

Operating instruction – Radio Certification regulatory testing



Product: Volvo CE CDC
Manufacturer: Visteon

Part number: VPMBEF-19C034-AI
OEM part number: 53788030

Revision history

Revision	Description	Responsible	Date
1.0	Initial version	Martin Tapankov	2023-02-23
1.1	QRCT compliance testing	Martin Tapankov	2023-04-28
1.2	Final version	Martin Tapankov	2023-08-08
1.3	Updated sections 3.5.2 and 3.5.4 to illustrate which connectors are used to plug in the antennas	Martin Tapankov	2023-08-23
1.4	Added TX and RX settings for Wi-Fi testing in QRCT (section 6.1)	Martin Tapankov	2023-11-22

1.5	Added instructions to update DisplayPort link speed (section 5.11). Compliance procedure set-up updated as well (section 5.12).	Martin Tapankov	2024-01-30
1.6	Updated antenna gain information as related to EIRP testing (section 2.5.1).	Martin Tapankov	2024-02-14
1.7	Updates to section 3.4 to include information about the standard test box without termination.	Martin Tapankov	2024-04-01
1.8	Added note about undervoltage limits in section 1.1)	Martin Tapankov	2024-04-11
1.9	Added instructions how to set up the tuner (section 5.12) Added instructions how to setup the module as Wi-Fi AP (section 5.13) Some proofreading updates	Martin Tapankov	2024-05-15
1.10	Added instructions how to change the regulatory region for Wi-Fi (section 5.14)	Martin Tapankov	2024-06-18

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1. General information

Brand name	Visteon
Model Name	VCE CDC
Product description	Infotainment controller with Bluetooth and Wi-Fi connectivity supporting reception of AM/FM and DAB broadcasts.
Embedded wireless modules	Bluetooth / Wi-Fi: Qualcomm QCA6574AU FM/AM tuner: NXP Dione SAF775DHV DAB tuner: NXP Saturn SAF3602EL
Output power	WLAN IEEE:
Power supply	Voltage range: 6-31V; current range: 5mA (standby)-12.5A+PBATT
Antennas	See ref 1 and ref 2.
Temperature range	-40 to +85°C (storage) -40 to +85°C (operational)
Air humidity	45-75% (storage) 45-75% (operational)
Size	312 x 239 x 69 mm
Weight	1.81 kg
Standard(s) applied	Article 3.1(a) (Health and safety): EN 62311:2020 / EN 62311 EN 62368-1:2014+AC:2015+AC:2017+A11:2017 Article 3.1(b) (EMC) EN 301 489-1 V2.2.3: 2019 EN 301 489-17 V3.2.4:2020 EN 55035 EN 55032 Article 3.2 (Radio Spectrum) EN 300 328 V2.2.2:2019 EN 301 893 EN 300 440 V2.2.1:2018
Product usage	Infotainment controller with Bluetooth and Wi-Fi connectivity supporting reception of AM/FM and DAB broadcasts.

1.1 Power supply

The module supports two separate power supply ratings:

	Voltage			Current		
	Min	Nominal	Max	Min	Nominal	Max
12V mode	4V ¹ 6V ²	14.4V	20V	5 mA (standby mode)	2.5A	7.5A
24V mode	7V	24V	37.5V	5 mA (standby mode)	5A+PBATT	12.5A+PBATT

Table 1: Power supply ratings for the VCE CDC device

¹ Transient limit (up to 100 ms)

² Steady-state limit

Note: all voltage ratings apply to voltage measured at the power pins of the device and not at the test power supply. Both test box types have voltage drop of their own (around 1.5 V) that need to be taken into account. For practical purposes, it is recommended that the testing power supply is set to 7.5V when testing undervoltage limits in 12V mode.

1.2 Internal power supplies

The module utilizes the following internal converters to power the respective components and integrated circuits.

Power supply	Feature
Buck Boost 12V	Cameras 1-4 ; LINs
Boost 5V	CANs
Buck 3.3V	permanent main
Buck 5V	USBs
Buck 1.2V	USBs ; camera deserializers
Buck 1.8V	Camera deserializers; display serializers
Buck 1.0V	Display serializer
LDO 1.8V	Ethernet switch
Buck 1.0V	Ethernet switch
Boost 12V	Central Warning Red Light
Buck 3.3V	GPU and Audio system incl. tuners
Buck 1.8V	Bluetooth / Wi-Fi

Table 2: Internal power supplies

2. Embedded wireless modules

2.1 Bluetooth / Wi-Fi combined module

Brand name	Qualcomm
Model name	QCA6574AU
Product description	The Qualcomm QCA6574AU System-on-Chip (SoC) is an automotive connectivity SoC with 2x2 802.11 a/b/g/n/ac and Bluetooth 5.0 technology.
Antenna	See section 2.5.1
Frequency ranges	WLAN IEEE 802.11a: 5150-5250 MHz 802.11b/g: 2412-2484 MHz 802.11n: 2412-2484 MHz, 5150-5250 MHz, 5750-5850 MHz 802.11ac: 5150-5250 MHz, 5750-5850 MHz Bluetooth: 2402-2480 MHz FM 76-108 MHz AM LW: 144-288 kHz MW: 522-1710 kHz DAB 175-240 MHz (Band 3)
Transmitter power (see [Ref 3] for additional information)	WLAN IEEE 802.11b CCK – 19 dBm 802.11g OFDM, 6 Mbps – 18 dBm 802.11g OFDM, 54 Mbps – 17 dBm 802.11n HT20, MCS0 – 18 dBm 802.11n HT20, MCS7 – 16 dBm 802.11n HT40, MCS0 – 17 dBm 802.11n HT40, MCS7 – 16 dBm 802.11ac VHT40, MCS9 – 14 dBm 802.11a OFDM, 6 Mbps – 14 dBm 802.11a OFDM, 54 Mbps – 13 dBm 802.11ac VHT20, MCS0 – 14 dBm 802.11ac VHT20, MCS7 – 12 dBm 802.11ac VHT40, MCS7 – 11 dBm 802.11ac VHT80, MCS9 – 10 dBm Bluetooth 11.5 dBm (GFSK)

Power supply	3.3 Vdc	
Data Rate / Modulation	WLAN IEEE 2.4 GHz Tx 802.11b CCK – 1 Mbps 802.11g OFDM – 54 Mbps 802.11n HT20 – MCS7 802.11ac VHT40 – MCS9	WLAN IEEE 5 GHz Tx 802.11a OFDM – 54 Mbps 802.11ac VHT20 – MCS7 802.11ac VHT40 – MCS7 802.11ac VHT80 – MCS9
Duty cycle		

Table 3: QCA6574AU Wi-Fi and Bluetooth characteristics

2.2 AM/FM tuner

Excerpt of the product datasheet with all radio characteristics available in [Ref 5].

Manufacturer	NXP Semiconductors
Model name	SAF775DHV
Product description	The SAF775D integrates audio and radio processing, sample rate converters and digital and analog audio output. The SAF775C; SAF775D include front ends to receive one AM station or one FM station.
Frequency range	FM: 65-108 MHz AM: 144-288 kHz MW: 522-1710 kHz SW: 2.3-27 MHz
Signal plus noise-to-noise ratio	60 dB min; 65 dB typical (stereo)
AM suppression	70 dB typical
Antenna	See section 0

Table 4: AM / FM tuner characteristics

2.3 DAB tuner

Excerpt of the product datasheet with all radio characteristics available in [Ref 6].

Manufacturer	NXP Semiconductors
Model name	SAF3602EL/V3040
Product description	The SAF3602 is a digital terrestrial radio processor with DAB capabilities
Frequency range	167.3 MHz – 240.06 MHz
Receiver sensitivity	-102 dBm
Adjacent channel rejection	45 dBc min; 55 dBc typical
Far-off selectivity	65 dBc min; 70 dBc typical
Maximum input signal	10 dBm
Antenna	See section 0

Table 5: DAB tuner characteristics

2.4 Crystal oscillator

Excerpt of crystal oscillator characteristics shown below. Further information available in [Ref 4].

Manufacturer	TXC Corporation
Product Type	SMD TCXO 2.0 * 1.6
Nominal frequency	48 MHz
Manufacturer P/N	AK48071501
Operating temperature range	-40 to 105°C
Harmonics	-8 dBc
Supply voltage	2.5V rated
Frequency tolerance	±2 ppm
Frequency stability vs temperature -40 ~ +105°C	±7 ppm
Frequency stability vs load 10 kΩ // 10 pF ±10%	±0.3 ppm

Frequency stability vs supply voltage Vcc 2.5V±5%	±0.2 ppm
--	----------

Table 6: Crystal oscillator characteristics

2.5 Antennas

The unit features two separate antennas which are used for Bluetooth/Wi-Fi [Ref 1] and tuners [Ref 2], respectively.

2.5.1 Bluetooth / Wi-Fi antenna

Full product specification available in [Ref 1]

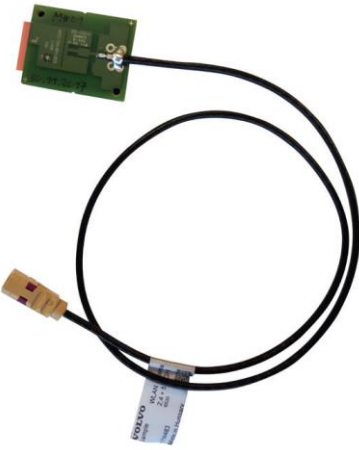
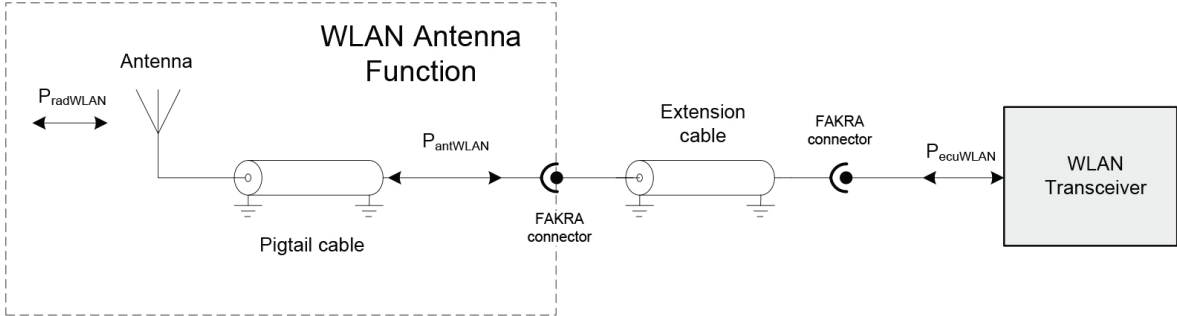
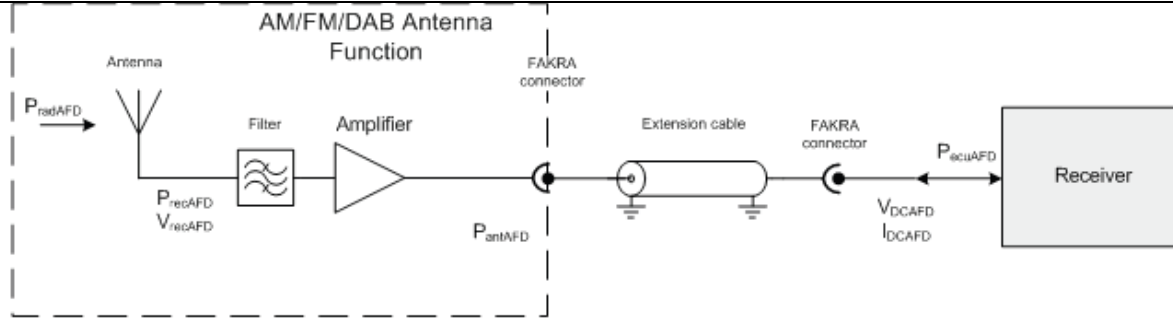
	
	
Manufacturer	TE Connectivity
Part number	23311706 / 920 638-001
Operating temperature	-40- +85°C
Storage temperature	-40- +85°C
Cable type	Dacar 302
Frequency bands	2400-2485 MHz 5150-5925 MHz
Return loss	≥8 dB
Polarization (vertically mounted)	Linear
Antenna gain (average)	≥ -1.5 dBi @ 2400–2485 MHz ≥ 0.5 dBi @ 5150–5925 MHz
Antenna gain (maximum)	5 dBi
Impedance	50 Ω
Power handling	≥ 30 dBm

Table 7: Wi-Fi / Bluetooth antenna characteristics

Note: Since the antenna is passive and of patch type, for the purposes of ERP/EIRP measurements, the average antenna gain (as specified in Table 7) shall be used (-1.5 dBi in the 2.4 GHz spectrum, and 0.5 dBi in the 5 GHz range).

2.5.2 Tuner antenna

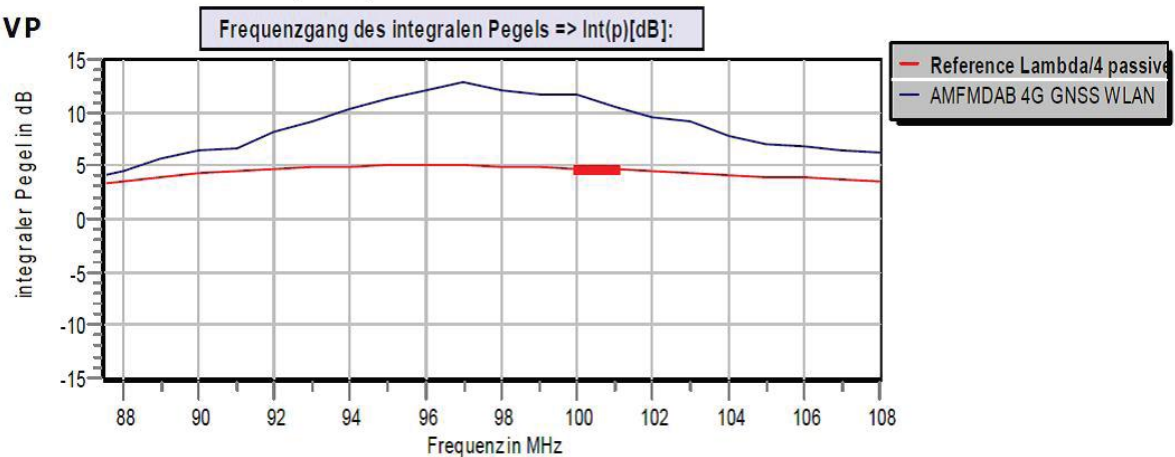
Full product specification available in [Ref 2]



Manufacturer	TE Connectivity
Part number	23311779/920 447-011 (Base) 224 729 86 (Rod, 400 mm)
Antenna type	Rod, 400 mm
Operating temperature	-40 - +85°C
Storage temperature	-40 - +85°C
Frequency bands	AM: 0.1485-1.705 MHz FM: 76-108 MHz DAB (Band III): 174-240 MHz
Return loss (output)	≥10 dB
Polarization	Vertical
Antenna gain (average)	AM-LF: 2.7 dBi AM-MF: 3.3 dBi FM: 9.4 dBi DAB: 16.6 dBi

AM/FM gain

VP



Mittelwert des integralen Pegels als f(f):

Avg(p)[int(p)] = 4.4dB

Avg(p)[int(p)] = 9.4dB

DAB gain

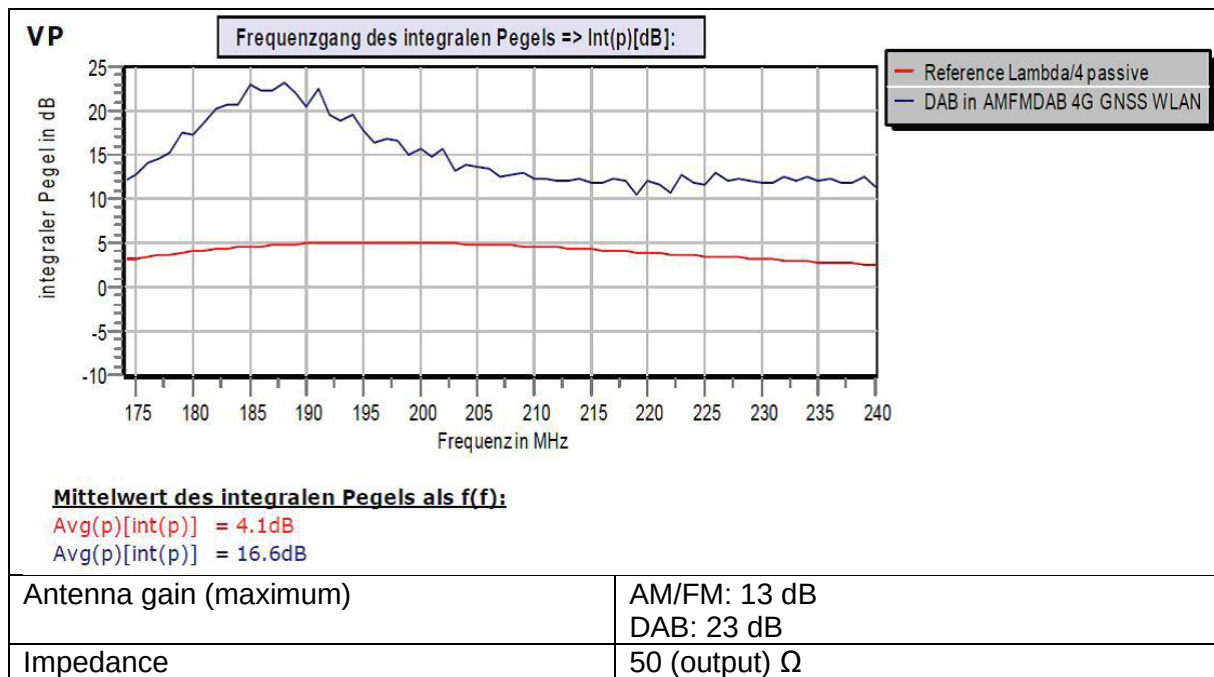


Table 8: Tuner antenna characteristics

3. Product description

1.3 Place of manufacture

1.4 Product variants

There is one product variants defined for the program:

Volvo part number	Visteon part number	Description
53788030	VPMBEF-19C034-AI	ICM unit

1.5 Product label

Product label is shown below.

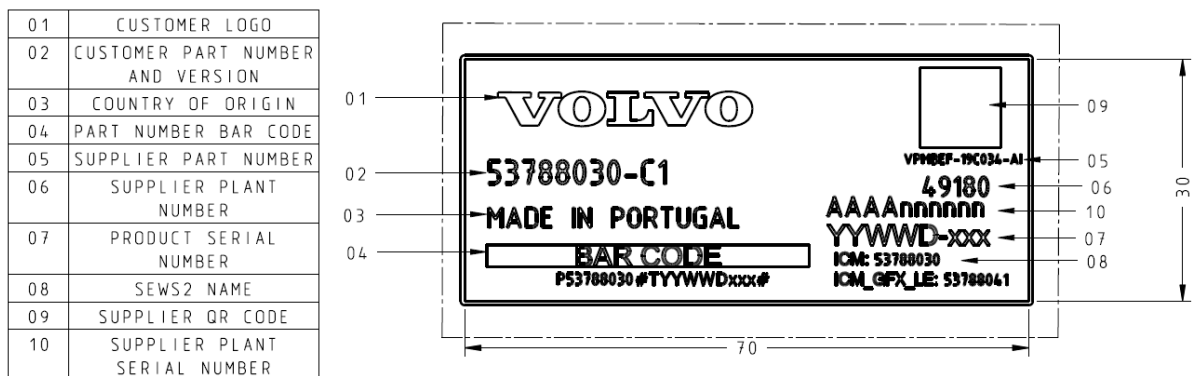


Figure 1. Product label

Product serial number follows the requirement [C01\PR:057:2], with the serial number parts following the pattern below:

YY	Year of manufacture
WW	Month of manufacture
D	Day in the week (Monday = 1, Friday = 5)
xxx	Running number (reset to 001 each week)

Table 9: Product serial number pattern

Example: Serial number 22265-333 refers to a part with running number 333 manufactured on Friday, Jul 1st, 2022.

1.6 Certification label

Certification label is fitted on the back of the module as seen on Figure 2.

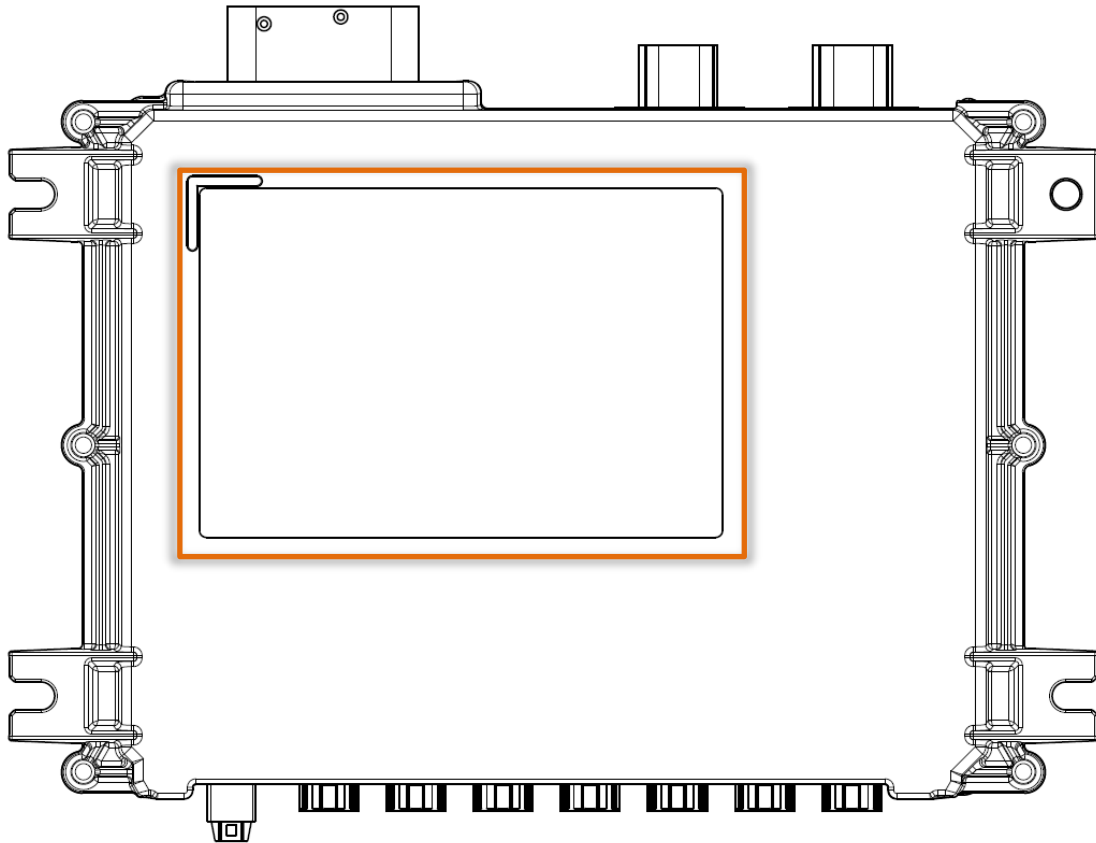


Figure 2: Certification label location (highlighted in orange)

The certification label applied on the part is shown on Figure 3. Countries and territories corresponding to the certification IDs are provided in Table 10.

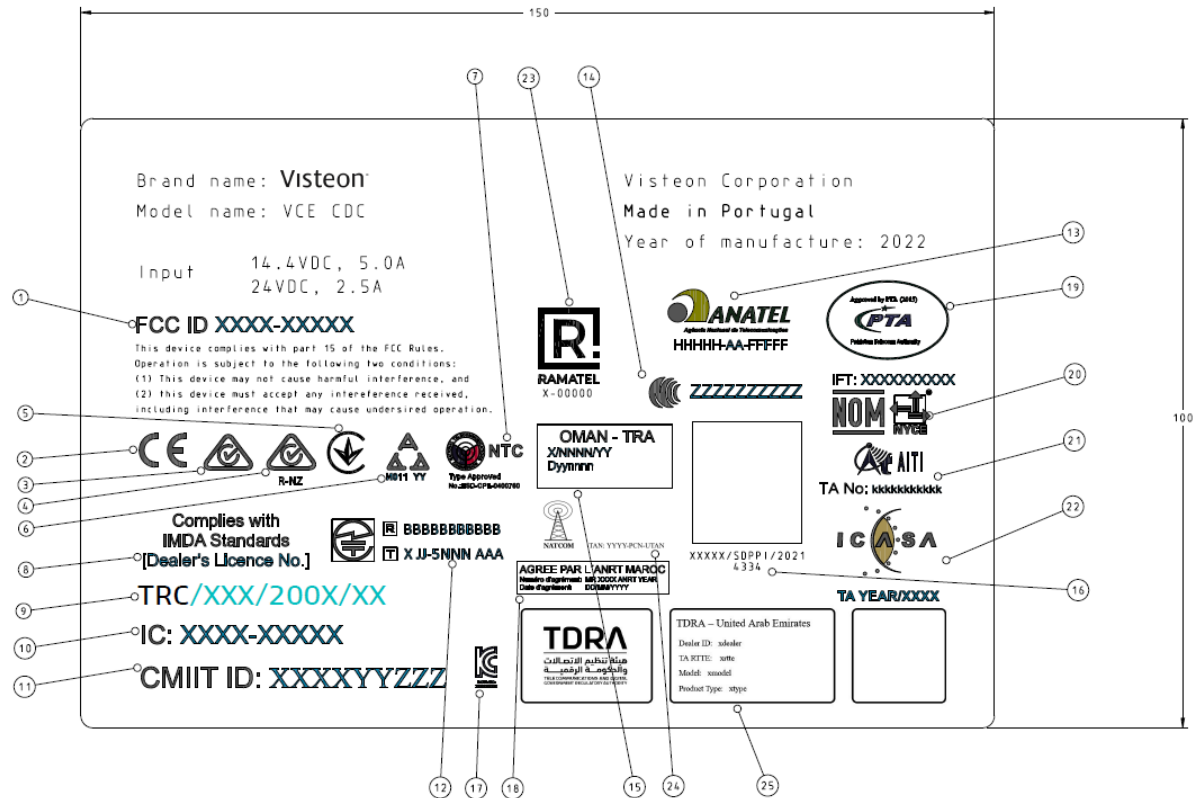


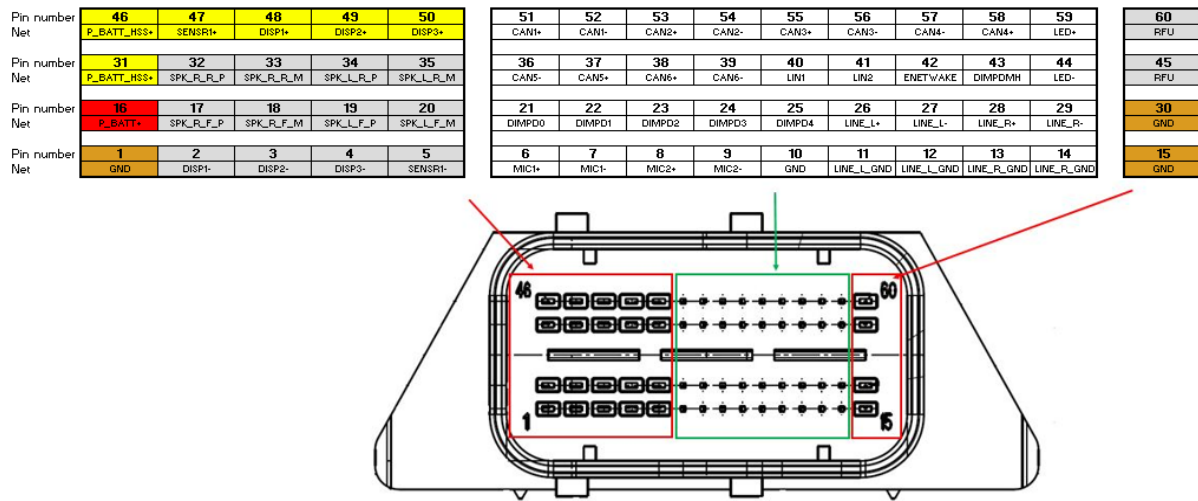
Figure 3: Certification label

Nr.	Territory	Certification ID	Nr.	Territory	Certification ID
1	USA		14	Taiwan	
2	European Union		15	Oman	
3	Australia		16	Indonesia	
4	New Zealand		17	South Korea	
5	Ukraine		18	Morocco	
6	Serbia		19	Pakistan	
7	Philippines		20	Mexico	
8	Singapore		21	Brunei	
9	Jordan		22	South Africa	
10	Canada		23	Argentina	
11	PR China		24	Sierra Leone	
12	Japan		25	UAE	
13	Brazil		26		

Table 10: Certification IDs per country/territory

2. Product interfaces

2.1 Main connector



Legend

Yellow	Pins related to displays' and power sensor's power delivery
Red	Main Battery rail
Brown	High current Ground pins
Grey	High current signal / power pins

Pin #	Signal Name	Description	Safety related	Harness Wire	I/O/S
1	GND	GND harness wire to Negative Battery Terminal	yes	yes	GND
2	GND	DISP1 Ground wire	-	yes	GND
3	GND	DISP2 Ground wire	-	yes	GND
4	GND	DISP3 Ground wire	-	yes	GND
5	GND	SENSR1 Ground wire	-	yes	GND
6	MIC 1 IN P	Microphone 1 Positive In	-	yes	I
7	MIC 1 IN M	Microphone 1 Negative In	-	yes	I
8	MIC 2 IN P	Microphone 2 Positive In	-	yes	I
9	MIC 2 IN M	Microphone 2 Negative In	-	yes	I
10	GND	Signal Ground	-	-	GND
11	GND	RFU (Ground connection for Single-Ended Low-level Amplifier LEFT)	-	-	GND
12	GND	RFU (Ground connection for Single-Ended Low-level Amplifier LEFT)	-	-	GND
13	GND	RFU (Ground connection for Single-Ended Low-level Amplifier RIGHT)	-	-	GND
14	GND	RFU (Ground connection for Single-Ended Low-level Amplifier RIGHT)	-	-	GND
15	GND	GND harness wire to Negative Battery Terminal	yes	yes	GND
16	P_BATT+	+BATT Supply for CDC (FUSE 1)	yes	yes	BATT
17	SPK_RIGHT_F_P	Front Right Speaker Positive Out	-	yes	O
18	SPK_RIGHT_F_M	Front Right Speaker Negative Out	-	yes	O
19	SPK_LEFT_F_P	Front Left Speaker Positive Out	-	yes	O
20	SPK_LEFT_F_M	Front Left Speaker Negative Out	-	yes	O
21	DIMPD_IN0	Digital Input 0	yes	yes	I
22	DIMPD_IN1	Digital Input 1	-	yes	I
23	DIMPD_IN2	Digital Input 2	-	yes	I
24	DIMPD_IN3_EOL	Digital Input 3 connected to RP CPU module (EOL)	-	yes	I

25	DIMPD_IN4	Digital input 4 connected to GPU (QC SIP) module (EOL)	-	yes	I
26	LINE_OUT_SPK_L_P	Low-level Amplifier LEFT Positive Out	-	yes	O
27	LINE_OUT_SPK_L_N	Low-level Amplifier LEFT Negative Out	-	yes	O
28	LINE_OUT_SPK_R_P	Low-level Amplifier RIGHT Positive Out	-	yes	O
29	LINE_OUT_SPK_R_N	Low-level Amplifier RIGHT Negative Out	-	yes	O
30	GND	GND harness wire to Negative Battery Terminal	yes	yes	GND
31	P_BATT_HSS+	+BATT Supply for DISP1/2/3 and SENSR1 (FUSE 2)	-	yes	BATT
32	SPK_RIGHT_R_P	Rear Right Speaker Positive Out	-	yes	O
33	SPK_RIGHT_R_M	Rear Right Speaker Negative Out	-	yes	O
34	SPK_LEFT_R_P	Rear Left Speaker Positive Out	-	yes	O
35	SPK_LEFT_R_M	Rear Left Speaker Negative Out	-	yes	O
36	CAN5_LOW	CAN5 Bus Low	yes	yes	I/O
37	CAN5_HIGH	CAN5 Bus High	yes	yes	I/O
38	CAN6_HIGH	CAN6 Bus High	yes	yes	I/O
39	CAN6_LOW	CAN6 Bus Low	yes	yes	I/O
40	LIN1_CONN	LIN1 bus	-	yes	I/O
41	LIN2_CONN	LIN2 bus	-	yes	I/O
42	ENET_PHYS_WAKE_UP	DOIP Wake-up In	-	yes	I
43	DIMPD_MHI0	Digital Input (Mode Handling Input)	-	yes	I
44	RED_LED_M	Low side switch for RED LED control (Minus)	yes	yes	S
45	NC / Reserved for future use	Not connected (Place holders for termination capacitors)	-	-	
46	P_BATT_HSS+	+BATT Supply for DISP1/2/3 and SENSR1 (FUSE 2)	-	yes	BATT
47	P_PWR_SENRSR1	+PWR External Power Sensor (SENRSR1)	-	yes	S
48	P_PWR_DISPLAY1	+PWR Display 1 (DISP1)	-	yes	S
49	P_PWR_DISPLAY2	+PWR Display 2 (DISP2)	-	yes	S
50	P_PWR_DISPLAY3	+PWR Display 3 (DISP3)	-	yes	S
51	CAN1_HIGH	CAN1 Bus High	yes	yes	I/O
52	CAN1_LOW	CAN1 Bus Low	yes	yes	I/O
53	CAN2_HIGH	CAN2 Bus High	yes	yes	I/O
54	CAN2_LOW	CAN2 Bus Low	yes	yes	I/O
55	CAN3_HIGH	CAN3 Bus High	yes	yes	I/O
56	CAN3_LOW	CAN3 Bus Low	yes	yes	I/O
57	CAN4_LOW	CAN4 Bus Low	yes	yes	I/O
58	CAN4_HIGH	CAN4 Bus High	yes	yes	I/O
59	RED_LED_P	High side switch for RED LED control (Plus)	yes	yes	S
60	NC / Reserved for future use	Not connected (Place holders for termination capacitors)	-	-	-

Table 11: Main connector pinout

2.2 High-speed connectors

Type	Coding	Colour	Connector type	Reference designator	Board connector P/N
Wi-Fi / BT antenna	I	Beige RAL 1001	FAKRA	J11701	59S17V-40MT5-I
AM/FM/DAB antenna	B	White RAL 9001	FAKRA	J11101	59S17V-40MT5-B
GMSL Camera 1	A	Black RAL 9005	FAKRA	J11601	59S17V-40MT5-A
GMSL Camera 2	C	Blue RAL 5005	FAKRA	J11602	59S17V-40MT5-C
GMSL Camera 3	D	Bordeaux RAL 4004	FAKRA	J11603	59S17V-40MT5-D
GMSL Camera 4	E	Green RAL 6002	FAKRA	J11604	59S17V-40MT5-E
GMSL Display 1	B	Pure White RAL 9010	H-MTD	J11402	E6S24A-40MT5-B
GMSL Display 2	C	Light Blue RAL 5012	H-MTD	J11403	E6S24A-40MT5-C
GMSL Display 3	A	Jet Black RAL 9005	H-MTD	J11401	E6S24A-40MT5-A
100Base-T1	G	Platinum Gray RAL 7036	H-MTD	J11302	E6S24A-40MT5-G
100Base-T1	H	Light Pink RAL 3015	H-MTD	J11303	E6S24A-40MT5-H
100Base-T1	L	Yellow Green RAL 6018	H-MTD	J11304	E6S24A-40MT5-L
100Base-T1	M	Pastel Orange RAL 2003	H-MTD	J11305	E6S24A-40MT5-M
100Base-Tx	D	Claret Violet RAL 4004	HSD	J11301	D4S24V-40 MA5-D

Table 12: High-speed connectors and their coding

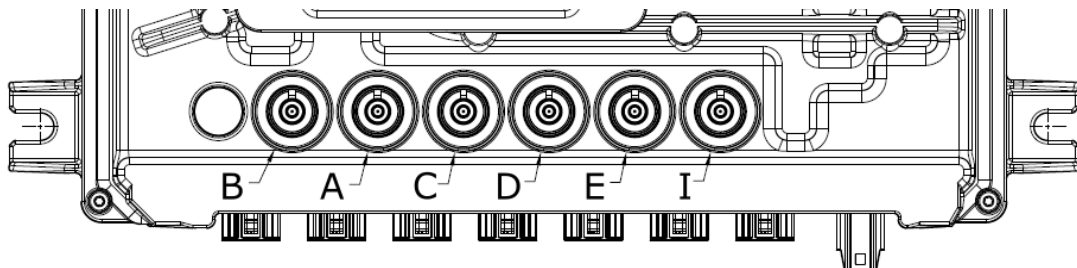


Figure 4: FAKRA connector order and coding

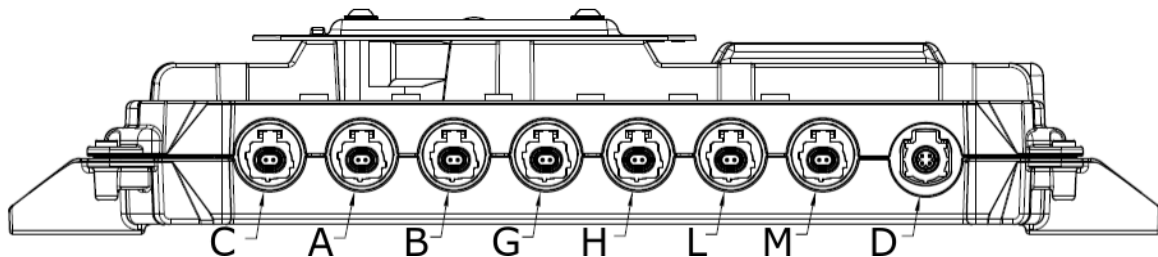
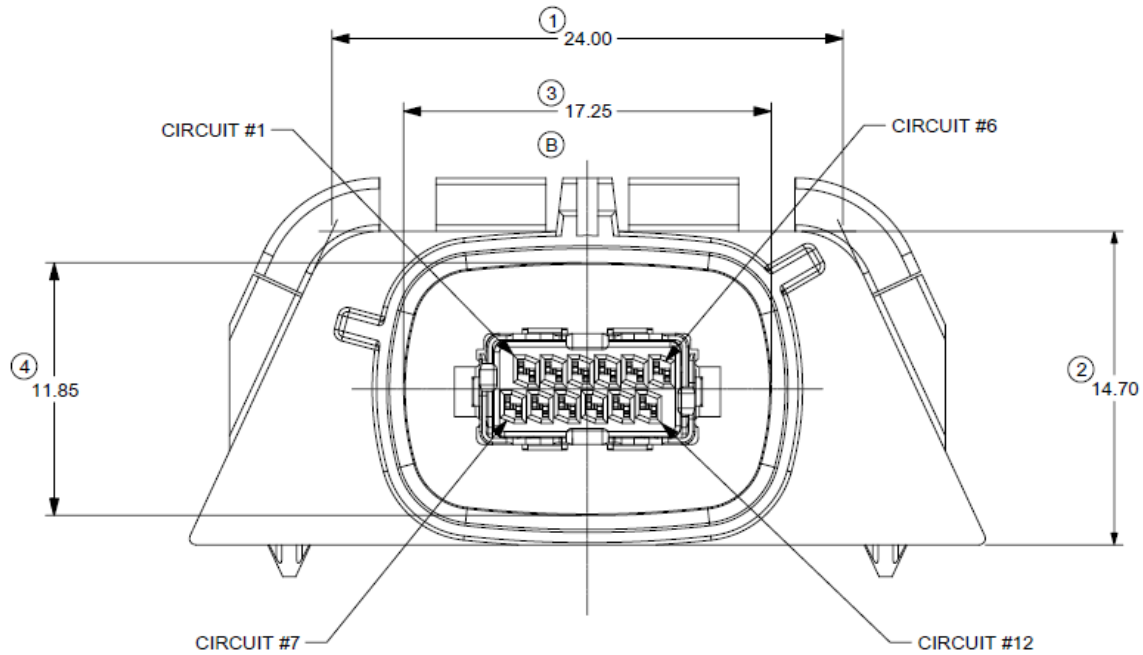


Figure 5: H-MTD and HSD connector order and coding

2.3 USB connectors



Pin #	Signal Name	Description	I/O/S	Comments
1	GND	Signal ground	G	Connected to PCB ground
2	USB3_CPM1/2_SSRXM	USB3_RX-	I/O	USB3.0 Super Speed Receive Negative
3	USB3_CPM1/2_SSRXP	USB3_RX+	I/O	USB3.0 Super Speed Receive Positive
4	GND	Signal ground	G	Connected to PCB ground
5	USB3_CPM1/2_SSTXM	USB3_TX-	I/O	USB3.0 Super Speed Transmit Negative
6	USB3_CPM1/2_SSTXP	USB3_TX+	I/O	USB3.0 Super Speed Transmit Positive
7	GND	Signal ground	G	Connected to PCB ground
8	USB3_CPM1/2_DP	USB3_D+	I/O	USB2.0 High Speed Data Positive
9	USB3_CPM1/2_DM	USB3_D-	I/O	USB2.0 High Speed Data Negative
10	USB3_CPM1/2_VBUS	USB3_VBUS	S	USB3_VBUS - Cable compensated voltage output
11	USB3_CPM1/2_VBUS	USB3_VBUS	S	USB3_VBUS - Cable compensated voltage output
12	USB3_CPM1/2_VBUS	USB3_VBUS	S	USB3_VBUS - Cable compensated voltage output
13	GND	Shield connection to signal ground	G	Connected to PCB ground

Table 13: USB connector pin-out

3. Equipment setup

3.1 PC Workstation prerequisites

- Windows 10 (any edition)
- Administrative access (for installation of software and running some applications).

3.2 Connectivity prerequisites

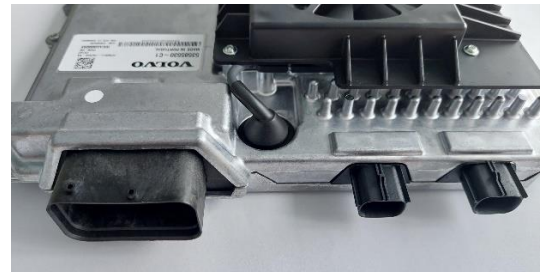
- Availability of Wi-Fi network to connect to
- Availability of Bluetooth devices to connect to (Android mobile phone recommended)

3.3 Device under test (DUT)

Several views of the ICM module are shown in Figure 6 below:



Top view



Back view

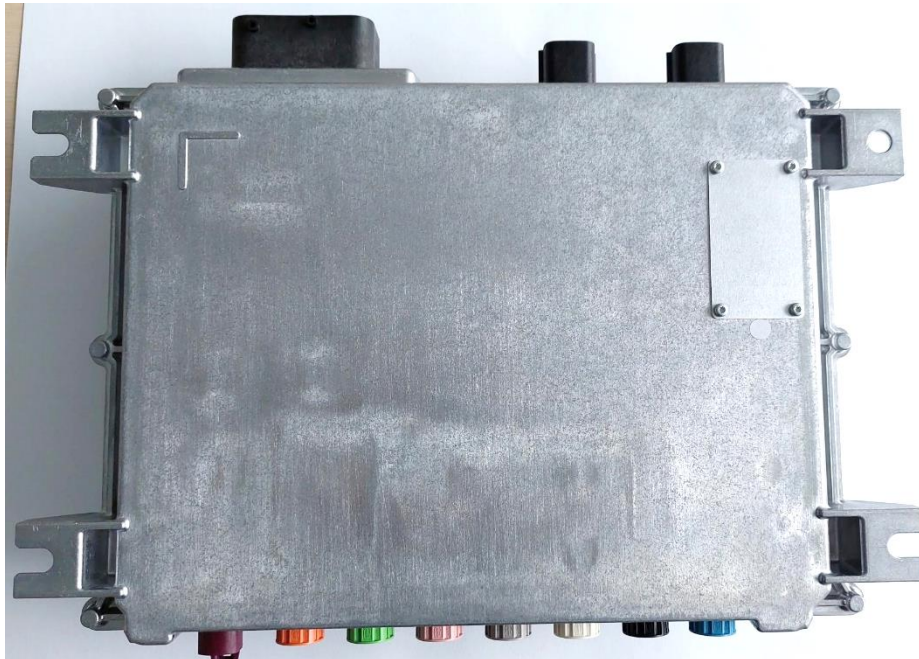


Front view

Figure 6: ICM views

The device does not have any user physical controls or buttons on the exterior; the only way to interact with it is through programming or debug interfaces.

The DUTs are equipped with debug connectors to facilitate control of the device during testing. The debug connection is protected by a small metal cover secured by four screws at the back of the device that needs to be removed.

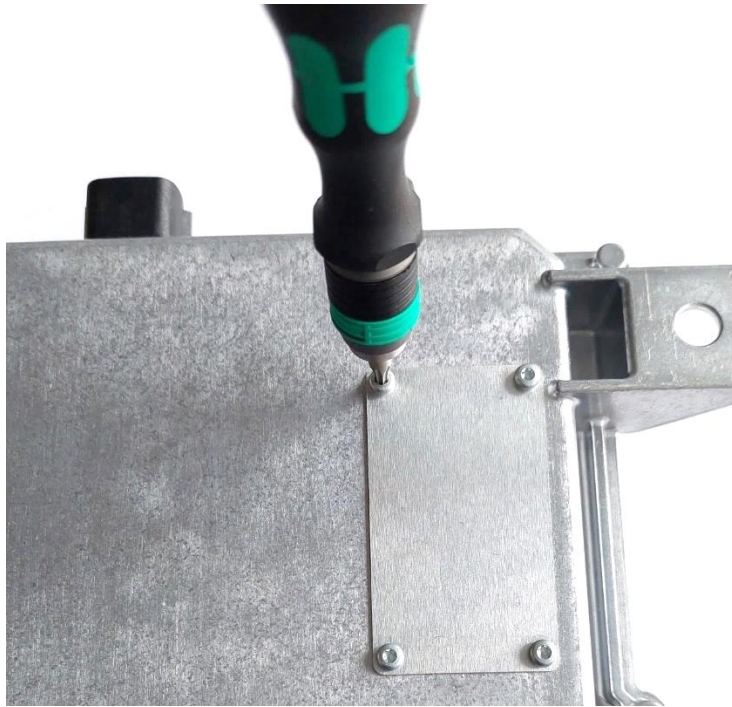


Note: this debug interface is not available for the serial production device. On the provided DUTs, it is used solely to facilitate device testing.

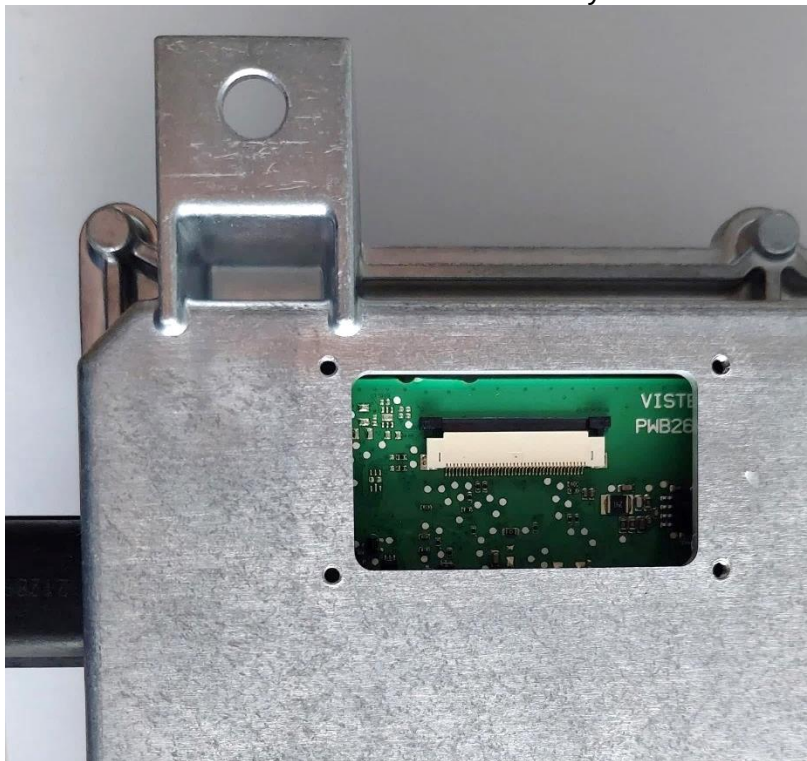
3.3.1 Removing the debug cover



Do not use power tools when removing or fitting the debug cover!

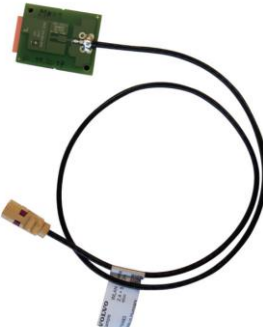
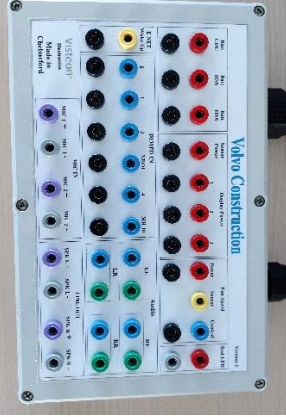


Unscrew the four small screws which attach the debug connector cover to the module. Use TX8 screwdriver or Torx L-key.



Remove the screws and the cover; keep them in a safe location in case they need to be fitted again.

3.4 Equipment list

 FAKRA to SMA adapter	 40-pin FFC cable	 AM/FM antenna base
 AM/FM antenna rod	 Wi-Fi / Bluetooth antenna	 USB 3.0 Type A cable, male-male
 AM/FM antenna cable	 ICM module	 Test box - terminated
 Engineering board	 Test box – standard	

Note: Power supply is not provided; 8-32V / 10A power supply required.

3.4.1 Test box - terminated

The terminated test box is used as a substitute for the vehicle harness to power up the DUT, and to terminate internally a number of interfaces (e.g. LIN, CAN, Ethernet, audio, among others).

The test box is powered through an external power supply (not provided) which should be capable of supplying at least 15A of current at 24V. Power supply terminals are in the front; connect the **red** to the **(+)** terminal of the PSU, and the **black** one to the **(-)** terminal.

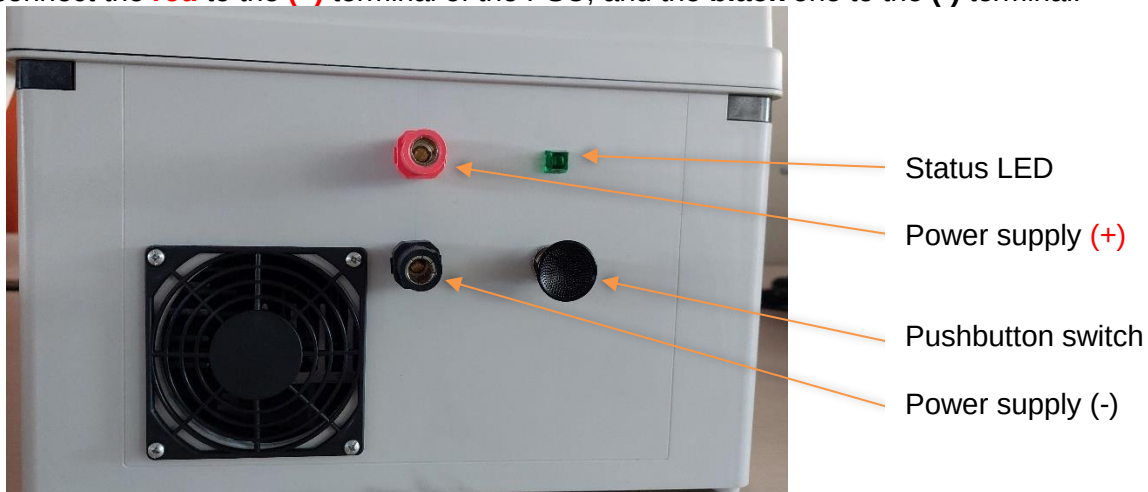


Figure 7: Terminated test box - Front

On the back, the test box features three groups of cables which connect to the DUT:

- Main connector harness
- High-speed connections (H-MTD, HSD, FAKRA)
- USB cables

Within each specific group, the cables are interchangeable; it doesn't matter on which compatible interface they are attached.

3.4.1.1 Power on pushbutton switch

The test box is equipped with a quick disconnect pushbutton at the bottom to enable emergency separation of all circuits within the test box, as well as the output to the DUT. When pulled, the test box is turned on (fan starts operation), and the main connector harness is energized.

To power on the DUT:

- Connect the power supply cords of the PSU to the test box.
- Adjust the PSU current and voltage settings as needed for the particular test (or use the nominal values in Table 1.

3.4.1.2 Status LED

The box is equipped with a green LED which is illuminated when the box is powered.

3.4.1.3 Fan

Due to the number of terminated peripherals inside, the test box needs to be ventilated to avoid heat buildup. A fan is installed on the top of the box, and a grille at the front is used as exhaust.

Power supply to the fan is separated from the supply delivered to the DUT.

Note: due to the way the test box is powered, the fan on the test box may turn off at undervoltage or overvoltage conditions, while the DUT remains powered. This does not affect the function of the DUT in any way.

3.4.2 Test box – standard

The standard test box that is used with the module is shown on Figure 8 below. The box is equipped with the main harness to connect to the DUT, as well as with a number of CAN/LIN connectors (not used for the purposes of radio certification testing and can be left unconnected). This box is suitable for tests which do not require termination of all module outputs; if termination of all ports are required, please use the terminated test box described in Section 3.4.1.



Figure 8. Test box - standard

To power up the module using the standard test box, connect the main harness cable to the DUT. Power needs to be supplied externally by a DC power supply (at the appropriate voltage setting), connected to the “Batt CDC” inputs. The plus of the power supply is connected to the **red** input, and the minus to the **black** one, correspondingly. There is normally no need to connect any of the other inputs and outputs for the purposes of radio certification testing.

The box does not have a power switch; output to the DUT is enabled automatically as soon as the DC power supply is connected.

If audio output is needed to confirm that a sound is playing, a 4 Ohm speaker can be connected to either of LF / RF / LR or RR outputs in the Audio section. The audio output can be triggered through an application on the module, see for example sections 5.7 and 5.9.

3.4.3 Engineering board

The engineering board is used to facilitate debug connection between the DUT and the workstation, and to control the module either through ADB commands (see section 4.5 for setup) or through virtual screen output (see section 5.3). In all tests which require intervention with the device, the engineering board must be connected.

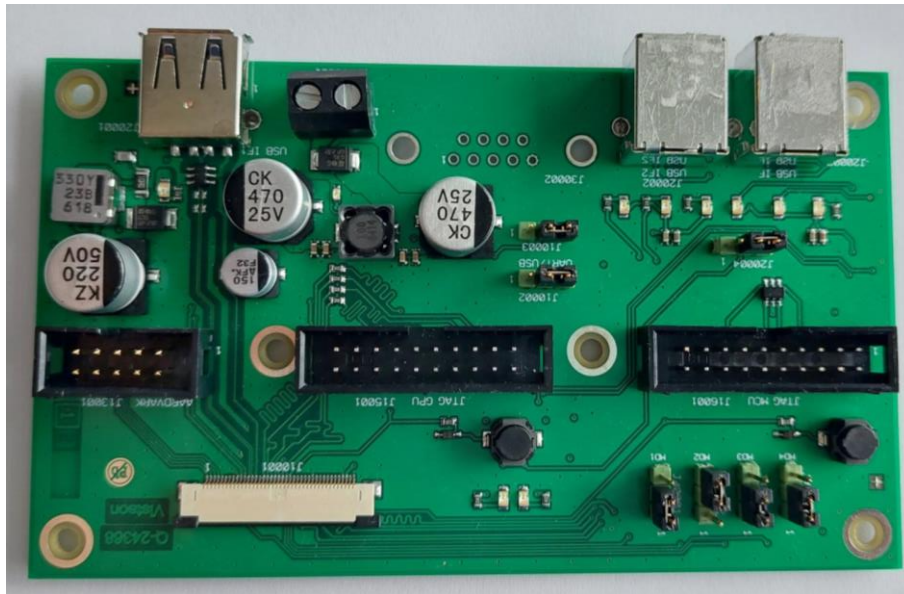


Figure 9: Engineering board

3.5 Test setup preparation

3.5.1 Overview

The setup is connected as follows:

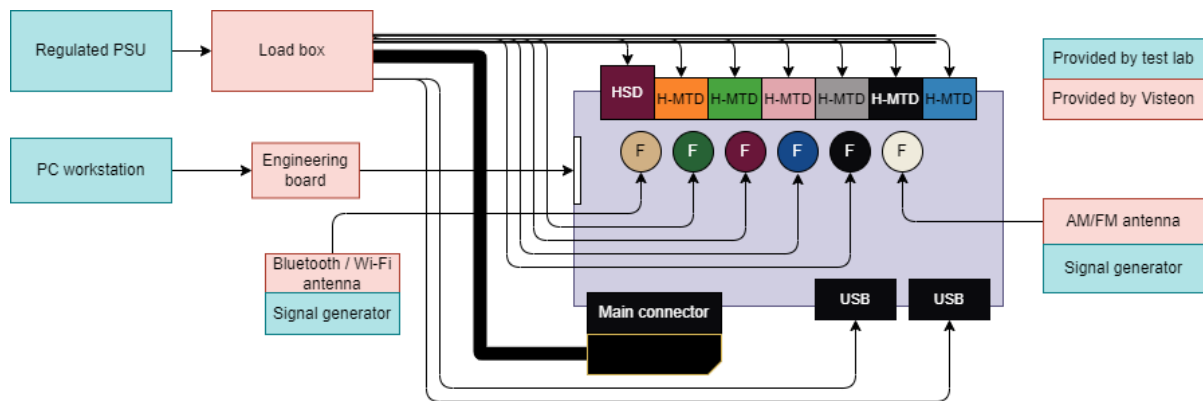
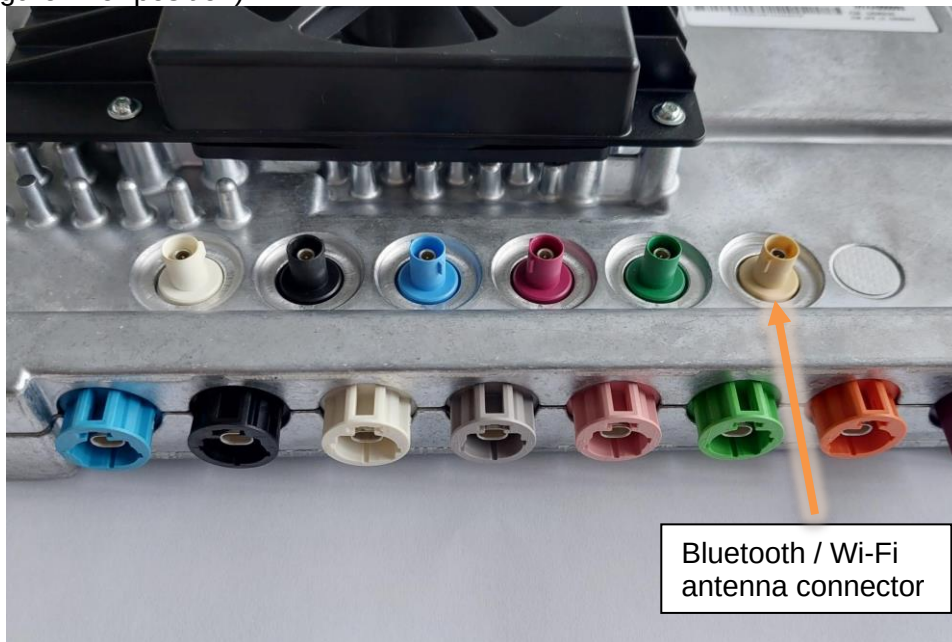


Figure 10: Test setup diagram

3.5.2 Connecting Wi-Fi antenna

- Connect the antenna to the DUT; antenna connector on the DUT is beige (coding I, see Figure 4 for position).

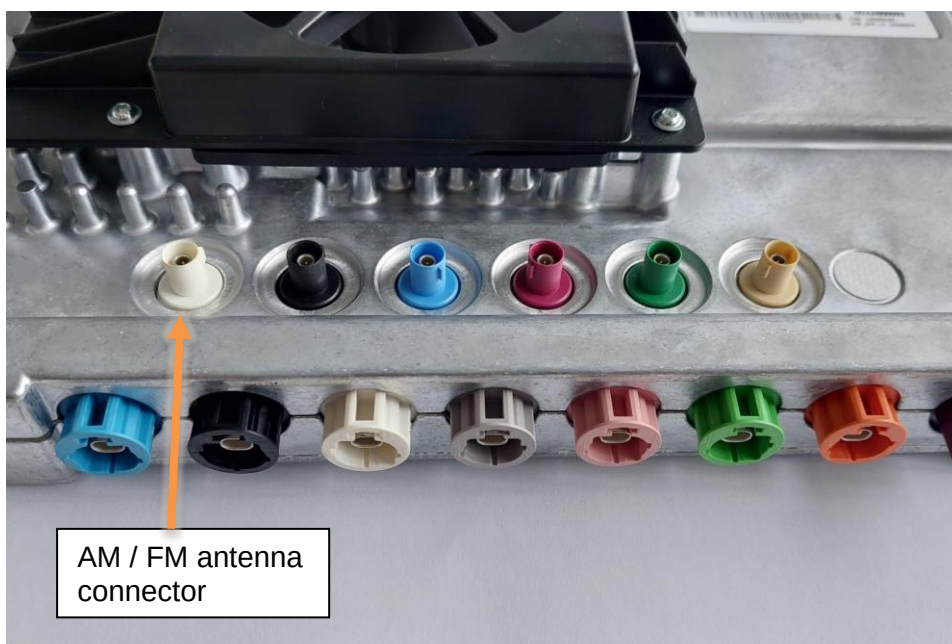


3.5.3 Connecting signal generator

- Attach the supplied FAKRA-to-SMA adapter on the requisite antenna port (either AM/FM or Wi-Fi/Bluetooth)
- Connect the signal generator through the SMA end of the adapter.

3.5.4 Connecting AM/FM antenna

- Assemble the antenna base to the rod.
- Connect the antenna cable to the antenna base from the side of the 90-angle FAKRA connectors.
- Connect the antenna to the DUT; antenna connector on the DUT is white (coding B, see Figure 4 for position).
-



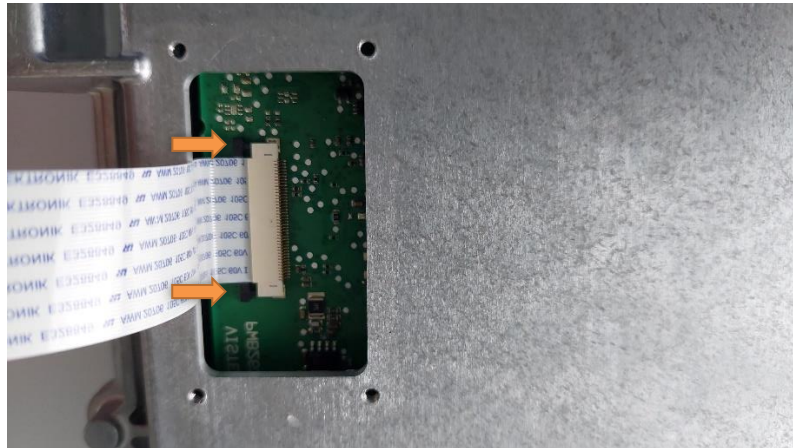
3.5.5 Connecting the engineering board



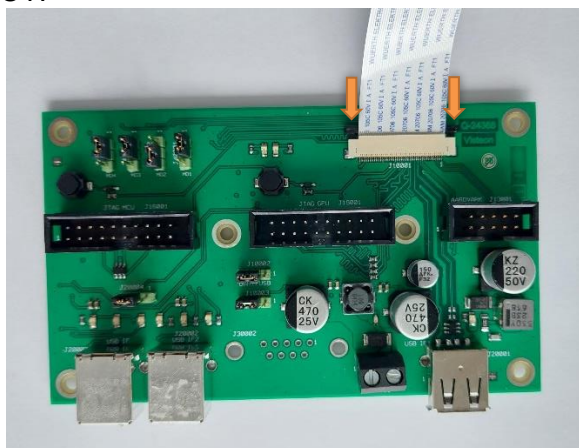
Never connect or disconnect the flat cable while the engineering board USB cable is connected to the workstation; this may damage the DUT irreversibly!

Always remove the USB cable from the engineering board before adjusting its connections.

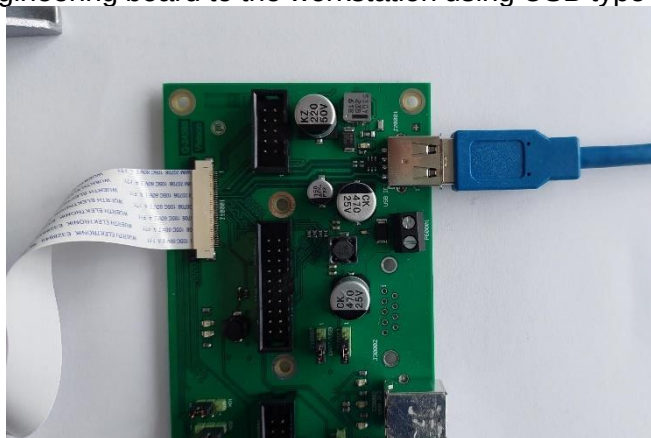
- Remove the debug cover from the DUT (section 3.3.1).
- Make sure the engineering board is disconnected from the PC workstation; detach the USB cable before proceeding (make sure the LEDs on the engineering board are off).
- Connect the flat cable to the DUT; make sure the cable is inserted all the way and is parallel to the connector.



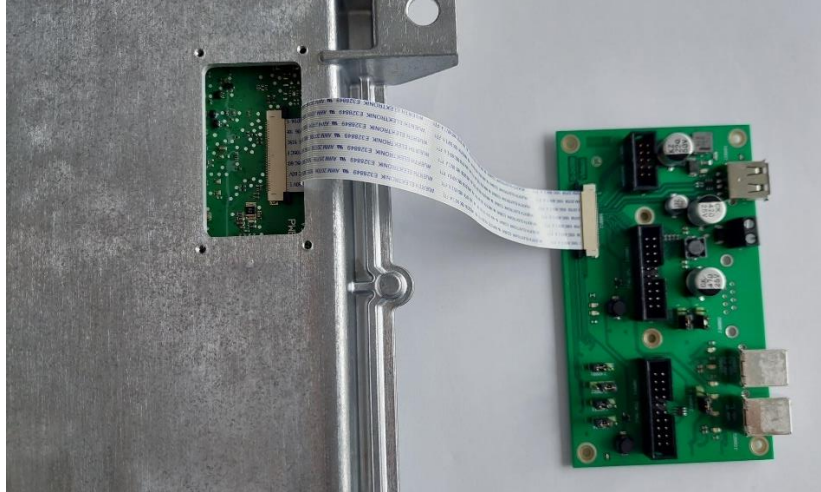
- Lock the cable in place using the black tabs (shown with arrows on the figure above) and tug gently the FFC to make sure the cable stays in place.
- Connect the flat cable to the engineering board. Lock the cable in place in the same manner as for the DUT.



- Connect the engineering board to the workstation using USB type A cable (male-male)



- The arrangement should now look something like this:



- Turn the DUT upside down so that it sits on the table on its legs.
- Connect the other end of the USB cable to the workstation. When the engineering board is connected to a powered-up workstation, several of its LEDs will be illuminated.

3.5.6 Connect the power supply

Connect the power supply to the test box (see section 3.4.1).

3.5.7 Connect the test box

- Connect the main harness coming out of the test box to the DUT. Make sure the harness connector is fully inserted and clamped into place.
- Connect the USB cables, H-MTD, HSD and FAKRA connections. Refer to section 3.5.1 for details.

3.5.8 Power up the setup

- Make sure all relevant peripherals for the test are connected:
 - Engineering board (section 3.5.5).
 - Test box
 - Antennas or signal generators
- Turn on and configure the external power supply to the desired voltage level.
- Enable output of the PSU to power up the setup
 - Test box fan should turn on, and the green LED should become illuminated
 - Fan of the DUT will start immediately, and will turn off after the DUT has booted completely.
- Wait approx. 20 seconds for the DUT to power up completely. DUT will not be responsive to ADB commands until the operating system fully boots.
- Verify that the DUT is accessible through the engineering board (section 4.5)

4. Pre-test: software configuration

The procedures in this section should be performed in preparation for the actual testing. It is strongly recommended that the configuration of the workstation be done well in advance of the actual testing, so that any IT-related issues can be resolved.

4.1 Install Qualcomm Radio Control Tool

Run the installer (QRCT4-setup.exe) and follow the installation instructions (requires administrative privileges).

Locate the BDF file and copy it from the source location to the following paths:

- C:\Windows\System32\drivers
- C:\Qualcomm\WCN\ProdTests\refDesigns\boardData

4.2 Install Qualcomm USB device driver

This tool installs the Qualcomm universal device driver to establish communication with the module.

- Extract the files from archive qud.win.1.1_installer_10060.1
- Run setup.exe and install the tool (requires administrative privileges)

4.3 Install QPST

- Extract the files from archive qpst.win.2.7_installer_00490.1
- Run QPST.2.7.490.1.exe and follow the installation instructions on the screen (requires administrative privileges)

4.4 Configure QPST

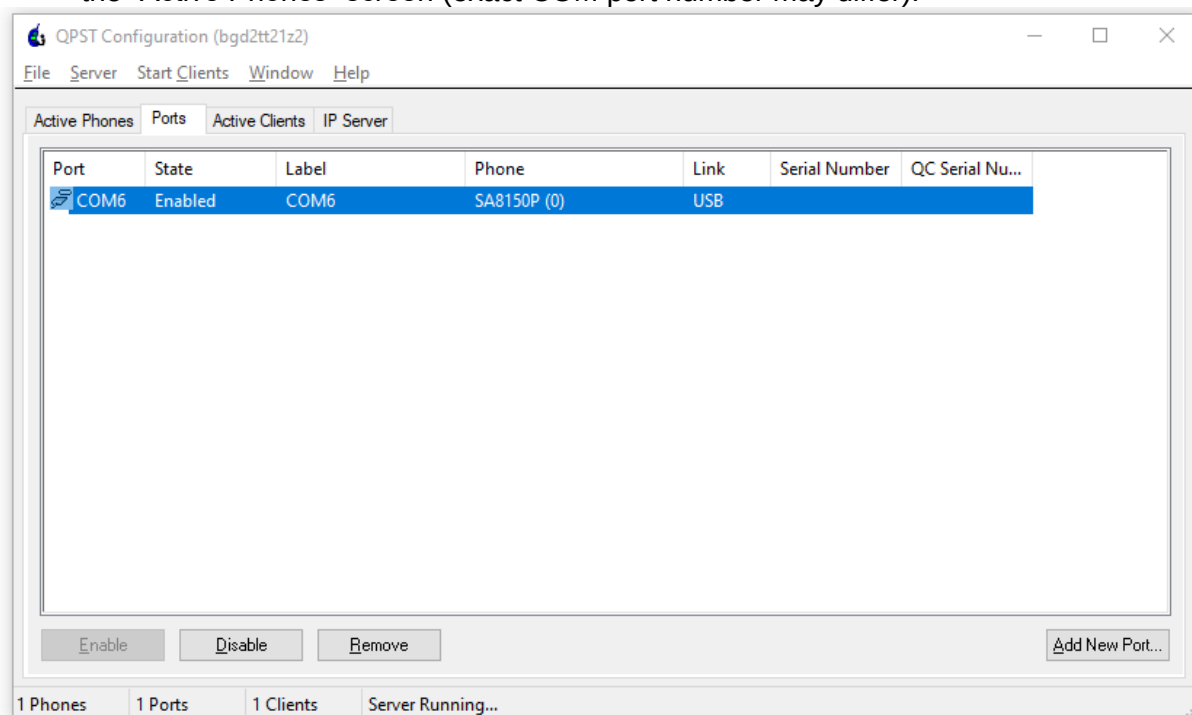
This procedure needs to be done only once; if there are no changes to the setup, the configuration should persist between testing sessions and workstation restarts.

Prerequisites

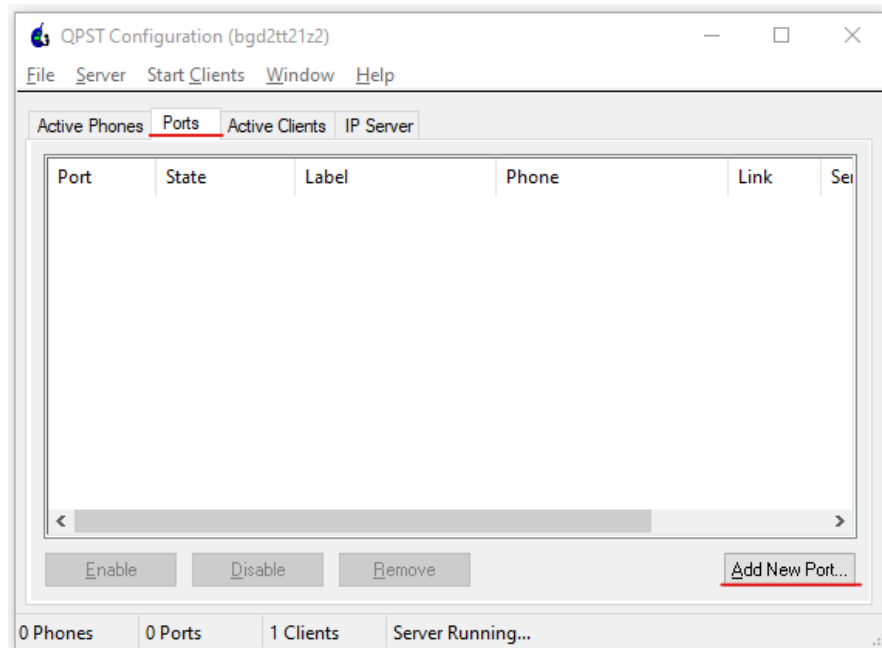
- Make sure the Qualcomm USB device driver is already installed (section 4.2)

Procedure

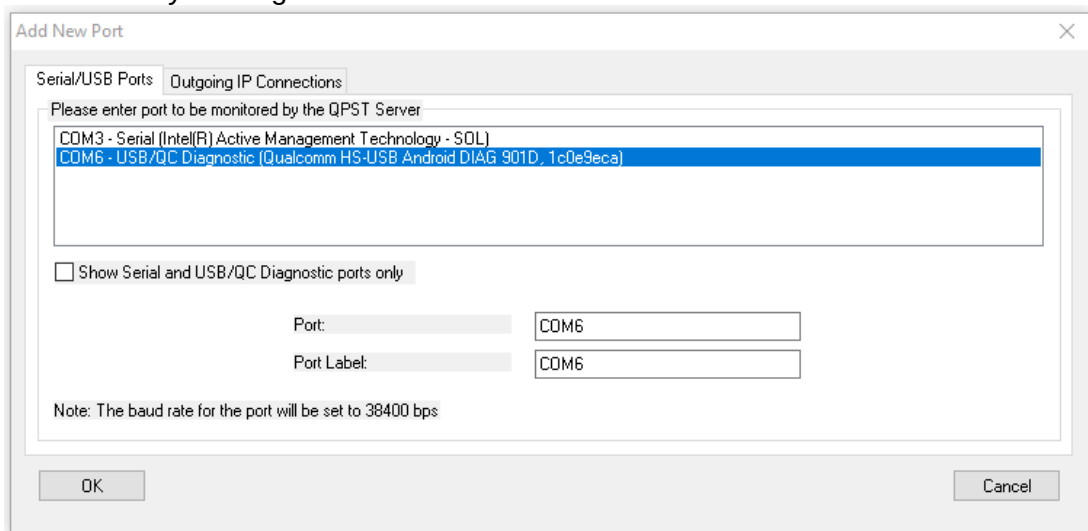
- Connect the engineering board to the DUT and then to the PC workstation (section 3.5.5)
- Connect the test box to the DUT (section 3.5.7).
- Connect the power supply to the test box (section 3.5.6).
- Power up the module through its test box.
- Wait ~30 seconds for the module to fully boot up.
- Confirm the module is up (section 4.5).
- Start the QPST application (in a default installation, it should have an entry in the Start menu).
- If the engineering board is connected, there may already be an auto-detected entry in the “Active Phones” screen (exact COM port number may differ):



- If the connection is not detected, or is removed for some reason, it can be added again
- In the application, go to the “Ports” tab, then click the button “Add New Port...” (see figure below)



- In the menu, select the entry “USB/QC Diagnostic” (exact COM port number may differ) and confirm by clicking OK.



4.5 Verify the DUT is connected and visible to the PC workstation

- Start command prompt shell (cmd.exe) on the workstation
- Switch directory to the installation folder of `scrcpy` (installation covered in section 4.6) where the executable `adb.exe` is located
- Issue the following command:

\$ `adb devices`

If the device is connected and recognized, the output would look something like the following (actual device ID may vary):

```
C:\ADB\scrcpy-win64-v1.24>adb devices
List of devices attached
36da61f0      device
```

If there is no device listed, make sure all equipment is properly connected and powered on as needed. Note that the DUT needs around 30 seconds to boot completely, and until then, ADB interface will not be available, and there will be no devices listed if the above command is issued.

4.6 Install screen copy (scrcpy)

Unpack the archive scrcpy-win64-v1.24.7z in a convenient location.

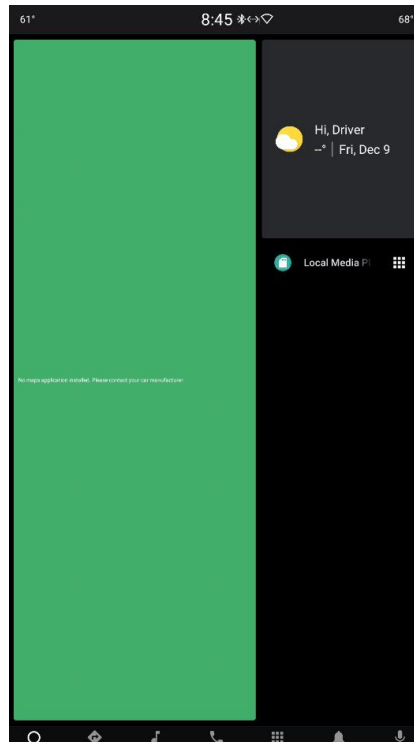
5. Operating procedures

Unless otherwise noted, the instructions assume that the complete setup is assembled and powered on. Refer to section 3.5.8 for the list of procedures for individual pieces of equipment.

5.1 Android menu navigation

The interface of the DUT features somewhat standard Android interface which should be mostly familiar to mobile phone users. Instead of touch, the interface is navigated through mouse, with limited support of gestures, such as long-press and drag.

After start, the DUT shows the standard Android home screen:



At the bottom, there are a few buttons, from left to right:



From left to right:

- **Main screen.** Returns to the main screen (shown above)
- **Navigation.** Not used.
- **Media.** Navigates to the local media player. May optionally be used for audio streaming.
- **Calls.** Opens the call interface (available when a Bluetooth device which supports calls is paired).
- **Grid.** Opens the apps menu
- **Notifications.** Opens the list of pending notifications. Not used.
- **Audio.** Not used.

5.2 Fan operation

The DUT is equipped with a fan which starts at every boot until the DUT can measure its own temperature. The fan may start and stop during operation (particularly stress testing and maximum power usage testing) unexpectedly when the temperature thresholds for the graphical CPU are exceeded.

5.3 Start screen copy (scrcpy)

Prerequisite: make sure scrcpy is already installed (section 4.6)

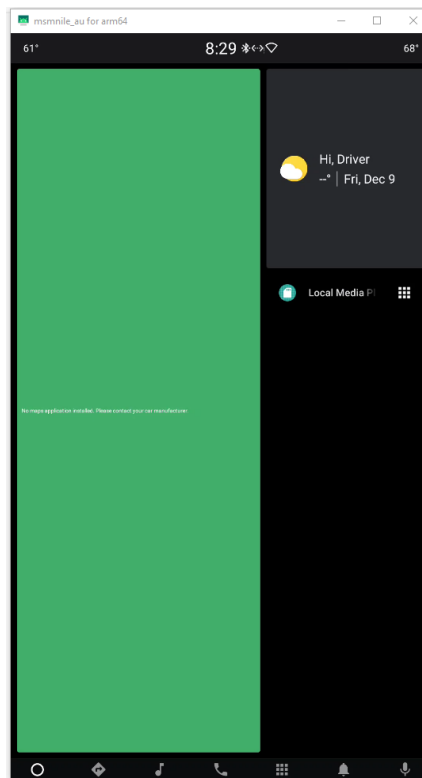
Procedure:

- Open a console and navigate to the installation folder of scrcpy (section 4.6)
- Issue the following command:

```
$ scrcpy
```

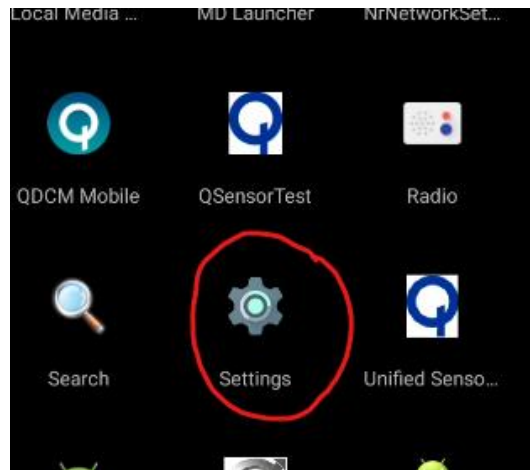
The screen copy interface will start in a separate window and will show the display output which would be obtained if a physical display is connected to the DUT.

The interface is based on Android operating system, and different menus can be navigated through use of the mouse instead of touch. Some gestures are recognized and intuitive: long-press mouse button is replicated as touch and hold, and mouse drag is also recognized within the appropriate context.



5.4 Connect to a wireless network

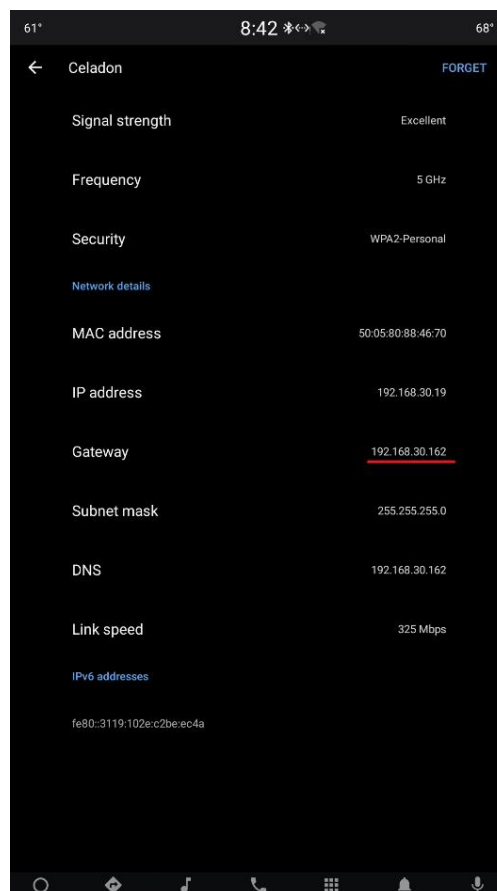
- Start screen copy (section 5.3)
- Go to the Apps menu (grid button at the bottom -- section 5.1)
- Locate and select the Settings app:



- Enable Wi-Fi (if disabled), and long-press to adjust the settings and connect to a network.
- If the antenna is connected, then there should be a list of Wi-Fi interfaces to connect to.
- Select and configure the network as appropriate.

5.5 Wi-Fi ping

- Connect to a Wi-Fi network (section 5.4)
- In the screen where the network is configured, click on the network name after the connection is established. This will open a window with details about the network connection.



- Record the gateway IP address (it will be different based on the network configuration). In the example above, the address is 192.168.30.162
- Open ADB console (section 4.5) and execute the following commands (replace the IP with the actual gateway address).

```
$ adb shell ping 192.168.30.162
```

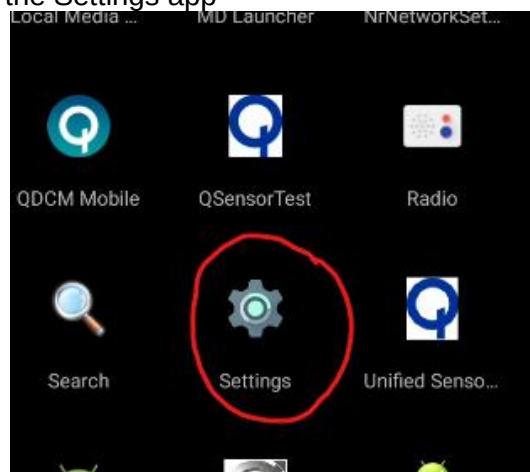
- The DUT will continuously ping the gateway until stopped.

Other IP addresses visible on the local network may be used, including DNS or locally resolved hostnames (e.g. google.com) if the network is configured appropriately.

5.6 Pair Bluetooth device

The DUT can pair over Bluetooth to consumer-grade mobile phones (both Android and Apple devices are supported, as well as others). The DUT supports both Bluetooth voice calls and Bluetooth audio streaming.

- Make sure the device you intend to pair over Bluetooth is turned on with Bluetooth enabled.
- Go to the Apps menu (grid button at the bottom – section 5.1)
- Locate and select the Settings app



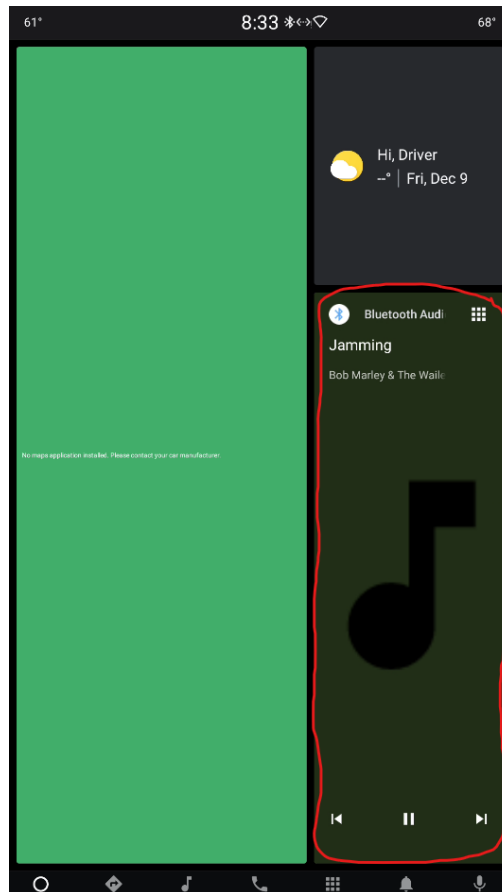
- Enable “Bluetooth” from the menu, if not enabled already.
- Long-press on the “Bluetooth” menu to open the Bluetooth menu with devices available to pair
- Make sure your device is paired.
- If your device is not paired yet, select the “Pair new device” entry and select your device from the list. You may need to confirm the pairing on both partner devices.

Your device should now be paired.

5.7 Start Bluetooth streaming

Prerequisite: Bluetooth-enabled device that supports Bluetooth streaming (e.g. mobile phone).

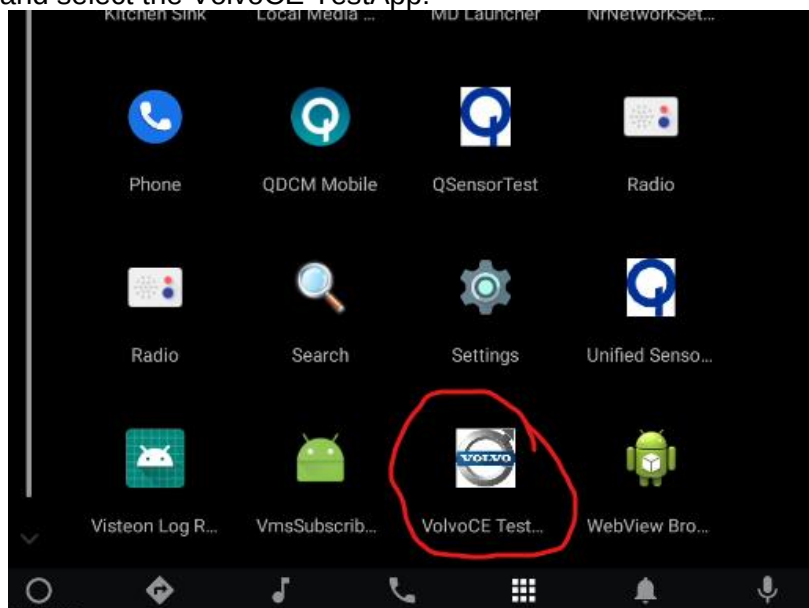
- Pair your Bluetooth (section 5.6)
- On the paired device, start an audio stream (from e.g. local media or online streaming service).
- On the main screen of the DUT, you should be able to access and control the audio:



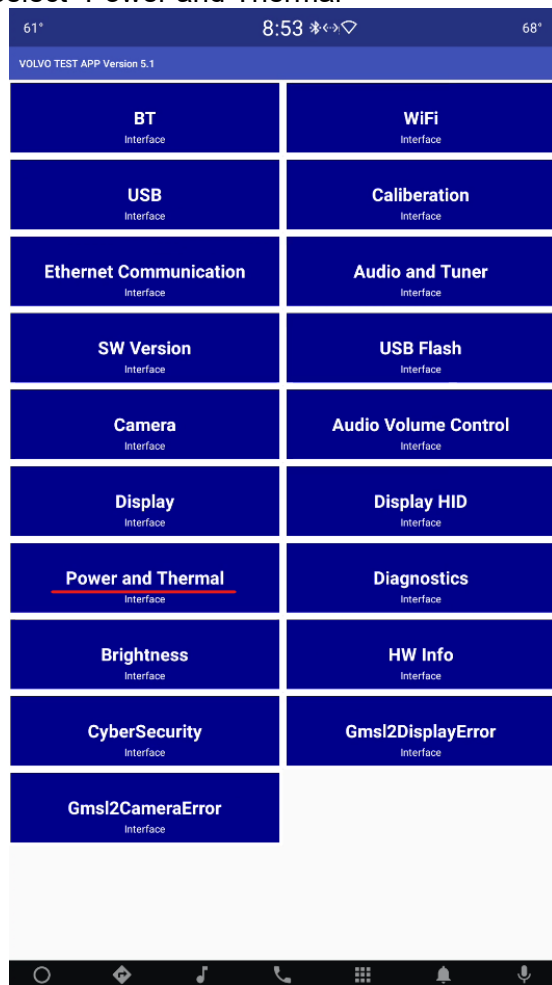
5.8 Artificial CPU load

On the DUT, there is an app installed to simulate different load levels of the CPU. This app can be used to load the CPU to specific discrete levels all the way up to 100% CPU load. Note that due to the increased load on the CPU, the fan is likely to start even at room temperature if the maximum load condition is maintained for a long time.

- Go to the Apps menu (grid button – section 5.1)
- Locate and select the VolvoCE TestApp:



- From the menu, select “Power and Thermal”



- In the Load-CPU section, select the “100% LOAD” radio button, and in the text field “Duration” write a large number, e.g. “10000” (milliseconds), then press the “SET” button. The text edit field label changes accordingly to represent the set duration. This represents the number of seconds the mode would be active. This can be changed at any time afterwards.

The screenshot shows the 'THERMAL' settings screen. At the top, there's a status bar with '61°' on the left, '9:01' in the center, and '68°' on the right. Below the status bar is a blue header with a back arrow and the word 'THERMAL'. The main content area is divided into two sections: 'LOAD- CPU' and 'LOAD- GPU'.

LOAD- CPU

Percentage	Radio Button	Label	Duration	Text Field	SET Button
50%	☐	LOAD	Duration=1	Enter	SET
60%	☐	LOAD	Duration=1	Enter	SET
70%	☐	LOAD	Duration=1	Enter	SET
80%	☐	LOAD	Duration=1	Enter	SET
90%	☐	LOAD	Duration=1	Enter	SET
100%	☒	LOAD	Duration=10000	Enter	SET

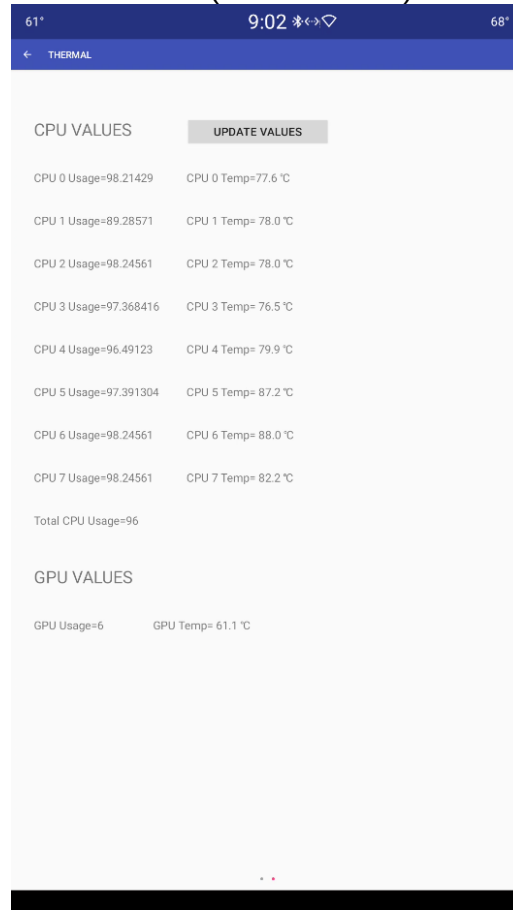
LOAD- GPU

GPU_TestCase	Range	Radio Button	Label
GPU_TestCase_1	20-30%	☐	LOAD
		☐	OFF
GPU_TestCase_2	30-40%	☐	LOAD
		☐	OFF
GPU_TestCase_3	40-50%	☐	LOAD
		☐	OFF
GPU_TestCase_4	60-70%	☐	LOAD
		☐	OFF

At the bottom of the screen, there are two small red dots, indicating a multi-page interface.

- Drag the screen right (or use the dot buttons at the bottom of the screens) to open the second page, where the current values of the load can be seen.

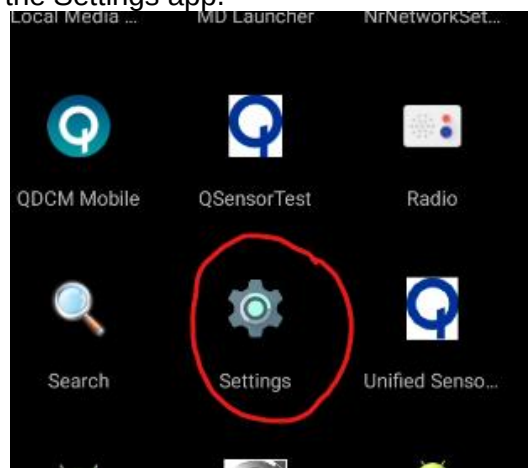
- Verify that the CPU load is correct (close to 100%) for the total CPU usage:



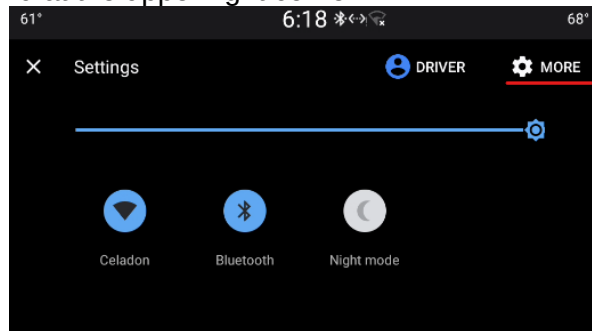
The CPU usage will revert to normal values without artificial load after the specified duration elapses.

5.9 Adjust Android audio volume

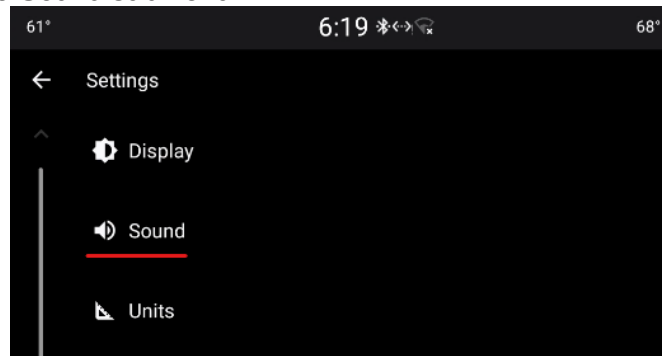
- Start screen copy (section 5.3)
- Go to the Apps menu (grid button at the bottom -- section 5.1)
- Locate and select the Settings app.



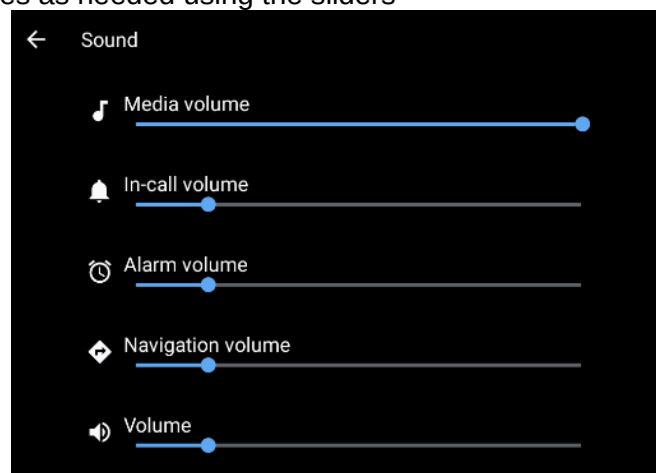
- Select the More menu at the upper right corner:



- From there, go to Sound submenu



- Adjust the volumes as needed using the sliders



5.10 Worst-case operating mode

This test exercises all peripherals of the DUT. A number of interfaces are loaded by default when connected to the test box (display power, display communication, USB charging, Ethernet ports, cameras, CAN, LIN).

The Wi-Fi interface is exercised through continuous pinging on the local network.

5.10.1 Audio output

Speaker outputs are connected, but not loaded by default. To load them to maximum output power, an audio file containing 1 kHz sinewave signal is provided (SINE_1_kHz_S0.85_SR48000_24bit.wav). This file is streamed through Bluetooth, which exercises both the speakers output as well as the Bluetooth interface itself.

The length of the file is 10 minutes; enable loop playback on the paired Bluetooth device to ensure the audio is played continuously.

5.10.2 Test procedure

Prerequisite: Load the sinewave signal on a Bluetooth device (e.g. mobile phone) that will be used during the test.

- Attach all the periphery cables of the test box to the DUT.
- Power on the test setup
- Start Wi-Fi pinging (section 5.5)
- Pair a Bluetooth device (section 5.6)
- Turn up DUT volume all the way up for all volume groups (section 5.9). **Note:** volume settings are not persisted across device reboots.
- On the paired device, start streaming the sine signal. Since there is no audible noise, monitor the power supply output for a considerable jump in current consumption to ensure the load is correctly applied.
- Make sure paired device Bluetooth volume is turned all the way up, as well as within the playback application on the paired device.

The DUT is now consuming maximum power.

5.11 DisplayPort link speed update

The module has a DisplayPort interface which has link speed in the high GHz range. In order to prevent the DUT from emitting the carrier frequency (8.1 GHz), the link speed of the interface needs to be configured.

This configuration must happen every time the device is booted, and is only necessary when EMC and RF testing is being conducted.

Execute the following test steps:

- Start command prompt shell (cmd.exe) on the workstation
- Switch directory to the installation folder of scrcpy (installation covered in section 4.6) where the executable adb.exe is located
- Wait until the device is fully booted (around 30 seconds)
- Make sure the device is fully booted (run scrcpy, section 5.3)
- Execute the following commands in the shell:

```
$ adb root
$ adb shell
# mount -t debugfs debugfs /d/
# cat /d/drm_dp/dp_debug
```

You should see the following output from the last command:

```
state=0xa5
link_rate=810000
num_lanes=4
resolution=1280x720@60Hz
pclock=74250KHz
bpp=24
test_req=DS_PORT_STATUS_CHANGED
lane_count=4
bw_code=30
v_level=0
p_level=0
```

- Execute the following commands in the shell:

```
# echo 0 > /d/drm_dp/hpd
# i2cset -f -y 11 0x40 0x70 0x74 0x14 i
# echo 1 > /d/drm_dp/hpd
```

```
# cat /d/drm_dp/dp_debug
```

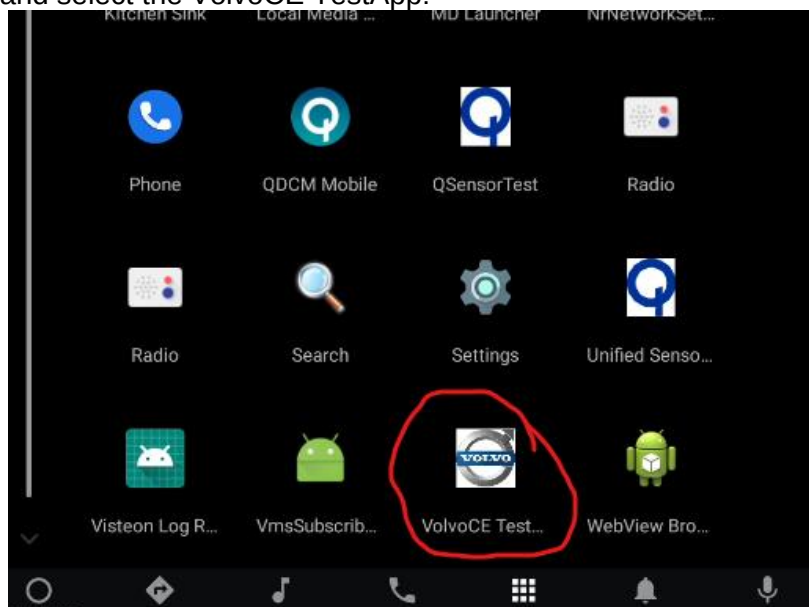
You should see the following output from the last command (note the different link rate speed in the second row):

```
state=0xa5
link_rate= 540000
num_lanes=4
resolution=1280x720@60Hz
pclock=74250KHz
bpp=24
test_req=DP_LINK_STATUS_UPDATED
lane_count=4
bw_code=20
v_level=0
p_level=0
```

- Close the shell window.

5.12 Tuner set-up

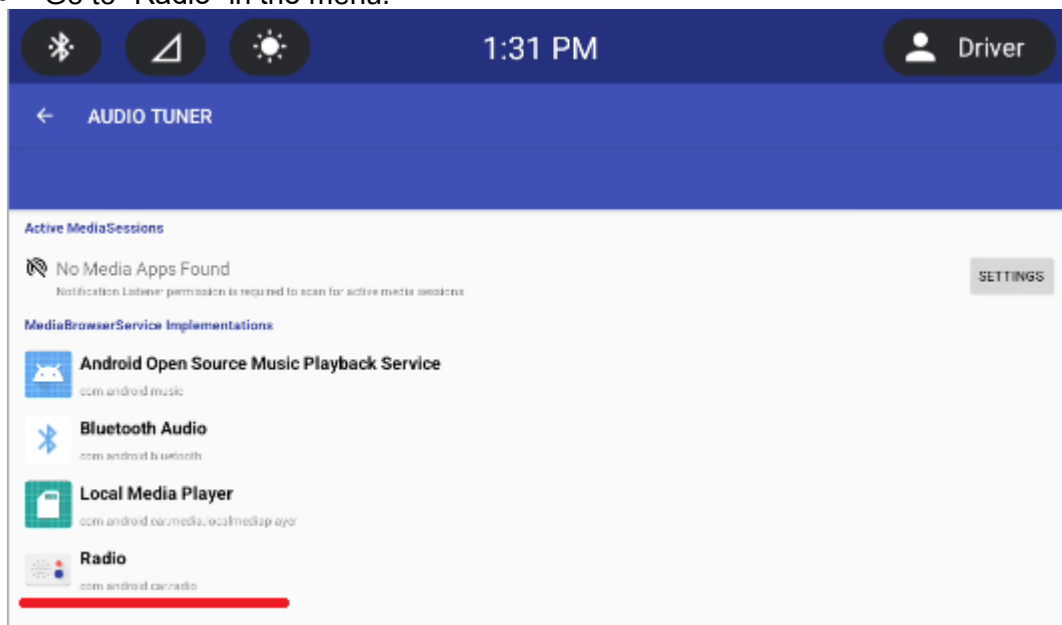
- Go to the Apps menu (grid button – section 5.1)
- Locate and select the VolvoCE TestApp:



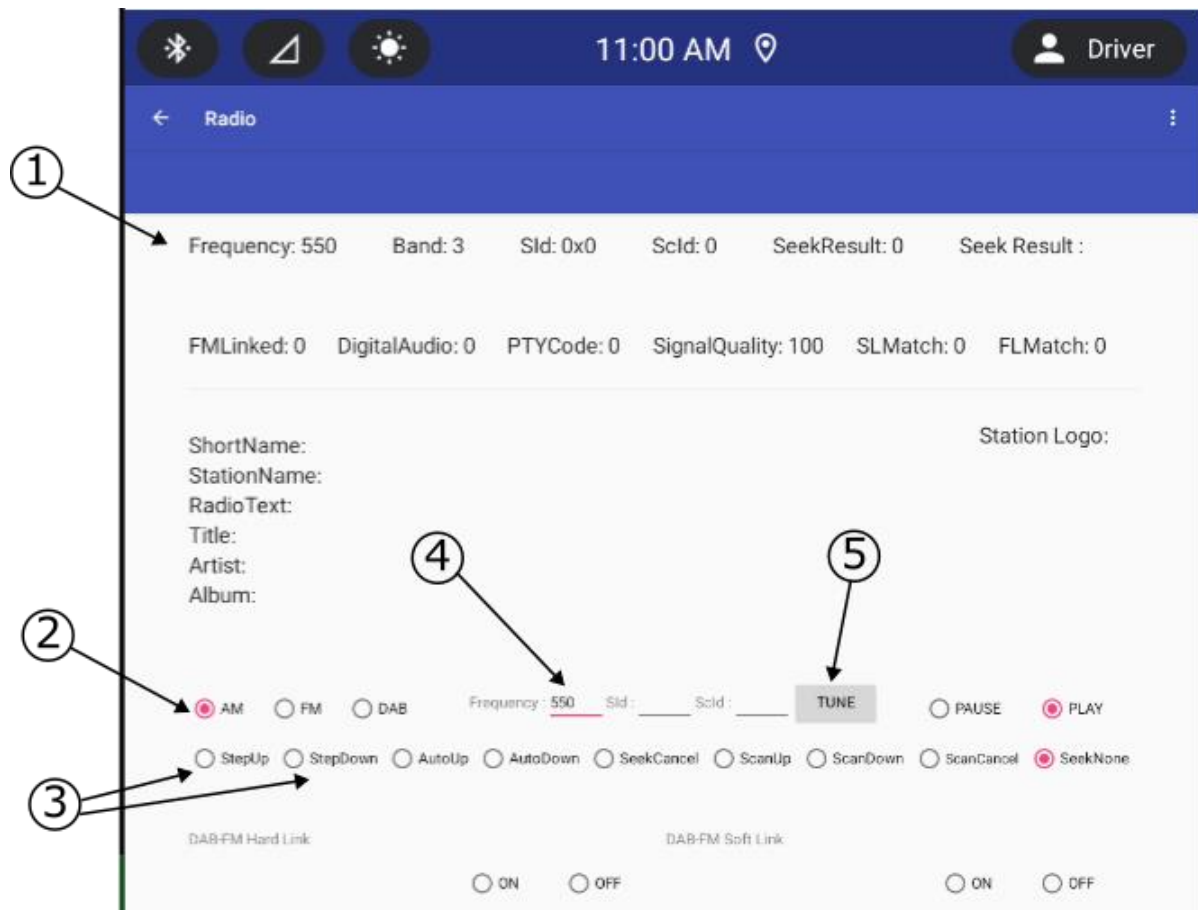
- From the menu, select “Audio and Tuner”



- Go to “Radio” in the menu.



- The Tuner interface is now opened.



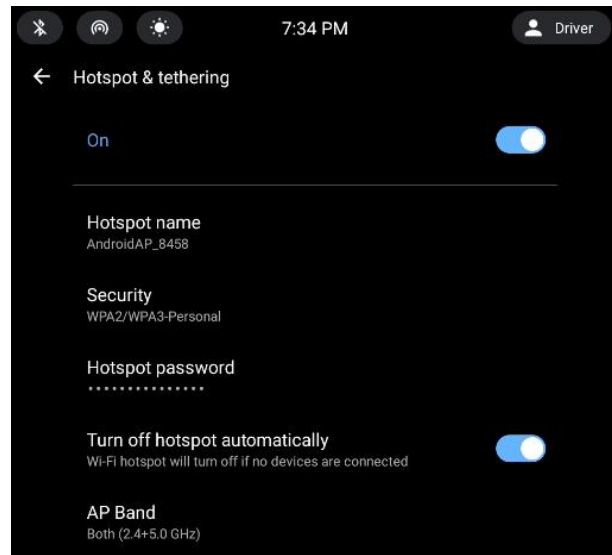
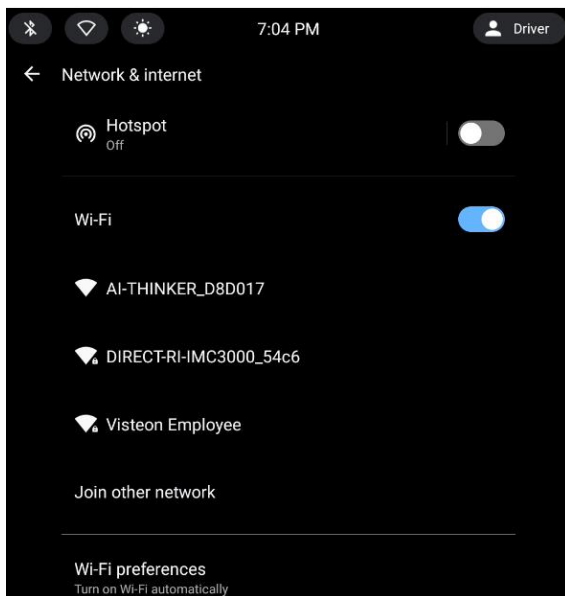
The relevant UI elements are as follows:

- (1) This label shows the currently tuned frequency (in kHz for both AM and FM)
- (2) These controls allow switching between AM and FM, and also to start playing the radio broadcast.
- (3) *StepUp* and *StepDown*. These buttons can be used to manually step up and down within the selected frequency band. The size of the step is region-specific.
- (4) In this input field, the exact frequency for tuning can be specified (in kHz in both for FM and AM)
- (5) When the frequency is manually specified in (4), with this button the tuner can be directed to tune it directly.

5.13 Enable Wi-Fi Hotspot (access point mode)

The module supports Wi-Fi access point (AP) mode, which in the software is called “Hot Spot”. This is enabled through the Wi-Fi menu (see section 5.4).

When the AP mode is activated through the interface, the AP access can be set up as needed: hotspot name and password, type of security protocol (WPA2/WPA3) as well as the band (2.4 GHz, 5 GHz or both), are all configurable.



5.14 Setting Wi-Fi regulatory region

During compliance testing (section 0), the channel and transmitted power (TX) can be freely set as needed to perform the testing. However, in normal mode, the Wi-Fi chip obeys the regulations for the currently set region (available channels for transmission and allowed maximum TX power).

Follow the instructions below in order to verify and change the regulatory region.

- Configure and power up the setup (section 3.5.8) and make sure the ADB connection is available (section 4.5).
- Make sure the Wi-Fi module is enabled (see section 5.4); do not connect to a network, just leave Wi-Fi enabled.
- Start the console (cmd.exe) and issue the following commands:

```
$ adb root
$ adb shell
# iw reg get
```

- The system will report the currently set region (in the form two-letter ISO-3166-1 alpha-2 code), as well as the available bands and maximum TX power. The input would be similar to what is shown below:

```
global
country 00: DFS-UNSET
    (2402 - 2472 @ 40), (6, 20), (N/A)
    (2457 - 2482 @ 20), (6, 20), (N/A), AUTO-BW, PASSIVE-SCAN
    (2474 - 2494 @ 20), (6, 20), (N/A), NO-OFDM, PASSIVE-SCAN
    (5170 - 5250 @ 80), (6, 20), (N/A), AUTO-BW, PASSIVE-SCAN
    (5250 - 5330 @ 80), (6, 20), (0 ms), DFS, AUTO-BW, PASSIVE-SCAN
    (5490 - 5730 @ 160), (6, 20), (0 ms), DFS, PASSIVE-SCAN
    (5735 - 5835 @ 80), (6, 20), (N/A), PASSIVE-SCAN
    (57240 - 63720 @ 2160), (N/A, 0), (N/A)

phy#0 (self-managed)
country GB: DFS-ETSI
    (2402 - 2482 @ 40), (N/A, 20), (N/A), AUTO-BW
    (5170 - 5250 @ 80), (N/A, 23), (N/A), NO-OUTDOOR, AUTO-BW
    (5250 - 5330 @ 80), (N/A, 23), (0 ms), NO-OUTDOOR, DFS, AUTO-BW
```

```
(5490 - 5730 @ 160), (N/A, 30), (0 ms), DFS, AUTO-BW
(5735 - 5875 @ 80), (N/A, 14), (N/A), AUTO-BW
```

In this particular case, the region is set to UK (country code: GB), and the requisite bands and other settings, such as max bandwidth supported (after the @ sign), and the maximum TX power (the number in the second set of parentheses in the output). At the end, there are additional flags and restrictions of use where applicable, for example DFS and NO-OUTDOOR.

- If the regulatory region needs to be changed, the following command should be used:

```
# iw reg set XX
```

where X is the two-letter ISO 3166 alpha-2 country/territory code (e.g. DE for Germany). If the code is correct, the system will not provide any output.

- After changing the region, wait at least 1 minute without powering off the device so that the Wi-Fi chip can reinitialize with the updated configuration.
- Verify that the region has been correctly set by checking the region:

```
# iw reg get
```

6. Compliance testing set up

Perform the DisplayPort link speed reconfiguration (section 5.11). This step must be performed every time the device is rebooted as a prerequisite for EMC and RF testing.

Execute the following commands in an ADB shell:

```
$ adb root && adb remount
$ adb shell rmmod wlan
$ adb shell insmod /vendor/lib/modules/qca_cld3_qca6174.ko con_mode_ftm=5
$ adb shell ifconfig wlan0 up
$ adb shell ftmdaemon -n -dd
```

The last command does not return to the shell immediately. Do not close or terminate the command prompt while testing is ongoing.

Open QRCT application – (normally located in C:\Program Files (x86)\Qualcomm\QDART\QRCT4\qrct.exe)

Select COM port menu and wait for ports to be discovered, then select it and click Connect when one appears in the list.

Connection to the Bluetooth/Wi-Fi chip is now established.

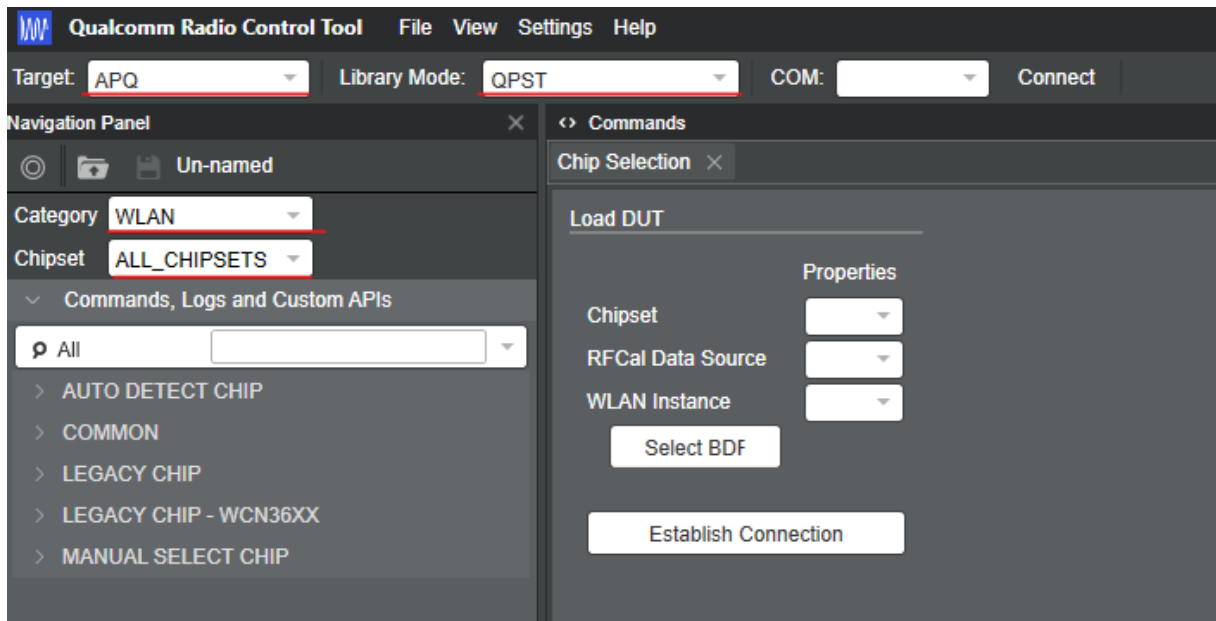
Note: The Bluetooth/Wi-Fi chip does not support simultaneous emission in both Bluetooth and Wi-Fi. This is limitation of the IC itself; in a specific instant in time, it transmits either Bluetooth or Wi-Fi signals, but not both.

Note: During compliance testing, at rare instances the interface between QRCT and the DUT may fail; in this case, the application must be restarted and the last test repeated again. In the QRCT application, select target APQ and Library Mode QPST,

6.1 Compliance testing for Wi-Fi

Note: In compliance mode, the DUT will be unable to connect to wireless networks. The device needs to be power cycled to resume normal operating mode for the Wi-Fi IC.

In QRCT, set category to WLAN, Chipset to “ALL_CHIPSETS”.



Go to “Commands, Logs and Custom APIs” menu on the right, and choose “Manual Select Chip” → “Chip Selection”.

Select QC6174 for the chipset, RFCAL Data Source is set to “File”, and WLAN instance is “inst0”.

Click the Select BDF file button and locate the BDF file which was copied when the QRCT tool was installed (C:\Qualcomm\WCN\ProdTests\refDesigns\boardData). Click Establish Connection button to link to the QCA6174 chipset.

6.1.1 Transmission settings

From the menu “Commands, Logs and Custom APIs”, go to “Manual Select Chip” and choose “TX”. Configure the desired transmission settings and click “Set TX On”.

Transmitter settings for 2.4 GHz and 5 GHz ranges are shown on Figure 11 and Figure 12, respectively.

On the figures, the settings that shall be adjusted by the test lab are shown in **red**; these settings are specific to the individual frequency band, channel, and transmission mode.

The settings in **blue** must be set as shown for all tests within the respective range (2.4 GHz or 5 GHz).

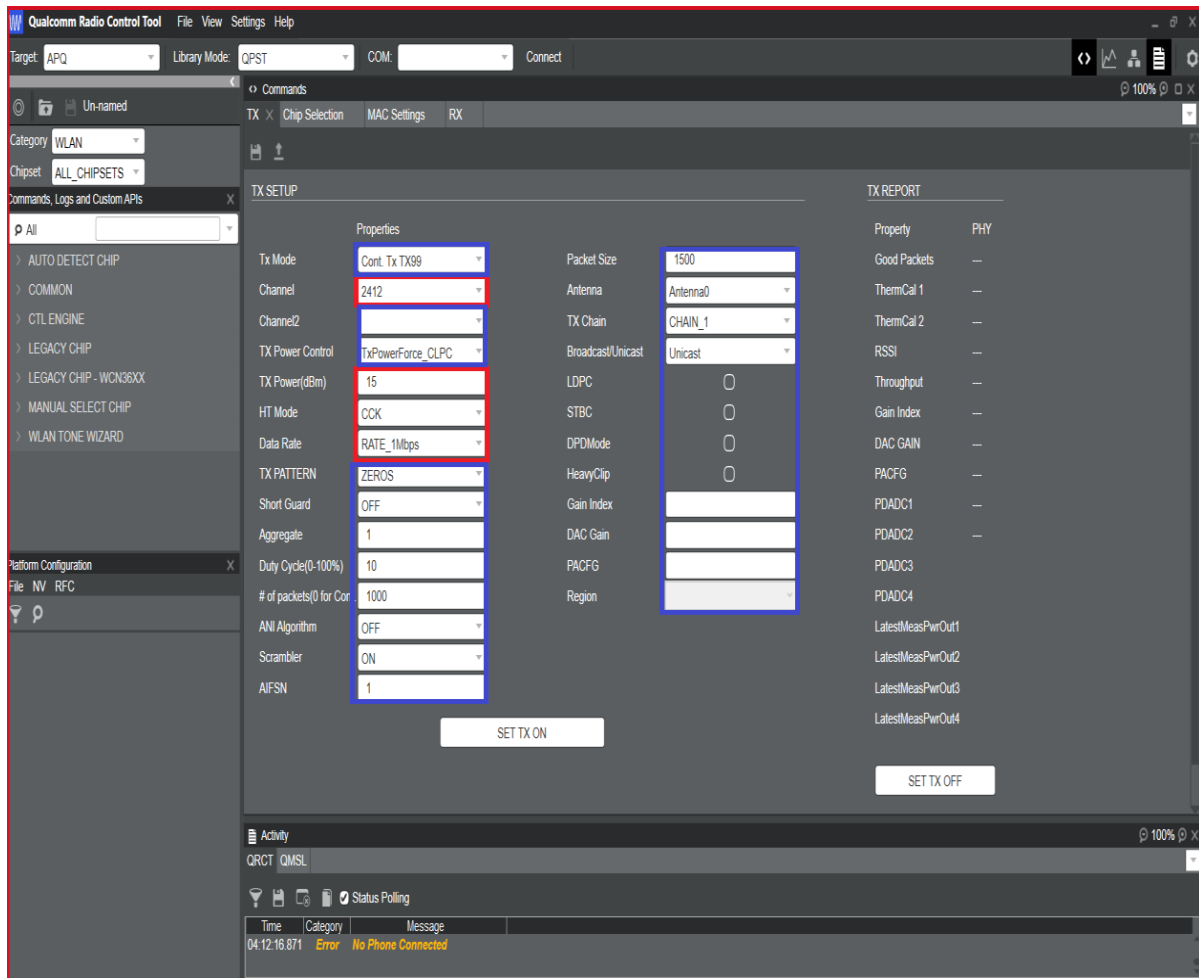


Figure 11. Transmitter settings - 2.4 GHz

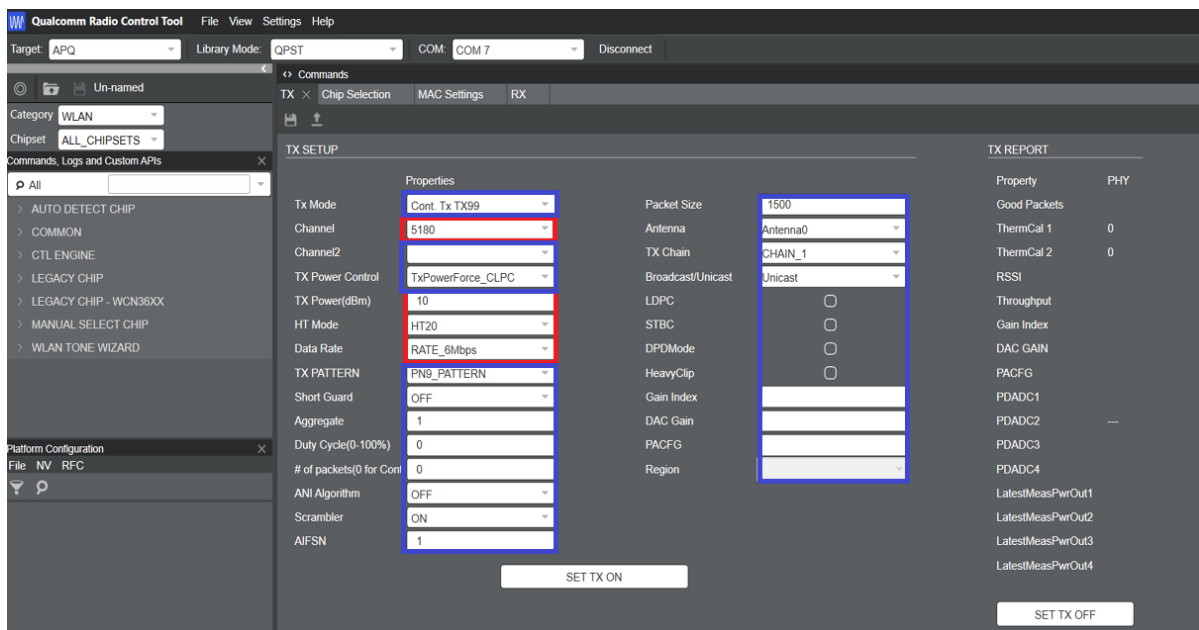


Figure 12. Transmitter settings - 5 GHz

6.1.2 Receiver settings

From the menu “Commands, Logs and Custom APIs”, go to “Manual Select Chip” and choose “RX”. Configure the desired transmission settings and click “Set Cont. RX”.

Receiver settings for 2.4 GHz and 5 GHz ranges are shown on Figure 13 and Figure 14, respectively.

On the figures, the settings that shall be adjusted by the test lab are shown in **red**; these settings are specific to the individual frequency band, channel, and transmission mode.

The settings in **blue** must be set as shown for all tests within the respective range (2.4 GHz or 5 GHz).

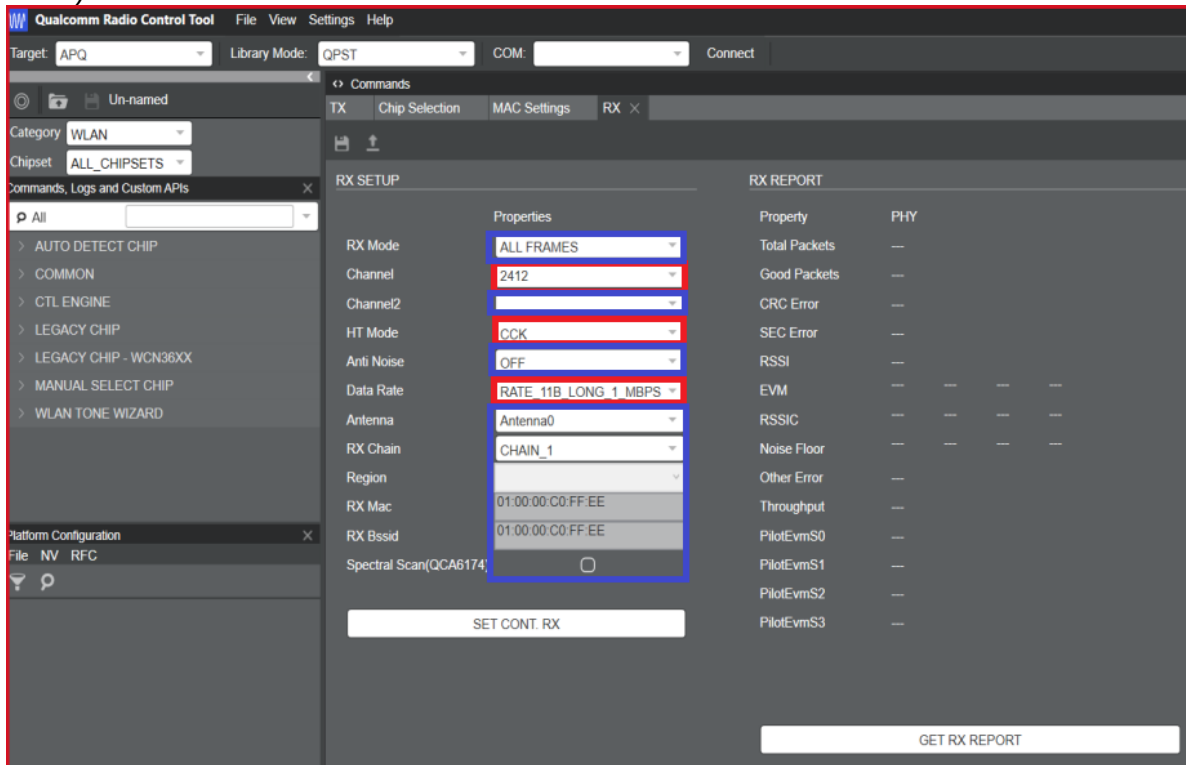


Figure 13. Receiver settings - 2.4 GHz

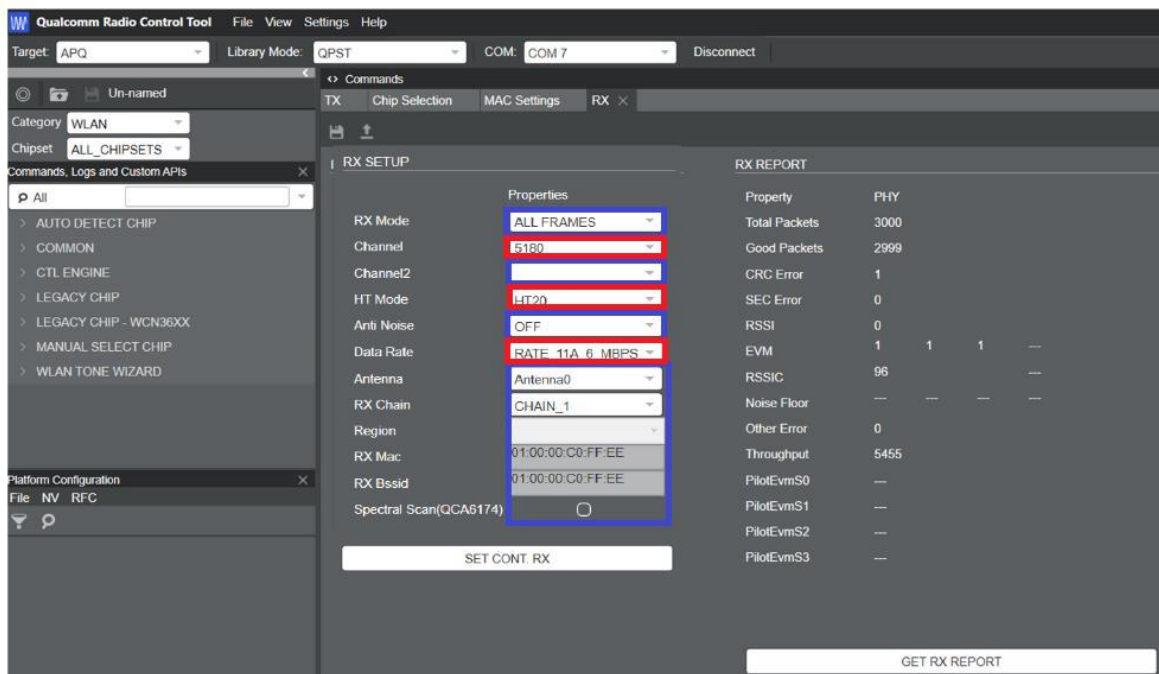
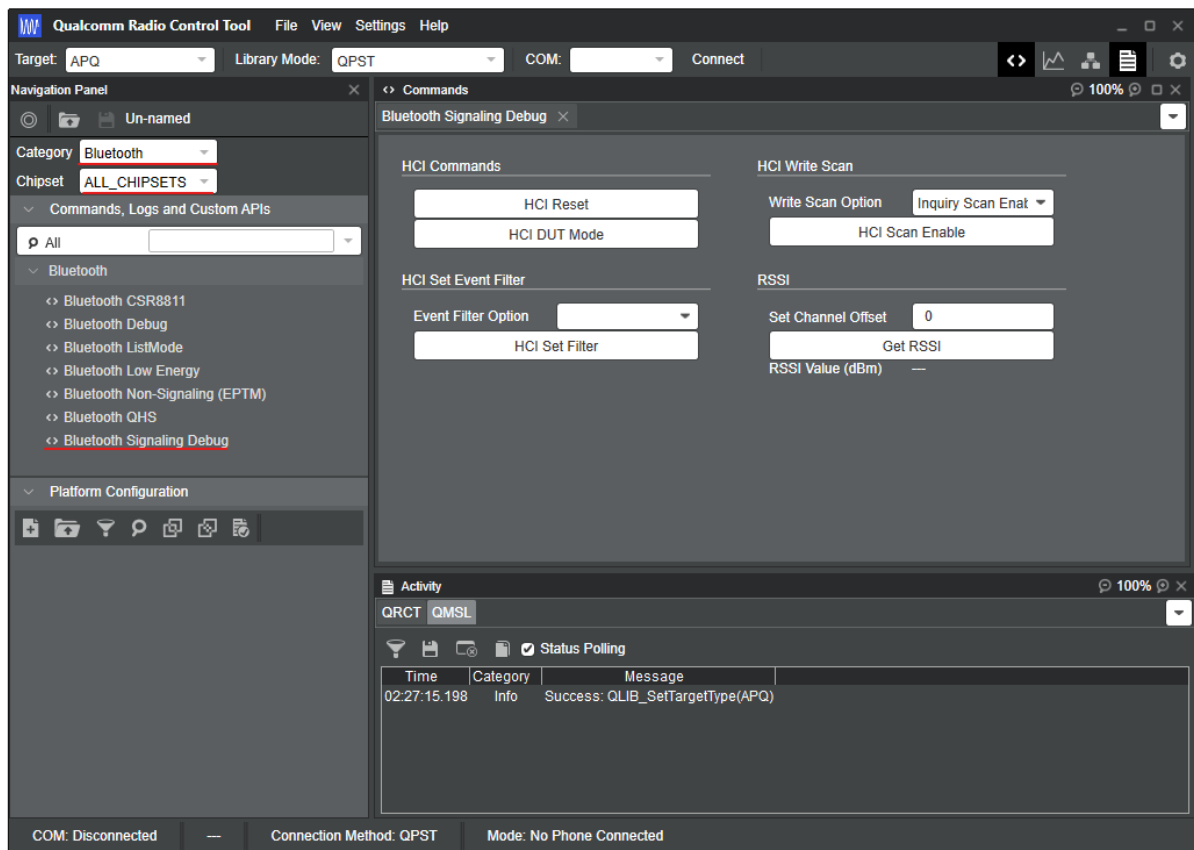


Figure 14. Receiver settings - 5 GHz

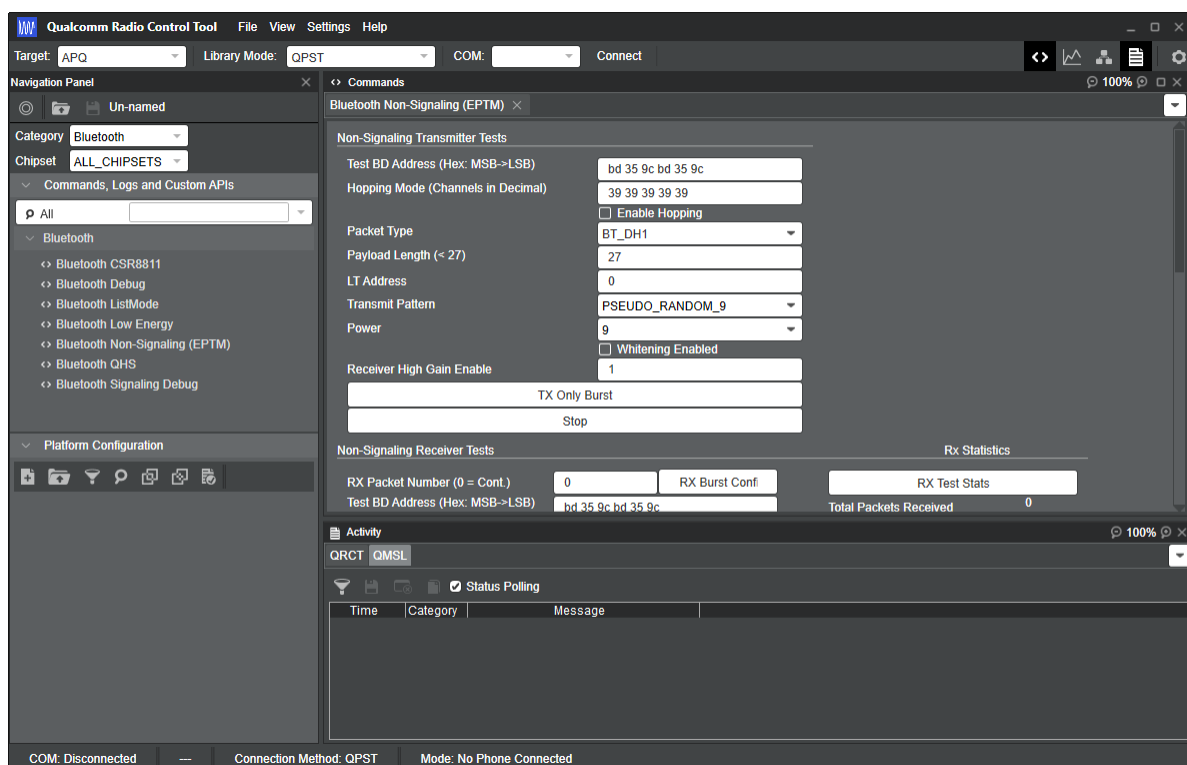
6.2 Compliance testing for Bluetooth

In the QRCT application, select target APQ and Library Mode QPST, Category to Bluetooth, Chipset to "ALL_CHIPSETS".



In the section “HCI Commands”, click first “HCI Reset”, and then “HCI DUT Mode”. The HCI DUT sets Write Scan Enable and Inquiry Scan Enable, which are required to perform further tests.

A number of non-signalling settings and tests are available in the “Bluetooth Non-Signalling (EPTM)” category:



Packet types, transmit power and transmission channel can be configured for both Tx and Rx in Burst and Continuous modes.

List mode options are also available, by selecting the section Bluetooth “ListMode” in the Commands menu. Channel, transmit power and Tx mode can be configured.

