM: 9.6 kbps/14.4 kbps

NOTE

5G Data service values may vary depending on the combination of support bands and CA.
The data service values shown in the table are the maximum data service values supported by the IC.

1) 5G NR Feature
 A. Wavefrom
  - DL : CP-OFDM only
  - UL : CP-OFFM and DFT-OFDM
 B. Modulation
  - QPSK, 16QAM, 64QAM, 256QAM
 C. Caarrier aggregation
  - DL max 4CC 180MHz(4Rx) for sub6G
  - UL max 4CC 300MHz for sub6G

2) LTE Feature
 A. FDD/TDD mode
 B. Variable bandwidth(BW)
  - 1.4, 2, 5, 10, 15, 20 MHz
 C. Modulation
  - QPSK, 16QAM, 64QAM, 256QAM.
.

Feature	Description
Power Class	LTE Output power (according to Release 8): Class 3 (+23 dBm±2 dB) for FDD LTE Band 1 Class 3 (+23 dBm±2 dB) for FDD LTE Band 2 Class 3 (+23 dBm±2 dB) for FDD LTE Band 3 Class 3 (+23 dBm±2 dB) for FDD LTE Band 4 Class 3 (+23 dBm±2 dB) for FDD LTE Band 5 Class 3 (+23 dBm±2 dB) for FDD LTE Band 7 Class 3 (+23 dBm±2 dB) for FDD LTE Band 8 Class 3 (+23 dBm±2 dB) for FDD LTE Band 9 Class 3 (+23 dBm±2 dB) for FDD LTE Band 10 Class 3 (+23 dBm±2 dB) for FDD LTE Band 12 Class 3 (+23 dBm±2 dB) for FDD LTE Band 13 Class 3 (+23 dBm±2 dB) for FDD LTE Band 17 Class 3 (+23 dBm±2 dB) for FDD LTE Band 18 Class 3 (+23 dBm±2 dB) for FDD LTE Band 19 Class 3 (+23 dBm±2 dB) for FDD LTE Band 20 Class 3 (+23 dBm±2 dB) for FDD LTE Band 21 Class 3 (+23 dBm±2 dB) for FDD LTE Band 25 Class 3 (+23 dBm±2 dB) for FDD LTE Band 26 Class 3 (+23 dBm±2 dB) for FDD LTE Band 28 Class 3 (+23 dBm±2 dB) for FDD LTE Band 34 Class 3 (+23 dBm±2 dB) for FDD LTE Band 66 Class 3 (+23 dBm±2 dB) for FDD LTE Band 71 Class 3 (+23 dBm±2 dB) for TDD LTE Band 34 Class 3 (+23 dBm±2 dB) for TDD LTE Band 38 Class 3 (+23 dBm±2 dB) for TDD LTE Band 39 Class 3 (+23 dBm±2 dB) for TDD LTE Band 40 Class 3 (+23 dBm±2 dB) for TDD LTE Band 41 GSM and UMTS Output power (according to Release 99): Class 4 (+33 dBm±2 dB) for EGSM 900 Class 1 (+30 dBm±2 dB) for GSM 1800 Class E2 (+27 dBm±3 dB) for GSM 900 8-PSK Class E2 (+26 dBm + 3/– 4 dB) for GSM 1800 8-PSK Class 3 (+24 dBm + 1/– 3 dB) for UMTS 2100, WCDMA Band 1 Class 3 (+24 dBm + 1/– 3 dB) for UMTS 900, WCDMA Band 8 5G Class 3 (+23 dBm±2 dB) for n1 Class 3 (+23 dBm±2 dB) for n2

	Class 3 (+23 dBm±2 dB) for n3 Class 3 (+23 dBm±2 dB) for n5 Class 3 (+23 dBm±2 dB) for n7 Class 3 (+23 dBm±2 dB) for n8 Class 3 (+23 dBm±2 dB) for n20 Class 3 (+23 dBm±2 dB) for n25 Class 3 (+23 dBm±2 dB) for n28 Class 3 (+23 dBm±2 dB) for n38 Class 3 (+23 dBm±2 dB) for n41 Class 3 (+23 dBm±2 dB) for n66 Class 3 (+23 dBm+2/-2.5 dB) for n71 Class 3 (+23 dBm+2/-3 dB) for n77 Class 3 (+23 dBm+2/-3 dB) for n78

4.2.3 EN-DC

SKU	EN-DC
Global	(Downlink) DC_1A_n28A, DC_1A_n77A, DC_1A_n78A, DC_2A_n5A, DC_2A_n71A, DC_2A_n78A, DC_3A_n28A, DC_3A_n77A, DC_3A_n78A, DC_5A_n66A, DC_5A_n78A, DC_7A_n28A, DC_7A_n78A, DC_8A_n77A, DC_8A_n78A, DC_12A_n66A, DC_18A_n77A, DC_18A_n78A, DC_19A_n77A, DC_19A_n78A, DC_20A_n77A, DC_20A_n78A, DC_21A_n77A, DC_21A_n78A, DC_26A_n41A, DC_26A_n77A, DC_26A_n78A, DC_28A_n77A, DC_28A_n78A, DC_38A_n78A, DC_39A_n78A, DC_40A_n77A, DC_41A_n77A, DC_41A_n78A, DC_66A_n5A, DC_66A_n71A, DC_66A_n78ADC_1A-3A_n28A, DC_1A-3A_n77A, DC_1A-3A_n78ADC_1A-5A_n78A, DC_1A-7A_n28A, DC_1A-7A_n78A, DC_1A-8A_n78A, DC_1A-18A_n77A, DC_1A-18A_n78A, DC_1A-19A_n77A, DC_1A-19A_n78A, DC_1A-20A_n78A, DC_1A-28A_n77A, DC_1A-28A_n78A, DC_2A-5A_n66A, DC_2A-12A_n66A, DC_2A-66A_n71A, DC_3A-5A_n78A, DC_3A-7A_n28A, DC_3A-7A_n78A, DC_3A-8A_n78A, DC_3A-19A_n77A, DC_3A-19A_n78A, DC_3A-20A_n78A, DC_3A-28A_n77A, DC_3A-28A_n78A, DC_3A-38A_n78A, DC_3C_n78A, DC_5A-7A_n78A, DC_5A-30A_n66A, DC_7A-20A_n78A, DC_7A-28A_n78A, DC_12A-30A_n66A, DC_19A-21A_n77A, DC_19A-21A_n78A, DC_21A-28A_n77A, DC_21A-28A_n78A, DC_1A_n77C, DC_1A_n78C, DC_3A_n77C, DC_3A_n78C, DC_19A_n77C, DC_19A_n78C, DC_21A_n77C, DC_21A_n78C, DC_28A_n77C, DC_28A_n78C, DC_1A_n28A-n78A, DC_3A_n28A-n78A, DC_7A_n28A-n78ADC_1A-3A-5A_n78A, DC_1A-3A-7A_n28A, DC_1A-3A-7A_n78A, DC_1A-3A-8A_n78A, DC_1A-3A-19A_n77A, DC_1A-3A-20A_n78A, DC_1A-3A-28A_n77A, DC_1A-3A-28A_n78A, DC_1A-3C_n78A, DC_1A-5A-7A_n78A, DC_1A-7A-20A_n78A, DC_3A-5A-7A_n78A, DC_3A-7A-7A_n78A, DC_3A-7C_n78A, DC_3A-7A-20A_n78A, DC_3A-7A-28A_n78A, DC_3C-7A_n78A, DC_3C-20A_n78A, DC_5A-7A-7A_n78A, DC_7C-28A_n78A, DC_1A-3A_n28A-n78A, DC_1A-3A_n77C, DC_1A-3A_n78C, DC_1A-7A_n28A-n78A, DC_1A-19A_n77C, DC_1A-19A_n78C, DC_1A-28A_n77A, DC_1A-28A_n78C, DC_3A-7A_n28A-n78A, DC_3A-19A_n77C, DC_3A-19A_n78C, DC_3A-28A_n77C, DC_3A-28A_n78C, DC_19A-21A_n77C, DC_19A-21A_n78C, DC_21A-28A_n77C, DC_21A-28A_n78C, DC_1A-3A-5A-7A_n78A, DC_1A-3A-7A-20A_n78A, DC_1A-3C-7A_n78A, DC_3A-7C-28A_n78A, DC_3C-7C_n78A, DC_1A-3A-7A_n28A-n78A (Uplink) DC_1A_n28A, DC_1A_n77A, DC_1A_n78A, DC_2A_n5A, DC_2A_n71A, DC_2A_n78A, DC_3A_n28A, DC_3A_n77A, DC_3A_n78A, DC_5A_n66A, DC_5A_n78A, DC_7A_n28A, DC_7A_n78A, DC_8A_n77A, DC_8A_n78A, DC_12A_n66A, DC_18A_n77A, DC_18A_n78A, DC_19A_n77A, DC_19A_n78A, DC_20A_n28A, DC_20A_n77A, DC_20A_n78A, DC_21A_n77A, DC_21A_n78A, DC_26A_n41A, DC_26A_n77A, DC_26A_n78A, DC_28A_n77A, DC_28A_n78A, DC_39A_n78A, DC_41A_n77A, DC_41A_n78A, DC_66A_n5A, DC_66A_n71A, DC_66A_n78A

4.3 Conducted RF Measurement

4.3.1 Test Environment

Test instrument	Keysight 8960, R&S CMW500, Anritsu MT8821C
Power supply	Agilent 66319
RF cable for testing	L08-C014-350 of DRAKA COMTEQ or Rosenberger Cable length: 29 cm

4.3.2 Test Standards

The modules meet all 3GPP test standards relating to 2G, 3G, 4G 5G. Each module passes strict tests at the factory and thus the quality of the modules is guaranteed.

4.4 Conducted Rx Sensitivity and Tx Power

4.4.1 Conducted Receive Sensitivity

The conducted receive sensitivity is a key parameter that indicates the receiver performance of the module. The conducted receive sensitivity refers to the weakest signal that the module at the antenna port can receive. The bit error rate (BER) must meet the 3GPP protocol requirements in the case of the minimum signal.

The 3GPP Protocol Claim column in Table 4-3 ~Table 4-4 lists the required minimum values, and the Test Value column lists the tested values of the module under 4 V voltage and normal temperature.

Table 4-2 Conducted Rx sensitivity of Customer NAD at 25℃

Item		3GPP Protocol Claim (dBm)	Test Value (dBm)		
			Min.	Typ.	Max.
GSM 850	GMSK (BER < 2.44%)	< –102	-	-108	-
	8PSK (MCS5, BLER < 10%)	< –98	-	-109	-
GSM 900	GMSK (BER < 2.44%)	< –102	-	-108	-
	8PSK (MCS5, BLER < 10%)	< –98	-	-109	-
GSM 1800	GMSK (BER < 2.44%)	< –102	-	-108	-
	8PSK (MCS5, BLER < 10%)	< –98	-	-108	-
GSM 1900	GMSK (BER < 2.44%)	< –102	-	-108	-
	8PSK (MCS5, BLER < 10%)	< –98	-	-108	-

UMTS Band 1 (BER < 0.1%)	< –106.7	-	-109	-
UMTS Band 2 (BER < 0.1%)	< –104.7		-109	
UMTS Band 3 (BER < 0.1%)	< –103.7		-109	
UMTS Band 4 (BER < 0.1%)	< –106.7		-109	
UMTS Band 5 (BER < 0.1%)	< –104.7		-109	
UMTS Band 8 (BER < 0.1%)	< –103.7		-109	
UMTS Band 19 (BER < 0.1%)	< –106.7		-109	

Item	3GPP Protocol Claim (dBm)	Test Value (dBm)		
		Min.	Typ.	Max.
LTE Band 1 RX (Main+AUX,10 MHz)	< –97	-	-99	-
LTE Band 2 RX (Main+AUX,10 MHz)	< –95	-	-100	-
LTE Band 3 RX (Main+AUX,10 MHz)	< –94	-	-100	-
LTE Band 4 RX (Main+AUX,10 MHz)	< –97	-	-100	-
LTE Band 5 RX (Main+AUX,10 MHz)	< –95	-	-100	-
LTE Band 7 RX (Main+AUX,10 MHz)	< –95	-	-98	-
LTE Band 8 RX (Main+AUX,10 MHz)	< –94	-	-100	-
LTE Band 9 RX (Main+AUX,10 MHz)	< –94	-	-99	
LTE Band 10 RX (Main+AUX,10 MHz)	< –94	-	-99	
LTE Band 12 RX (Main+AUX,10 MHz)	< –94	-	-99	-
LTE Band 13 RX (Main+AUX,10 MHz)	< –94	-	-99	
LTE Band 17 RX (Main+AUX,10 MHz)	< –94	-	-99	-
LTE Band 18 RX (Main+AUX,10 MHz)	< –97	-	-99	
LTE Band 19 RX (Main+AUX,10 MHz)	< –97	-	-99	
LTE Band 20 RX (Main+AUX,10 MHz)	< –94	-	-100	
LTE Band 21 RX (Main+AUX,10 MHz)	< –97	-	-99	
LTE Band 25 RX (Main+AUX,10 MHz)	< –93.5	-	-100	
LTE Band 26 RX (Main+AUX,10 MHz)	< –94.5	-	-100	
LTE Band 28 RX (Main+AUX,10 MHz)	< –95.5	-	-100	
LTE Band 29 RX (Main+AUX,10 MHz)	< –	-		
LTE Band 30 RX (Main+AUX,10 MHz)	< –	-		
LTE Band 32 RX (Main+AUX,10 MHz)	< –	-		
LTE Band 34 RX (Main+AUX,10 MHz)	< –97	-	-99	
LTE Band 38 RX (Main+AUX,10 MHz)	< –97	-	-98	
LTE Band 39 RX (Main+AUX,10 MHz)	< –97	-	-99	
LTE Band 40 RX (Main+AUX,10 MHz)	< –97	-	-98	
LTE Band 41 RX (Main+AUX,10 MHz)	< –95	-	-98	
LTE Band 42 RX (Main+AUX,10 MHz)	< –96	-	-98	
LTE Band 66 RX (Main+AUX,10 MHz)	< –96.5	-	-100	
LTE Band 71 RX (Main+AUX,10 MHz)	< –94.2	-	-100	

4.4.2 Conducted Transmit Power / ACLR

The conducted transmit power is another indicator that measures the performance of the module. The conducted transmit power refers to the maximum power that the module tested at the antenna port can transmit. According to the 3GPP protocol, the required transmit power varies with the power class.

Table 4-5 list the required ranges of the conducted transmit power of the module under 4 V voltage and normal temperature. The tested values listed in the **Test Value** column must range from the minimum power to the maximum power.

Table 4-6 list the required ranges of the conducted Adjacent Channel Leakage power Ratio(ALCR) criteria and measurements of the module under 4 V voltage and normal temperature.

Table 4-3 Conducted Tx power of Customer NAD at 25℃

Item		3GPP Protocol Claim (dBm)	Test Value (dBm)		
			Min.	Typ.	Max.
GSM 850	GMSK (1Tx Slot)	31–35	31	33	35
	8PSK (1Tx Slot)	24–30	24	27	30
GSM 900	GMSK (1Tx Slot)	31–35	31	33	35
	8PSK (1Tx Slot)	24–30	24	27	30
GSM 1800	GMSK (1Tx Slot)	28–32	28	29.5	32
	8PSK (1Tx Slot)	22–29	24.5	27	29
GSM 1900	GMSK (1Tx Slot)	28–32	28	29.5	32
	8PSK (1Tx Slot)	22–29	24.5	27	29
UMTS Band 1		21-25	21	23	25
UMTS Band 2		21-25	21	23	25
UMTS Band 3		21-25	21	23	25
UMTS Band 4		21-25	21	23	25
UMTS Band 5		21-25	21	23	25
UMTS Band 8		21-25	21	23	25
UMTS Band 19		21-25	21	23	25

Item	3GPP Protocol Claim (dBm)	Test Value (dBm)		
		Min.	Typ.	Max.
LTE Band 1	21-25	21	22.5	25
LTE Band 2	21-25	21	22.5	25
LTE Band 3	21-25	21	23	25
LTE Band 4	21-25	21	23	25
LTE Band 5	21-25	21	23	25
LTE Band 7	21-25	21	23	25
LTE Band 8	21-25	21	23	25
LTE Band 9	21-25	21	23	25
LTE Band 10	21-25	21	23	25
LTE Band 12	21-25	21	23	25
LTE Band 13	21-25	21	23	25
LTE Band 17	21-25	21	23	25
LTE Band 18	21-25	21	23	25
LTE Band 19	21-25	21	23	25
LTE Band 20	21-25	21	23	25
LTE Band 21	21-25	21	23	25
LTE Band 25	21-25	21	23	25
LTE Band 26	21-25	21	23	25
LTE Band 28	21-25	21	23	25
LTE Band 29 (Downlink only)		-		
LTE Band 30 (Downlink only)		-		
LTE Band 32 (Downlink only)		-		
LTE Band 34	21-25	21	23	25
LTE Band 38	21-25	21	23	25
LTE Band 39	21-25	21	23	25
LTE Band 40	21-25	21	23	25
LTE Band 41	21-25	21	23	25
LTE Band 42	21-25	21	23	25
LTE Band 66	21-25	21	23	25
LTE Band 71	21-25	21	23	25

NOTE

- LTE test data was written based on data measured in Uplink 1RB & QPSK condition.

Table 4-4 Conducted ACLR value of NAD at 25℃

Item	Test condition	Test Value (dBm)		
		Min.	Typ.	Max.
UMTS Band 1	Adjacent channel Leakage Power_Ratio @ +10MHz Offset			-42.2
UMTS Band 2	Adjacent channel Leakage Power_Ratio @ +10MHz Offset			-42.2
UMTS Band 3	Adjacent channel Leakage Power_Ratio @ +10MHz Offset			-42.2
UMTS Band 4	Adjacent channel Leakage Power_Ratio @ +10MHz Offset			-42.2
UMTS Band 5	Adjacent channel Leakage Power_Ratio @ +10MHz Offset			-42.2
UMTS Band 8	Adjacent channel Leakage Power_Ratio @ +10MHz Offset			-42.2
UMTS Band 19	Adjacent channel Leakage Power_Ratio @ +10MHz Offset			-42.2

Item	3GPP Protocol Claim (dBm)	Test Value (dBm)		
		Min.	Typ.	Max.
LTE Band 1	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 2	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 3	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 4	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 5	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 7	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 8	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 9	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 10	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 12	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 13	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 17	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 18	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 19	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 20	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 21	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 25	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 26	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 28	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 29 (Downlink only)		-		
LTE Band 30 (Downlink only)		-		
LTE Band 32 (Downlink only)		-		
LTE Band 34	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 38	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 39	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 40	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 41	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 42	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 66	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2
LTE Band 71	Adjacent Channel Leakage power Ratio_RB_LOW_UTRA			-35.2

4.5 Antenna Design Requirements

4.5.1 Antenna Design Indicators

4.5.1.1 Antenna efficiency

The **efficiency** of an antenna is a ratio of the power delivered to the antenna relative to the power radiated from the antenna. A high efficiency antenna has most of the power present at the antenna's input radiated away. A low efficiency antenna has most of the power absorbed as losses within the antenna, or reflected away due to impedance mismatch.

4.5.1.2 VSWR

VSWR stands for Voltage Standing Wave Ratio, and is also referred to as Standing Wave Ratio (SWR). VSWR is a function of the reflection coefficient, which describes the power reflected from the antenna.

4.5.1.3 Isolation

Antenna to antenna isolation is a measure of how tightly coupled antennas are. Typically, antenna isolation is measured for antennas on the same product - that is, the isolation between a smartphone gps and wifi antenna, for instance. When specified in this manner, the isolation should be as large as possible.

4.5.1.4 Antenna line PCB drawing guide

Antenna line must be designed to match impedance to minimize loss. The filcut should be applied to layer 2 to match the impedance and optimize the loss. Figure 4-1 and Figure 4-2 shows examples of antenna line.

Figure 4-1 Recommended layer 1 of antenna line

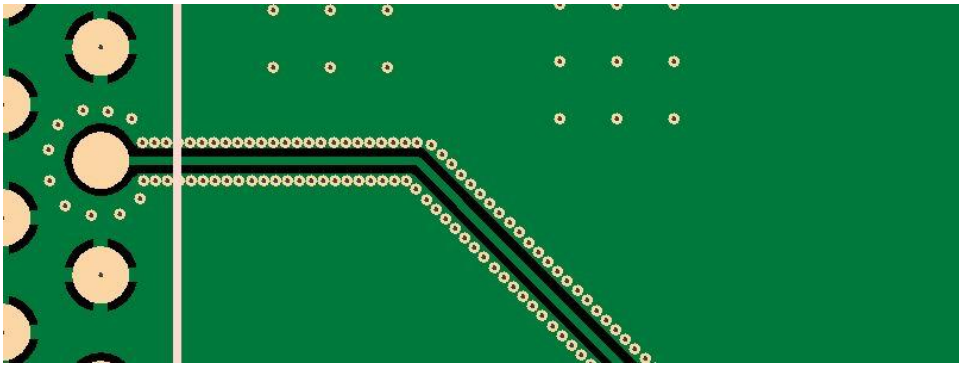
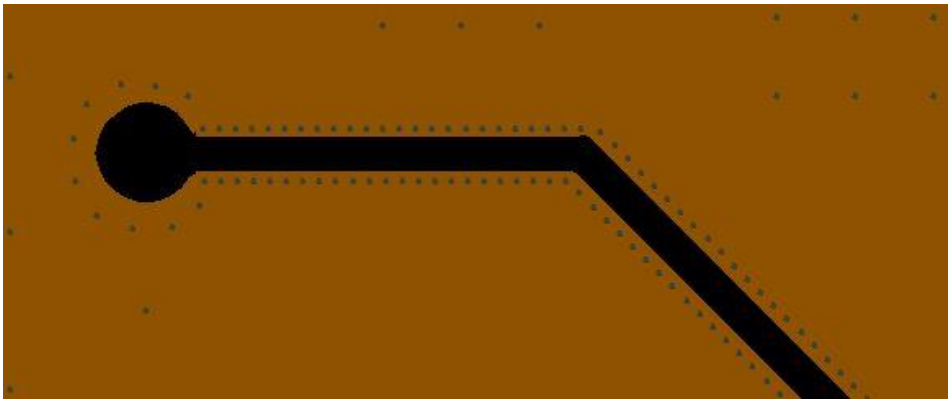


Figure 4-2 Recommended layer 2 of antenna line



4.5.2 Interference

Besides the antenna performance, the interference on the user board also affects the radio performance (especially the TIS) of the module. To guarantee high performance of the module, the interference sources on the user board must be properly controlled.

On the user board, there are various interference sources, such as the LCD, CPU, audio circuits, and power supply. All the interference sources emit interference signals that affect the normal operation of the module. For example, the module sensitivity can be decreased due to interference signals. Therefore, during the design, need to consider how to reduce the effects of interference sources on the module. It is recommended to take the following measures:

- Shield the signal cable of the board.
- Design filter circuits.

Samsung is able to make technical suggestions on radio performance improvement of the module.

4.5.3 GSM/WCDMA/LTE Antenna Requirements

The antenna for the module must fulfill the requirements as shown in Table 4-10 .

Table 4-5 Requirements for GSM/WCDMA/LTE antenna

Frequency range	Depending on frequency band(s) provided by the network operator, the customer must use the most suitable antenna for that/those band(s).
Bandwidth of primary antenna	70 MHz in GSM 850 80 MHz in GSM 900 170 MHz in GSM 1800 140 MHz in GSM 1900 250 MHz in WCDMA/LTE Band 1 140 MHz in WCDMA/LTE Band 2 170 MHz in WCDMA/LTE Band 3 445 MHz in WCDMA/LTE Band 4 70 MHz in WCDMA/LTE Band 5 80 MHz in WCDMA/LTE Band 8 60 MHz in WCDMA/LTE Band 19 190 MHz in LTE Band 7 130 MHz in LTE Band 9 460 MHz in LTE Band 10 47 MHz in LTE Band 12 41 MHz in LTE Band 13 42 MHz in LTE Band 17 60 MHz in LTE Band 18 71 MHz in LTE Band 20 63 MHz in LTE Band 21 145 MHz in LTE Band 25 80 MHz in LTE Band 26 100 MHz in LTE Band 28 11 MHz in LTE Band 29 10 MHz in LTE Band 30 44 MHz in LTE Band 32 15 MHz in LTE Band 34 50 MHz in LTE Band 38 40 MHz in LTE Band 39 100 MHz in LTE Band 40 194 MHz in LTE Band 41 200 MHz in LTE Band 42 490 MHz in LTE Band 66 81 MHz in LTE Band 71

Bandwidth of diversity antenna	250 MHz in WCDMA/LTE Band 1 140 MHz in WCDMA/LTE Band 2 170 MHz in WCDMA/LTE Band 3 445 MHz in WCDMA/LTE Band 4 70 MHz in WCDMA/LTE Band 5 80 MHz in WCDMA/LTE Band 8 60 MHz in WCDMA/LTE Band 19 190 MHz in LTE Band 7 130 MHz in LTE Band 9 460 MHz in LTE Band 10 47 MHz in LTE Band 12 41 MHz in LTE Band 13 42 MHz in LTE Band 17 60 MHz in LTE Band 18 71 MHz in LTE Band 20 63 MHz in LTE Band 21 145 MHz in LTE Band 25 80 MHz in LTE Band 26 100 MHz in LTE Band 28 11 MHz in LTE Band 29 10 MHz in LTE Band 30 44 MHz in LTE Band 32 15 MHz in LTE Band 34 50 MHz in LTE Band 38 40 MHz in LTE Band 39 100 MHz in LTE Band 40 194 MHz in LTE Band 41 200 MHz in LTE Band 42
Gain	≤ 2 dBi
Impedance	50 Ω
VSWR absolute max	≤ 3:1
VSWR recommended	≤ 2:1

4.6 Link budget

4.6.1 Tx link budget

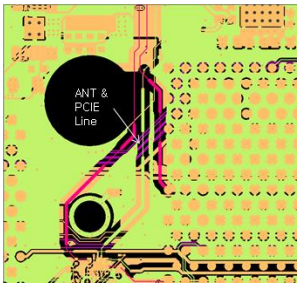
Table 4-6 Tx link budget MPR 0

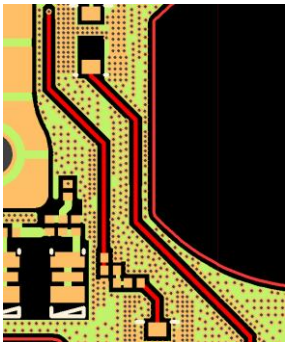
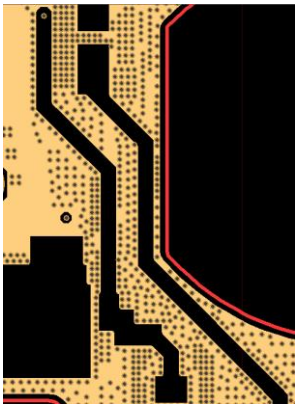
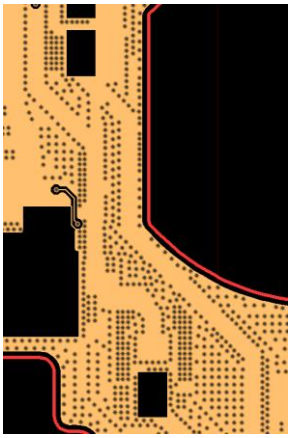
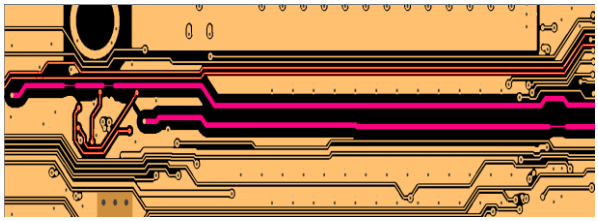
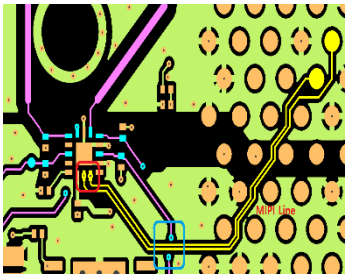
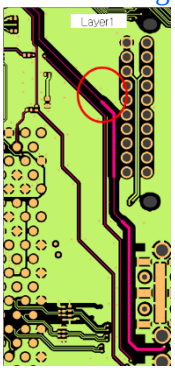
P/N	Band	MHz	PA max output power (expected, dBm)	DPX	SP3T	Coupler	Triplexer	IL(dB)	LineLoss	ANT(dBm)	comment
QPF7612Q	B26(5/18/19)	814~849	26.7		0.35	0.08	0.8	1.23	0.4	25.07	
	B8	880~915	26.8		0.35	0.08	0.83	1.26	0.4	25.14	
	B12(17)	699~716	26.6		0.35	0.08	0.78	1.21	0.4	24.99	
	B13	777~787	26.6		0.35	0.08	0.79	1.22	0.4	24.98	
	B20	832~862	26.7		0.35	0.08	0.82	1.25	0.4	25.05	
	B28	703~748	26.6		0.35	0.08	0.78	1.21	0.4	24.99	
	B71	663~698	29	2.8	0.35	0.08	0.76	3.99	0.4	24.61	
QPF7806											
	B1	1920~1980	25.1				0.79	0.79	0.45	23.86	
	B25(2)	1850~1915	25.1				0.78	0.78	0.45	23.87	
	B3(9)	1710~1785	25.1				0.8	0.8	0.45	23.85	
	B66(10/4)	1710~1780	25.1				0.8	0.8	0.45	23.85	
	B7	2500~2570	25.1				1.1	1.1	0.45	23.55	
	B34	2010~2025	25.1				0.93	0.93	0.45	23.72	
	B38(41N)	2545~2655	25.1				0.95	0.95	0.45	23.7	
	B39	1880~1920	25.1				0.79	0.79	0.45	23.86	
	B40	2300~2400	28				1	1	0.45	26.55	PC2
	B41	2496~2690	28.5				0.95	0.95	0.45	27.55	PC2
QPA5201						coupler/OMH					
	GSM850/900	824~915	35		0.3	0.08	0.83	1.21	0.4	33.39	
	DCS/PCS	1710~1910	33			1.9	0.8	2.7	0.45	29.85	
RF7921Y						OMH					
	B21	1448~1463	27	1.3		1.7	0.82	3.82	0.45	22.73	
SKY5A3000											
	n77(78/48)	3300~4200	29				1.47	1.47	0.6	26.93	PC2
	n79	4400~5000	29				1.2	1.2	1	26.8	PC2
QPF1002Q							filter				
	B47	5855 – 5925	29				1.5	1.5	1	26.5	

4.7 PCB Recommendation

This chapter provides a guide for optimizing RF line.

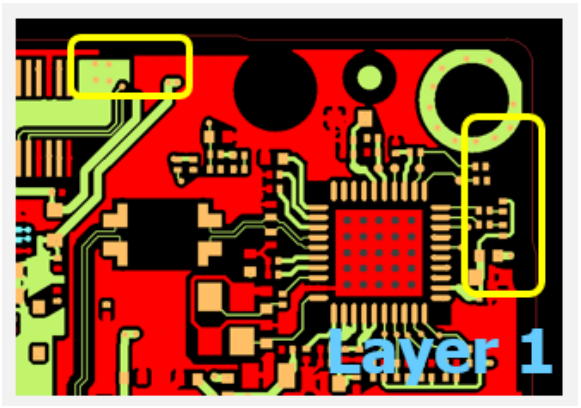
Table 4-7 Recommend RF guide

<table>
<tr><th>Not recommend</th><th>Recommend</th></tr>
<tr><td>- RF Signals and PCIE line are not Isolated and it will cause cross talk.
 

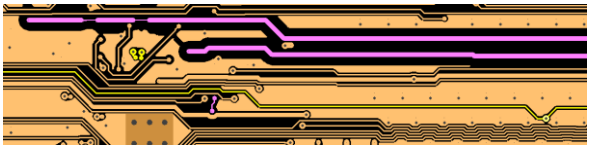
-</td><td rowspan="4">Layer 1
 
Layer 2
 
Layer 3
  </td></tr>
<tr><td>- RF Signals are not shielded with GND. There are not GND Via next to the signal lines. This Impedance mismatch causes High insertion loss.
  </td></tr>
<tr><td>- RF Signals and too many digital/analog lines are not isolated.(Cross talk and Impedance mismatch)
  </td></tr>
<tr><td>- There are line width discontinuity and Impedance mismatch. This Impedance mismatch causes High insertion loss
  </td></tr>
</table>

<table>
<tr><th>Not recommend</th><th>Recommend</th></tr>
<tr><td>

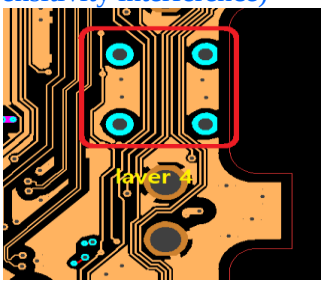
- GND Traces are needed to shield outline of PCB. GND shielding and more GND Vias can prevent the board from EMC issue.(RE, ESD, noise protect etc.)



- Clock line is not shielded with GND. This can be a noise source and cause RX sensitivity interference.

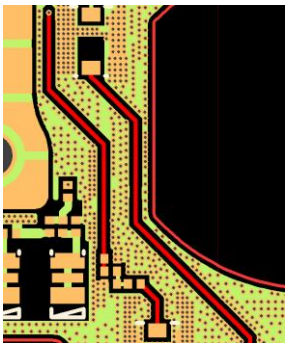


- Signal Vias are not shielded with GND. These can cause cross talk (RX sensitivity interference)



</td><td>

Layer 1



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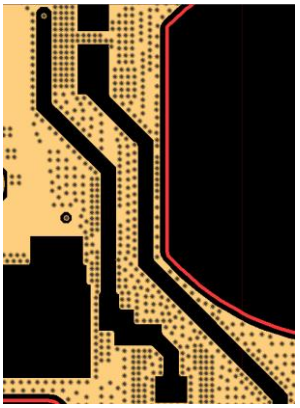
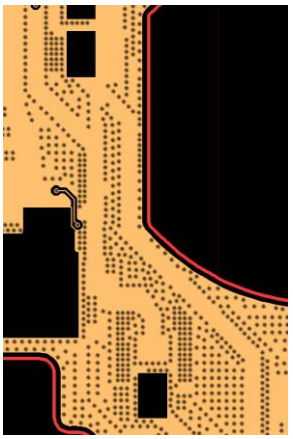


Layer 3



</td></tr>
</table>

5 Electrical Features

5.1 About This Chapter

This chapter describes the electrical features of the interfaces in the module, including:

- Absolute Ratings
- Operating and Storage Temperatures and Humidity
- Electrical Features of Application Interfaces
- Power Supply Features
- EMC and ESD Features

5.2 Absolute Ratings

WARNING

Table 5-1 lists the absolute ratings for the module. Using the module beyond these conditions may result in permanent damage to the module.

Table 5-1 Absolute ratings

Symbol	Specification	Min.	Max.	Unit
VBAT	External power voltage	–0.3	4.5	V

5.3 Operating and Storage Temperatures and Humidity

Table 5-2 lists the operating and storage temperatures and humidity for the WAVE LGA module.

Table 5-2 Operating and storage temperatures and humidity

Specification	Min.	Max.	Unit
Normal operating temperature	–40	+85	℃
Extended operating temperature[1]	–40	+95	℃
Ambient storage temperature	–40	+95	℃
Moisture	5	95	%

5.4 Electrical Features of Application Interfaces

Table 5-3 Electrical features of Digital Pins(GPIO/PCM/UART/SPI/SIM/Control GPIO)

Parameter	Description	Min.	Max.	Unit
V_{IH}	Logic high-level input voltage	0.7 x DVDD	DVDD + 0.3	V
V_{IL}	Logic low-level input voltage	–0.3	0.3 x DVDD	V
V_{OH}	Logic high-level output voltage	0.8 x DVDD	DVDD	V
V_{OL}	Logic low-level output voltage	VSS	0.2 x DVDD	V

5.5 Power Supply Features

5.5.1 Input Power Supply

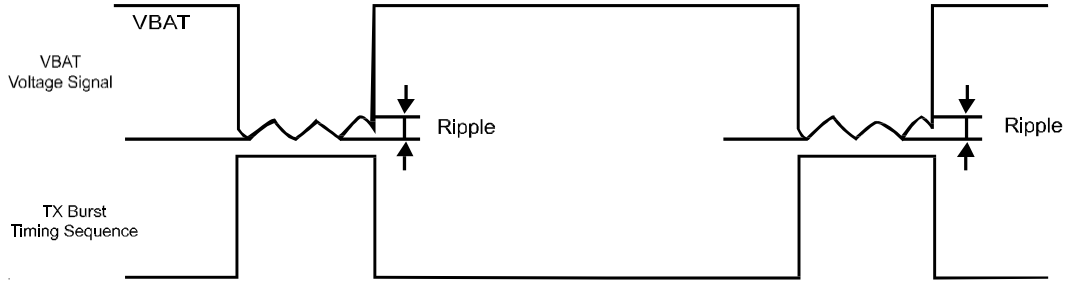
Table 5-4 lists the requirements for input power of the NAD LGA module.

Table 5-4 Requirements for input power

Parameter	Min.	Typ.	Max.	Ripple	Unit
VPH_PWR	4.0	4.2	4.4	0.05	V

The minimum voltage of VBAT can extend to 3.6 V, under this condition, only ensure the module will not restart, but the characteristics cannot be guaranteed.

Figure 5-1 Power supply during burst emission



NOTE
The VBAT minimum value must be guaranteed during the burst (with 2.8 A Peak in GPRS or GSM mode).

Table 5-5 Requirements for input current

Power	Peak (GSM 1 slot)	Normal (WCDMA)	Normal (LTE)
VBAT	2.8 A	1.4 A	1.4 A

5.5.2 Power Consumption

Table 5-6 Average current consumption

Description	Bands	Max. average current consumption	Unit	Power (dBm)
LTE	Band 1	360	mA	1 dBm Tx Power
		550		10 dBm Tx Power
		900		Max Tx Power
	Band 2	360	mA	1 dBm Tx Power
		540		10 dBm Tx Power
		950		Max Tx Power
	Band 3	360	mA	1 dBm Tx Power
		540		10 dBm Tx Power
		950		Max Tx Power
	Band 4	430	mA	1 dBm Tx Power
		560		10 dBm Tx Power
		1000		Max Tx Power
	Band 5	430	mA	1 dBm Tx Power
		560		10 dBm Tx Power
		1000		Max Tx Power
	Band 7	430	mA	1 dBm Tx Power
		560		10 dBm Tx Power
		1000		Max Tx Power
	Band 8	360	mA	1 dBm Tx Power
		550		10 dBm Tx Power
		900		Max Tx Power
	Band 9	360	mA	1 dBm Tx Power
		540		10 dBm Tx Power
		950		Max Tx Power
	Band 10	370	mA	1 dBm Tx Power
		520		10 dBm Tx Power
		950		Max Tx Power
	Band 12	350	mA	1 dBm Tx Power
		400		10 dBm Tx Power
		900		Max Tx Power

Description	Bands	Max. average current consumption	Unit	Power (dBm)
LTE	Band 13	360	mA	1 dBm Tx Power
		550		10 dBm Tx Power
		900		Max Tx Power
	Band 17	360	mA	1 dBm Tx Power
		540		10 dBm Tx Power
		950		Max Tx Power
	Band 18	360	mA	1 dBm Tx Power
		540		10 dBm Tx Power
		950		Max Tx Power
	Band 19	430	mA	1 dBm Tx Power
		560		10 dBm Tx Power
		1000		Max Tx Power
	Band 20	430	mA	1 dBm Tx Power
		560		10 dBm Tx Power
		1000		Max Tx Power
	Band 21	430	mA	1 dBm Tx Power
		560		10 dBm Tx Power
		1000		Max Tx Power
	Band 25	360	mA	1 dBm Tx Power
		550		10 dBm Tx Power
		900		Max Tx Power
	Band 26	360	mA	1 dBm Tx Power
		540		10 dBm Tx Power
		950		Max Tx Power
	Band 28	370	mA	1 dBm Tx Power
		520		10 dBm Tx Power
		950		Max Tx Power
	Band 29	350	mA	1 dBm Tx Power
		400		10 dBm Tx Power
		900		Max Tx Power

Description	Bands	Max. average current consumption	Unit	Power (dBm)
LTE	Band 30	360	mA	1 dBm Tx Power
		550		10 dBm Tx Power
		900		Max Tx Power
	Band 66	430	mA	1 dBm Tx Power
		560		10 dBm Tx Power
		1000		Max Tx Power
	Band 71	360	mA	1 dBm Tx Power
		550		10 dBm Tx Power
		900		Max Tx Power
	Band 34	360	mA	1 dBm Tx Power
		540		10 dBm Tx Power
		950		Max Tx Power
	Band 38	370	mA	1 dBm Tx Power
		520		10 dBm Tx Power
		950		Max Tx Power
	Band 39	350	mA	1 dBm Tx Power
		400		10 dBm Tx Power
		900		Max Tx Power
	Band 40	360	mA	1 dBm Tx Power
		540		10 dBm Tx Power
		950		Max Tx Power
	Band 41	370	mA	1 dBm Tx Power
		520		10 dBm Tx Power
		950		Max Tx Power
	Band 42	350	mA	1 dBm Tx Power
		400		10 dBm Tx Power
		900		Max Tx Power

Description	Bands	Max. average current consumption	Unit	Power (dBm)
WCDMA	Band 1	360	mA	1 dBm Tx Power
		550		10 dBm Tx Power
		900		Max Tx Power
	Band 2	360	mA	1 dBm Tx Power
		540		10 dBm Tx Power
		950		Max Tx Power
	Band 3	430	mA	1 dBm Tx Power
		560		10 dBm Tx Power
		1000		Max Tx Power
	Band 4	360	mA	1 dBm Tx Power
		550		10 dBm Tx Power
		900		Max Tx Power
	Band 5	360	mA	1 dBm Tx Power
		540		10 dBm Tx Power
		950		Max Tx Power
	Band 8	370	mA	1 dBm Tx Power
		520		10 dBm Tx Power
		950		Max Tx Power
	Band 19	370	mA	1 dBm Tx Power
		520		10 dBm Tx Power
		950		Max Tx Power

Description	Max. average current consumption	Unit	PCL	Configuration
GPRS 850	320	mA	5	1 Up/1 Down
	450			2 Up/1 Down
	650			4 Up/1 Down
	200	mA	10	1 Up/1 Down
	280			2 Up/1 Down
	630			4 Up/1 Down
GPRS 900	320	mA	5	1 Up/1 Down
	450			2 Up/1 Down
	650			4 Up/1 Down
	200	mA	10	1 Up/1 Down
	280			2 Up/1 Down
	630			4 Up/1 Down
GPRS 1800	320	mA	5	1 Up/1 Down
	450			2 Up/1 Down
	650			4 Up/1 Down
	200	mA	10	1 Up/1 Down
	280			2 Up/1 Down
	630			4 Up/1 Down
GPRS 1900	320	mA	5	1 Up/1 Down
	450			2 Up/1 Down
	650			4 Up/1 Down
	200	mA	10	1 Up/1 Down
	280			2 Up/1 Down
	630			4 Up/1 Down

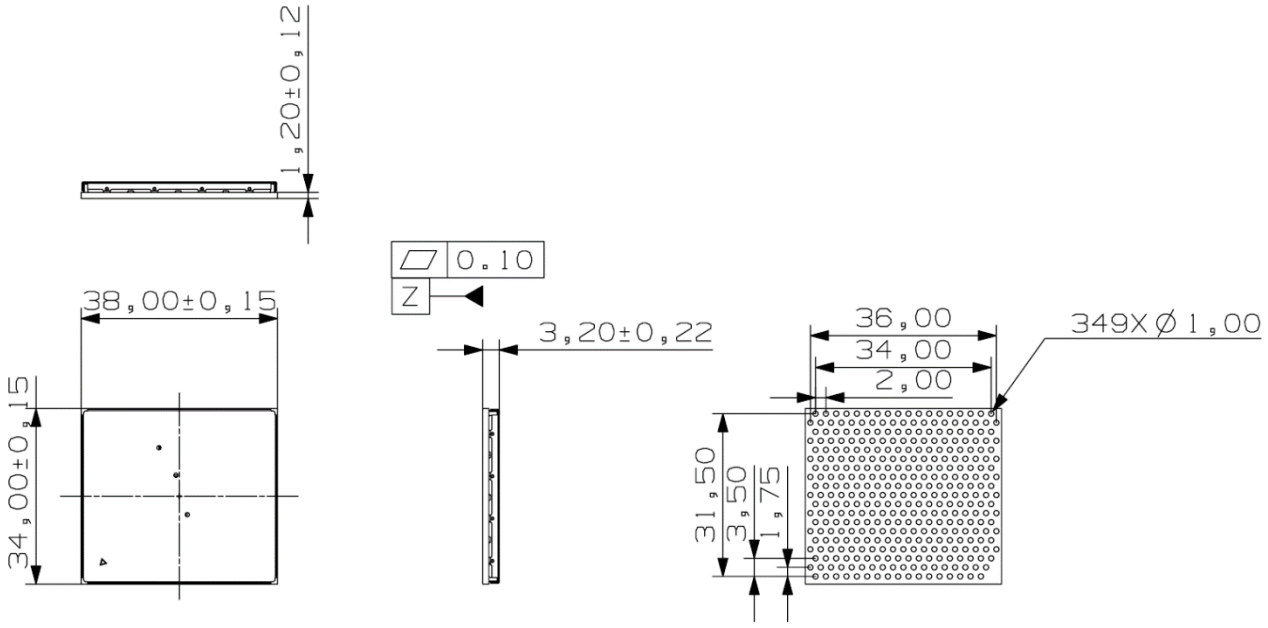
5.6 EMC and ESD Features

- Electrostatic Discharge (ESD) is an electrical transient that poses a serious threat to electronic circuits. The circuit must be configured to protect NAD Module from electrical damage or ESD.
- To protect the circuit from ESD, TVS Diode should be added to RF, antenna port, USIM, USB port.
- An integrated ground plane is necessary for EMC design.
- To protect sensitive circuitry from electrical overstress failures, ESD protection diodes are connected to each signal line between the interface connector and the NAD Module.
- In the factory line, the operator must remove the element that the ESD affects the NAD module. Operator should wear ESD strap and ESD gloves and work.

6 Package Information

6.1 Dimensions

Figure 6-1 Dimension



6.2 Shield-can information

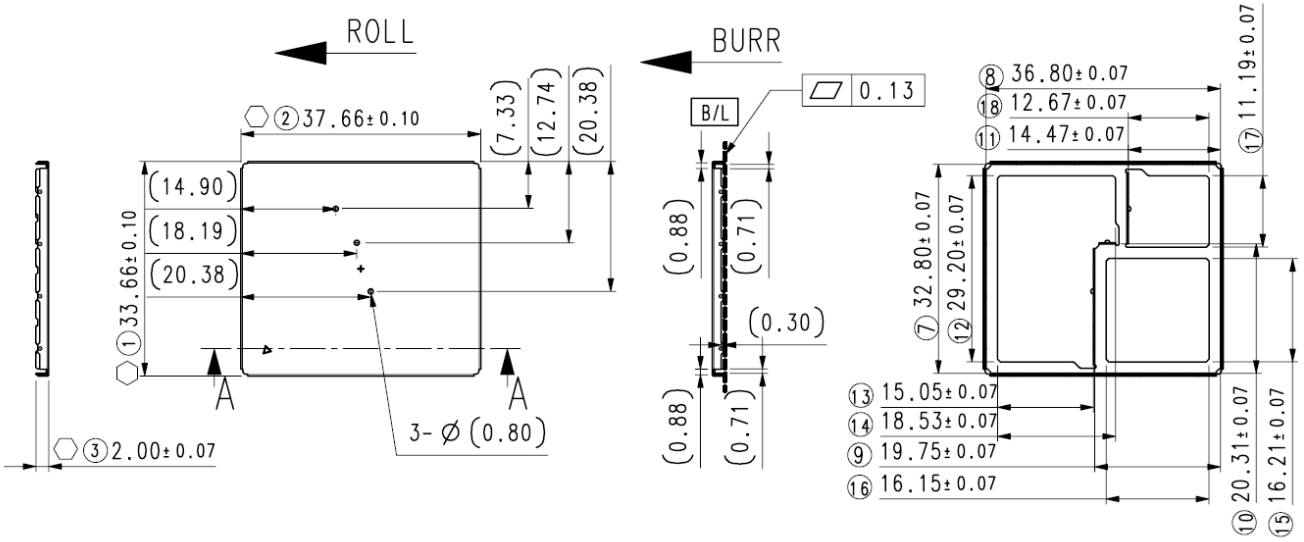
This chapter describe shield can information for WAVE NAD.

- Shield-can material

i) Frame : C7701 1/2H T0.20 (Nickel Silver)

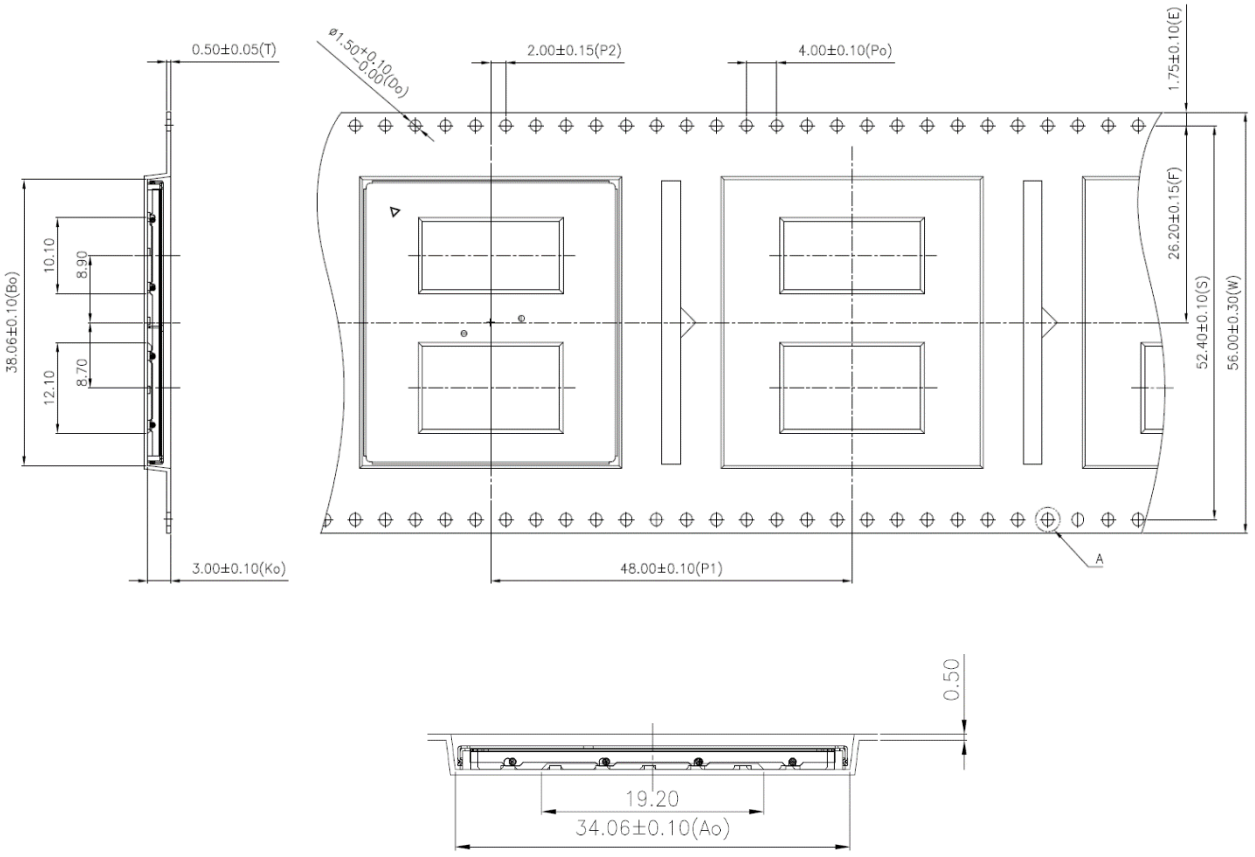
ii) Cover : SUS304 (Stainless)

Figure 6-2 Shield-can cover



6.3 Packaging

Figure 6-3 Packaging



6.4 Label

Figure 6-4 Label

6.5 Storage Guidelines

The module must be properly stored and sealed in the vacuum package under temperatures below 40℃ and relative humidity below 90% to ensure weldability.

6.6 Moisture Sensitivity

- Moisture Sensitivity Level 3
- After unpacking, the module shall be assembled within 168 hours under environmental conditions where the temperature is less than 30℃ and the relative humidity is less than 60%. If the above conditions cannot be met, the module shall be used after baking.
- Baking is recommended for about 8 hours at 125℃.

7 Certification

This chapter describes the status of wave NAD module approval.

7.1 Certifications

Table 7-1 Product certifications

Certification	Status
GCF	
CE	
RoHS	
REACH	
FCC	
IC	
CCC	
KCC	
Jate	
Telec	

7.2 FCC/IC Regulatory notices

Modification statement

The FCC requires the user to be notified that any changes or modifications made to this device that are not expressly approved by Samsung Electronics Co. & Harman could void the user's authority to operate the equipment.

⚠ Manufacturers of mobile or fixed devices incorporating this module series are authorized to use the FCC Grants of the for their own final products according to the conditions referenced in the certificates.

⚠ The FCC Label shall in the above case be visible from the outside, or the host device shall bear a second label stating:

"Contains FCC ID: T8GSAN9001"

⚠ IMPORTANT: Manufacturers of portable applications incorporating this series modules are required to have their final product certified and apply for their own FCC Grant related to the specific portable device. This is mandatory to meet the SAR requirements for portable devices. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

ISED Canada requires the user to be notified that any changes or modifications made to this device that are not expressly approved by Samsung Electronics Co. & Harman could void the user's authority to operate the equipment.

⚠ Manufacturers of mobile or fixed devices incorporating these modules are authorized to use the ISED Canada Certificates of this series modules for their own final products according to the conditions referenced in the certificates.

⚠ The ISED Canada Label shall in the above case be visible from the outside, or the host device shall bear a second label stating:

"Contains IC: 6434A-SAN9001

⚠ **Innovation, Science and Economic Development Canada (ISED) Notices**

This Class B digital apparatus complies with Canadian CAN ICES-3(B) / NMB-3(B).

Operation is subject to the following two conditions:

- this device may not cause interference

- this device must accept any interference, including interference that may cause undesired operation of the device

Radio Frequency (RF) Exposure Information

The radiated output power of the Samsung Electronics Co. & Harman Cellular Module is below the Innovation, Science and Economic Development Canada (ISED) radio frequency exposure limits. The Samsung Electronics Co. & Harman Cellular Module should be used in a manner such that the potential for human contact during normal operation is minimized.

This device has been evaluated and shown compliant with the IC RF Exposure limits under mobile exposure conditions (antennas are greater than 20 cm from a person's body).

This device has been certified for use in Canada. Status of the listing in the Industry Canada's REL (Radio Equipment List) can be found at the following web address:

http://www.ic.gc.ca/app/sitt/reltel/srch/nwRdSrch.do?lang=eng

Additional Canadian information on RF exposure also can be found at the following web address:
http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf08792.html

⚠ IMPORTANT: Manufacturers of portable applications incorporating the wave series modules are required to have their final product certified and apply for their own Industry Canada Certificate related

to the specific portable device. This is mandatory to meet the SAR requirements for portable devices.

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

⚠ **Avis d'Innovation, Sciences et Développement économique Canada (ISDE)**

Cet appareil numérique de classe B est conforme aux normes canadiennes CAN ICES-3(B) / NMB-3(B). Son fonctionnement est soumis aux deux conditions suivantes:

- cet appareil ne doit pas causer d'interférence
- cet appareil doit accepter toute interférence, notamment les interférences qui peuvent affecter son fonctionnement

Informations concernant l'exposition aux fréquences radio (RF)

La puissance de sortie émise par l'appareil de sans-fil Samsung Electronics Co. & Harman Cellular Module est inférieure à la limite d'exposition aux fréquences radio d'Innovation, Sciences et Développement économique Canada (ISDE). Utilisez l'appareil de sans-fil Samsung Electronics Co. & Harman Cellular Module de façon à minimiser les contacts humains lors du fonctionnement normal.

Ce périphérique a été évalué et démontré conforme aux limites d'exposition aux fréquences radio (RF) d'IC lorsqu'il est installé dans des produits hôtes particuliers qui fonctionnent dans des conditions d'exposition à des appareils mobiles (les antennes se situent à plus de 20 centimètres du corps d'une personne).

Ce périphérique est homologué pour l'utilisation au Canada. Pour consulter l'entrée correspondant à l'appareil dans la liste d'équipement radio (REL - Radio Equipment List) d'Industrie Canada rendez-vous sur: http://www.ic.gc.ca/app/sitt/reltel/srch/nwRdSrch.do?lang=fra

Pour des informations supplémentaires concernant l'exposition aux RF au Canada rendez-vous sur: http://www.ic.gc.ca/eic/site/smt-gst.nsf/fra/sf08792.html

⚠ IMPORTANT: les fabricants d'applications portables contenant les modules de la wave series doivent faire certifier leur produit final et déposer directement leur candidature pour une certification FCC ainsi que pour un certificat ISDE Canada délivré par l'organisme chargé de ce type d'appareil portable. Ceci est obligatoire afin d'être en accord avec les exigences SAR pour les appareils portables. Tout changement ou modification non expressément approuvé par la partie responsable de la certification peut annuler le droit d'utiliser l'équipement.

SA-N9001

- **FCC ID: T8GSAN9001**
- **IC ID: 6434A-SAN9001**

8 Safety information

8.1 Safety information

Ensure that this product is only used in authorized countries and in required environments.

Avoid use in the following areas as it may cause problems when used elsewhere than authorized.

- It can interfere with other electronic devices in the environment such as aircraft, hospitals, etc.
- It is the responsibility of the user to use it in a place where there is a risk of explosion or a prohibited place.

Do not disassemble the product unless it is the authorized person in charge.

The warranty for the product may be difficult when arbitrarily disassembled. It is recommended that you follow the instructions of the Hardware Guide for the correct use of the product.

This product must supply stabilized voltage sources and wiring must comply with security and fire prevention regulations.

Because electrostatic discharge may damage the product itself, it is necessary to handle the product carefully by avoiding contact with the pin.

The same attention should be paid to SIMs, and the instructions for use should be carefully checked.

Do not insert or remove the SIM when the product is in active mode and power on conditoin.

If you have any questions, please refer to the technical documents and the regulations in progress.

European Conformance

The modules have been evaluated against the essential requirements of the Radio Equipment Directive 2014/53/EU (RED).Thus, the following marking is included in the product:

CE

⚠ Radiofrequency radiation exposure Information: this equipment complies with radiation exposure limits prescribed for an uncontrolled environment for fixed and mobile use conditions. This equipment should be installed and operated with a minimum distance of 20 cm between the radiator and the body of the user or nearby persons. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter except as authorized in the certification of the product.

9 Software information

9.1 AT Command

Table 8-1 AT Command List

Command	TX	RX
H/W REV	**AT+HWREV**	Ex) HWREV:6
SKU	AT+CPSKU	CPSKU:0
NAD S/W Version	AT+CGMR	S5123_WAVEM_SGC_xxxxxxx

10 Acronyms and Abbreviations

Acronym or Abbreviation	Expansion
3GPP	Third Generation Partnership Project
8PSK	8 Phase Shift Keying
ADC	Analog To Digital Converter
AMPR	Additional Maximum Power Reduction
AP	Access Point
AUX	Auxiliary
BC	Band Class
BER	Bit Error Rate
BLER	Block Error Rate
BIOS	Basic Input Output System
CA	Carrier Aggregation
CCC	China Compulsory Certification
CE	European Conformity
CMOS	Complementary Metal Oxide Semiconductor
CPU	Central Processing Unit
CS	Circuit Switched
CUST	Customer NAD
DVDD	Digital power source
DC	Direct Current
DCE	Data Communication Equipment
DCS	Digital Cellular System
DL	Down Link
DMA	Direct Memory Access
DNL	Differential Nonlinearity
DRX	Discontinuous Reception
DVK	Development Kit
ECC	Envelope Correlation Coefficient
ETSI	European Telecommunication Standard Institute

Acronym or Abbreviation	Expansion
EDGE	Enhanced Data Rate for GSM Evolution
EGSM	Extended GSM
EMC	Electromagnetic Compatibility
ENIG	Electroless Nickel Immersion Gold
EPA	Electrostatic Discharge Protected Area
ESD	Electrostatic Discharge
E SIM	Embedded Subscriber Identity Module
EU	European Union
EVDO	Evolution Data Optimized
FCC	Federal Communications Commission
FDD	Frequency Division Duplex
GCF	Global Certification Forum
GMSK	Gaussian Minimum Shift-frequency Keying
GPIO	General Purpose I/O
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communication
GLONASS	Global Navigation Satellite System
GNSS	Global Navigation Satellite System
HBM	Human Body Model
HSDPA	High Speed Downlink Packet Access
HSPA	High Speed Packet Access
HSPA+	Enhanced High Speed Packet Access
HSUPA	High Speed Up-link Packet Access
IC	Integrated Circuit
ILPC	Inner Loop Power Control
IMC	Inter Metallic Compound
IMT	International Mobile Telephony
INL	Integral Nonlinearity
IQ	In-phase and Quadrature phase
ISO	International Standards Organization

Acronym or Abbreviation	Expansion
JTAG	Joint Test Action Group
LCD	Liquid Crystal Display
LDO	Low Dropout Regulator
LED	Light Emitting Diode
LGA	Land Grid Array
LPF	Low Pass Filter
LTE	Long Term Evolution
MCP	Multi Chip Package
MCS	Modulation and Coding Scheme
MIMO	Multiple Input-Multiple Output
MPR	Maximum Power Reduction
MO	Mobile Originated
MT	Mobile Terminated
NC	Not Connected
NR	New Radio
NSMD	Non Solder Mask Defined
OC	Open Collector
PA	Power Amplifier
PD	Pull Down resistor
PCB	Printed Circuit Board
PCL	Power Control Level
PCM	Pulse Code Modulation
PCS	Personal Communications System
PDU	Protocol Data Unit
PID	Product Identity
PMU	Power Management Unit
PS	Packet Switched
QPSK	Quadrature Phase Shift Keying
QAM	Quadrature Amplitude Modulation
RF	Radio Frequency
RH	Relative Humidity

Acronym or Abbreviation	Expansion
RoHS	Restriction of the Use of Certain Hazardous Substances
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
RSE	Radiated Spurious Emission
RUIM	Removable User Identity Module
RX	Receive
SAW	Surface Acoustic Wave
SIMO	Single Input Multiple Output
SMS	Short Message Service
SMT	Surface Mounting Technology
TBD	To Be Determined
TCU	Telematics Control Unit
TDD	Time Division Duplex
TIS	Total Isotropic Sensitivity
TTFF	Time to First Fix
TVS	Transient Voltage Suppressor
TX	Transmit Direction
UART	Universal Asynchronous Receiver/Transmitter
UL	Up Link
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
USIM	Universal Subscriber Identity Module
V2X	Vehicle-to-Everything
VoLTE	Voice over LTE
VSWR	Voltage Standing Wave Ratio
WEEE	Waste Electrical and Electronic Equipment
WCDMA	Wideband Code Division Multiple Access
WiFi	Wireless Fidelity
WWAN	Wireless Wide Area Network

* Hardware Guide Change list

[2020.02.24]
1) p.37 RF support band update : LTE DLCA support band removed 5A-40A-41A(CHINA, ROW SKU)
2) p.38 RF support band update : LTE ULCA support band removed 1A-19A, 1A-42A(ECE SKU)
3) P.13 LGA Pin Map Update

PIN #	BMW WAVE C2.0	eAP NAD
H9	Reserved	PCIE1_RST_N
L15	GPS_PPS	RAN_SYNC
N17	DCXO_1P8	GNSS_PPS
J5	Reserved	UART1_CTSB_N
J7	Reserved	UART1_RTSB_N
K6	XCP_GPIO_RSV7	UART2_CTSB_N
K8	XCP_GPIO_RSV8	UART_RTSB_N
C26	GNSS_CHUB_TX	GNSS_UART_TX
D27	GNSS_CHUB_RX	GNSS_UART_RX
D23	GNSS_DEBUG_RX	GNSS_UART_CTS
C22	GNSS_DEBUG_TX	GNSS_UART_RTS
I6	Reserved	XUSI00_I2C_SDA
I4	Reserved	XUSI00_I2C_SCL
Q30	Reserved	XUSI01_I2C_SDA
R29	Reserved	XUSI01_I2C_SCL
O2	Reserved	I2C1_SDA
P11	Reserved	I2C1_SCL
F17	CP2AP_NOTIFY_ACTIVE	XCP_GPIO3_CPALV
F19	CP_AP_WAKE	XCP_GPIO4_CPALV
R5	CP2MCU_WAKEUP	XCP_GPIO_23
H7	Reserved	XCP_GPIO_46
I8	Reserved	XCP_GPIO_47
B25	ETH_ENABLE	XCP_GPIO_57
B27	XETH_RESOUT_N	XCP_GPIO_60
P7	GPIO_ANT_SW1	XCP_GPIO_48
P9	GPIO_ANT_SW2	XCP_GPIO_49
Q6	GPIO_ANT_SW3	XCP_GPIO_54
Q8	GPIO_ANT_SW4	XCP_GPIO_55
P5	XCP_GPIO_RSV1	XCP_GPIO_63
M4	XCP_GPIO_RSV2	XCP_GPIO_50
M6	XCP_GPIO_RSV3	XCP_GPIO_51
L3	XCP_GPIO_RSV4	XCP_GPIO_52
L5	XCP_GPIO_RSV5	XCP_GPIO_53

L7	XCP_GPIO_RSV6	XCP_GPIO_62
R25	AP_26M	XCP_GPIO_61
R27	PM_WRSTBI	XCP_GPIO_58
M32	PCIE1_RST_N	AP_XEINT_0
G6	AP_CP_WAKE	AP_XEINT_1
G8	AP2CP_NOTIFY_ACTVIE	AP_XEINT_2
G10	Reserved	AP_XEINT_3
G12	MCU2CP_WAKEUP	AP_XEINT_4
E16	XMMC_CARD1_CMD	AP_GPIO_SDIO0_CLK
B19	XMMC_CARD0_D3	AP_GPIO_SDIO0_CMD
C18	XMMC_CARD0_D0	AP_GPIO_SDIO0_D0
E20	XMMC_CARD1_D0	AP_GPIO_SDIO0_D1
C16	XMMC_CARD0_CLK	AP_GPIO_SDIO0_D2
C14	XMMC_CARD0_CMD	AP_GPIO_SDIO0_D3
B15	XMMC_CARD0_D1	AP_GPIO_SDIO1_CLK
D17	XMMC_CARD1_D2	AP_GPIO_SDIO1_CMD
B17	XMMC_CARD0_D2	AP_GPIO_SDIO1_D0
E18	XMMC_CARD1_CLK	AP_GPIO_SDIO1_D1
D19	XMMC_CARD1_D3	AP_GPIO_SDIO1_D2
D15	XMMC_CARD1_D1	AP_GPIO_SDIO1_D3
O4	Reserved	CP_SPI1_TXD_FLASH
O6	Reserved	CP_SPI1_CSN_FLASH
O8	Reserved	CP_SPI1_RXD_FLASH
N3	Reserved	CP_SPI1_CLK_FLASH
N5	Reserved	CP_SPI1_WPN_FLASH
Q36	FromAP_TCXO_REQ	Reserved
D21	SD_ENABLE	Reserved
V33	GPIO_CV2X_TX_RX	Reserved

[2020.03.10 v08]
1) p.8 RF support band update : [NA] n78 removed
[ECE] n79 removed
[CHN] WCDMA B5 add, TDD B34,B39 removed
[ROW] WCDMA B3, B5 add, 5G n3, n8 add
[Global] WCDMA B3 add, 5G n8 add
2) p.9 CA combination support band removed : 7A-20A-38A, 7A-28A-38A
3) p.12 Power voltage change : typical 4.0V -> 4.2V
Dimension H value change : 43 mm × 38 mm × 2.5 mm -> 34 mm × 38 mm × 3.4 mm
4) p.13 Block diagram update
5) p.14 Application Block Diagram eMMC update
6) p.16 Figure 2-1 LGA interface update
7) p.28 2.3 CP HW Revision update
8) p.31 Table 3-1 Definitions of the pins on the power supply interface USIM1 add
9) p.33 PCIe Interface Figure 3-5,3-6,3-7 update
10) p.37 4.2.2 Data Services and Power Class update
11) p.40 4.2.3 EN-DC upsupport band removed : DC_3A-41A_n78A, DC_1A-41A_n77A, DC_1A-41C_n77A,
DC_1A-41A_n78A, DC_1A-41C_n78A, DC_1A-41C_n79A,
DC_2A-5A_n66A, DC_2A-12A_n66A

12) p.65 Figure 6-2 Shield-can cover update

[2020.04.10 v09]
1) p.30 USB Interface add

[2020.05.06 v10]
1) p.8 Global sku support band updated
2) p.45 Global sku ENDC support band updated
3) p.53 Safety updated
4) CHN, Global sku n79 removed

[2020.07.24 v11]
1) p.21 Pin description change
R11 : NAD2_SPI_MISO / AP2CP_DUMP_NOTI
G8 : AP_CP2_ACTIVE
G10 : Reserved (Not connected, leave open)
2) p.22 H9 : RC Removed
p.23 M30 : EP Removed
3) p.21 3gpp test low temperature revised –20°C ~ +55°C -> –10°C ~ +55°C
4) p.9 7A-7A-66A, 7A-66A-66A, 7A-7A-66A-66A, 7C-66A, 7C-66A-66A, 7A-12A-66A, 7A-12B-66A -> B66 SCC only support
ULCA 8B, 41A-42C, 40D Not offered

[2020.12.01 v12]
1) p.8 NA/CHN/ECE Skew removed
p.9 LTE CA list update : 2A-28A, 4A-28A, 20A-42A, 20A-42A-42A, 32A-42A, 39A-42A, 39A-42C, 39A-42D, 39A-42E, 39C-42A, 39C-42D, 2A-4A-28A, 3A-3A-7A-7A-8A, 3A-20A-42A, 3A-32A-42A, 7A-20A-42A, 20A-32A-42A added

2) p.18 SPI Interface update : Q12, Q10, R11, R9
3) p.37 Data Services update
4) P.66 Label updated
5) p.68 7.2 FCC/IC Regulatory notices added
6) p.40 EN-DC combination removed : NA/CHN/ECE Skew

[2020.12.03 v13]
1) p.68 FCC warning update