Prüfbericht - Produkte
Test Report - Products

VLAC Lab Accreditation VLAC-017

TÜVRheinland®

Prüfbericht-Nr.: *Test Report No.:*	**JP22QYUI 001**	**Auftrags-Nr.:** *Order No.:*	**150260909**	**Seite 1 von 60** *Page 1 of 60*
Kunden-Referenz-Nr.: *Client Reference No.:*	N/A	**Auftragsdatum:** *Order Date:*	2022-05-18	
Auftraggeber: *Client:*	Nisshinbo Micro Devices Inc. 1-1, Fukuoka 2-Chome Fujimino City Saitama, 356-8510 Japan			
Prüfgegenstand: *Test Item:*	60GHz Smart Sensor			
Bezeichnung / Typ-Nr.: *Identification / Type No.:*	NJR4652F2S1 NJR4652F2S2	**Serien-Nr.:** *Serial No.:*	Refer to section 4.3	
Auftrags-Inhalt: *Order Content:*	Radio Testing			
Prüfgrundlage: *Test Specification:*	FCC 47 CFR Part 15, Subpart C, Section 15.255 ANSI C63.10-2013			

Wareneingangsdatum: *Date of Receipt:*	2022-05-27
Prüfmuster-Nr.: *Test Sample No.:*	A003268907
Prüfzeitraum: *Testing Period:*	2022-06-01 to 2022-07-06
Ort der Prüfung: *Place of Testing:*	Yokohama EMC Laboratory
Prüflaboratorium: *Testing Laboratory:*	TÜV Rheinland Japan Ltd.
Prüfergebnis*: *Test Result*:*	Pass

-/-

zusammengestellt von: *compiled by:*	T. Nagata	**genehmigt von:** *authorized by:*	P. Zhang
Datum: *Date:* 2022-08-04	Takeshi Nagata	**Ausstellungsdatum:** *Issue date:* 2022-08-04	Pin Zhang
Stellung / *Position:*	Inspector	**Stellung** / *Position:*	Reviewer

Sonstiges / *Other:*

Zustand des Prüfgegenstandes bei Anlieferung: Prüfmuster vollständig und unbeschädigt
Condition of the Test Item at Delivery: *Test item complete and undamaged*

* Legende:	P(ass) = entspricht o.g. Prüfgrundlage(n)	F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	N/A = nicht anwendbar	N/T = nicht getestet
* *Legend:*	*P(ass) = passed a.m. test specification(s)*	*F(ail) = failed a.m. test specification(s)*	*N/A = not applicable*	*N/T = not tested*

V05

REVISIONS

Report No.	Issue date	Changes / Remarks
JP22QYUI 001	2022-08-04	Original document (Test report for Intentional radiator aspects)

Contents

1. General Remarks

1.1 Test Specifications

Table 1: Test Summary

Test	Specifications	Result
Emission: FCC 47 CFR Part 15, Subpart C, Section 15.255 ANSI C63.10-2013		
Supply Voltage Requirements FCC §15.31(e)	See the section 5.1.1.	Pass
Antenna Requirements FCC §15.203	See the section 5.1.2.	Pass
Restricted Bands of Operation FCC §15.205	See the section 5.1.3.	Pass
Duty Cycle	-/-	Reference
20dB Bandwidth FCC §15.215 (c)	20dB bandwidth shall be contained within the designated frequency band.	Pass
99% Bandwidth RSS-Gen §6.7 and §8.11	-/-	Reference
Radiated e.i.r.p. Power FCC §15.255(c)(2)	43dBm (Peak), 40dBm (Average)	Pass
Radiated Spurious Emissions of Transmitter FCC §15.209 and §15.255(d)	9kHz – 40GHz 40GHz – 200GHz 3m below 1GHz 3m above 1GHz to 40GHz 1m above 40GHz	Pass
Frequency Stability FCC §15.255(f)	-20 to +70°C 85%, 115% to Nominal Voltage	Pass
Conducted Peak Output Power FCC §15.255(e)	500mW (26.9dBm, Peak)	Pass
Conducted Emission on AC Power Ports of Transmitter FCC §15.207	150kHz - 30MHz	Pass

1.2 Complementary Materials

There is no attachment to this test report.

2. Test Sites

2.1 Test Facilities

TÜV Rheinland Japan Ltd. – Global Technology Assessment Center
4-25-2 Kita-Yamata, Tsuzuki-ku, Yokohama 224-0021, Japan

The used test equipment is in accordance with CISPR 16 for measurement of radio interference.

The test facility is recognized by the Federal Communications Commission (FCC) as Accredited Testing Laboratory under designation number JP0017.

The test facility is recognized by Innovation, Science and Economic Development Canada (ISED) as Wireless Device Testing Laboratory under ISED number 3466B and CAB identifier JP0011.

The test facility is accredited by VLAC (member of ILAC) under number VLAC-017-1 according to ISO/IEC 17025:2017.

2.2 List of Test and Measurement Instruments

Table 2: List of Test and Measurement Equipment

Kind of Equipment	Manufacturer	Model Name	Serial Number	Equip. ID	Cal. Interval	Cal. Date	Next Cal.
For Power Port Conducted Emission (CE)							
Path Loss Correction Factors for CE	-/-	-/-	-/-	RF-0597	1 year	2022-02-14	2023-02-14
Conducted Emission Measurement Software	Toyo Corporation	EP9/CE	Ver. 4.2.010	RF-0810	N/A	N/A	N/A
EMI Receiver	Rohde & Schwarz	ESU 8	100025	RF-0020	1 year	2022-03-16	2023-03-16
LISN	Rohde & Schwarz	ENV216	100276	RF-0016	1 year	2022-05-18	2023-05-18
LISN	Rohde & Schwarz	ENV216	101958	RF-0708	1 year	2022-05-18	2023-05-18
For Radiated Emission (RE)							
Path Loss Correction Factors for RE below 1GHz	-/-	-/-	-/-	RF-0596	1 year	2022-02-14	2023-02-14
Path Loss Correction Factors for RE above 1GHz	-/-	-/-	-/-	RF-0995	1 year	2022-03-16	2023-03-16

Kind of Equipment	Manufacturer	Model Name	Serial Number	Equip. ID	Cal. Interval	Cal. Date	Next Cal.
Radiated Emission Measurement Software (below 30MHz)	Toyo Corporation	EP5/ME	Ver. 5.2.10	RF-0172	N/A	N/A	N/A
Radiated Emission Measurement Software (above 30MHz)	Toyo Corporation	EP7/RE	VER. 8.0.90	RF-0026	N/A	N/A	N/A
EMI Receiver	Rohde & Schwarz	ESU 8	100025	RF-0020	1 year	2022-03-16	2023-03-16
EMI Receiver	Rohde & Schwarz	ESU 40	100029	RF-0021	1 year	2021-08-25	2022-08-25
RF Selector (10m Chamber)	Toyo Corporation	NS4900	0703-182	RF-0029	N/A	N/A	N/A
Loop Antenna with Amplifier, 9kHz-30MHz	Rohde & Schwarz	HFH2-Z2	100139	RF-0048	1 year	2022-05-02	2023-05-02
Trilog Antenna No. 2, 30-1000MHz	Schwarzbeck	VULB 9168	9168-475	RF-0462	1 year	2022-05-19	2023-05-19
5dB Attenuator	Pasternack	PE7047-5	-/-	RF-0731	1 year	2022-05-20	2023-05-20
Low Noise Preamplifier, 9kHz-1GHz	TSJ	MLA-10K01-B01-35	1370750	RF-0253	1 year	2021-12-23	2022-12-23
Low Pass Filter, DC-1GHz	R&K	LP1000CH3	12104001	RF-0515	1 year	2021-12-23	2022-12-23
Horn Antenna, 1-8GHz	Schwarzbeck	BBHA 9120 D	1059	RF-0553	1 year	2022-03-19	2023-03-19
Microwave Preamplifier, 1-8GHz	Toyo Corporation	TPA0108-40	0634	RF-0052	1 year	2021-12-23	2022-12-23
Horn Antenna with Preamplifier, 8-18GHz (RX)	Toyo Corporation	HAP06-18W	00000025	RF-0065	1 year	2022-04-10	2023-04-10
High Pass Filter, 8-18GHz	Micro-Tronics	HPM50107	006	RF-0334	1 year	2022-04-10	2023-04-10
Horn Antenna with Preamplifier, 18-26.5GHz (RX)	Toyo Corporation	HAP18-26N	00000010	RF-0070	1 year	2022-04-10	2023-04-10
Horn Antenna with Preamplifier, 26.5 -40GHz (RX)	Toyo Corporation	HAP26-40N	00000007	RF-0069	1 year	2022-04-10	2023-04-10
Preamplifier, 26.5-40GHz	Toyo Corporation	HAP2640-S	-/-	RF-0258	1 year	2022-03-16	2023-03-16
For Transmitter and Receiver Radiated Spurious Emission (above 40GHz)							
Spectrum Analyzer	Rohde & Schwarz	FSW85	101545	RF-1039	1 year	2021-06-16	2022-06-16
Spectrum Analyzer	Keysight	N9041B	US57220181	BT-1825220	2 years	2021-04-21	2023-04-21
Horn Antenna 40-60GHz (RX)	Custom Microwave Inc.	HO19R	-/-	BT-8334	1 year	2021-08-20	2022-08-20
Horn Antenna 50-75GHz (RX)	Custom Microwave Inc.	HO15R	-/-	BT-8336	1 year	2021-08-20	2022-08-20
Horn Antenna 75-110GHz (RX)	Custom Microwave Inc.	HO10R	-/-	BT-8338	1 year	2021-08-20	2022-08-20

Kind of Equipment	Manufacturer	Model Name	Serial Number	Equip. ID	Cal. Interval	Cal. Date	Next Cal.
Horn Antenna 110-170GHz (RX)	Custom Microwave Inc.	HO6R	-/-	BT-8358	N/A	N/A	N/A
Horn Antenna 140-220GHz (RX)	Custom Microwave Inc.	HO5R	-/-	BT-8359	N/A	N/A	N/A
Harmonic mixer 75GHz-110GHz	Rohde & Schwarz	FS-Z110	101655	RF-1035	2 years	2021-03-26	2023-03-26
Harmonic Mixer 110-170GHz	Rohde & Schwarz	RPG FS-Z170	101017	RF-1036	2 years	2021-07-02	2023-07-02
Harmonic Mixer 140-220GHz	Rohde & Schwarz	RPG FS-Z220	101055	RF-1037	2 years	2021-02-04	2023-02-04
LNA (40G-60GHz)	SAGE Millimeter, Inc.	SBL-4036033080-1919-S1	13421-01	G18103 40	2 years	2020-06-23	2022-06-23
LNA (50G-75GHz)	SAGE Millimeter, Inc.	SBL-5037533550-1515-E1	13352-01	G18103 47	2 years	2020-06-24	2022-06-24
LNA for Power detector (50G-75GHz)	AT Microwave	AT-LNA-5075-3804T	MCDE02	RF-0972	1 year	2022-07-25	2023-07-25
Digital Storage Oscilloscope	Keysight	DSOX6002A	MY59240302	RF-0823	1 year	2022-01-20	2023-01-20
V Band RF Detector	ERAVANT	SFD-503753-15SF-P1	16352-01	RF-0982	1 year	2022-07-25	2023-07-25
Analog Signal Generator	Keysight	PSG67	MY57280619	G18252 21	2 years	2021-03-22	2023-03-22
Power Meter	Keysight	U8489A	RF-1044	G18252 24	1 year	2021-07-06	2022-07-06
Temperature Chamber	Voetsch	VT 4018	58566025090010	BT-8012	1 year	2021-07-02	2022-07-02
Constant Voltage Constant Frequency Stabilizers and Power Accessories							
CVCF (10m Chamber)	NF Corporation	ES2000U	9067307	RF-0212	1 year	2022-03-16	2023-03-16
CVCF Booster (10m Chamber)	NF Corporation	ES2000B	9074408	RF-0213	1 year	2022-03-16	2023-03-16
CVCF (Shielded Room)	NF Corporation	ES2000S	9075612	RF-0210	1 year	2022-03-16	2023-03-16
CVCF Booster (Shielded Room)	NF Corporation	ES2000B	9074403	RF-0211	1 year	2022-03-16	2023-03-16
DC Power Supply	Hewlett Packard	6653A	3640A03102	RF-0004	N/A	N/A	N/A
DC Power Supply	Agilent	E3646A	MY50350007	RF-0412	N/A	N/A	N/A
True RMS Multimeter	Fluke	87V	97680445	RF-0281	1 year	2021-12-15	2022-12-15

Conformance of the used measurement and test equipment with the requirements of ISO/IEC 17025:2017 has been confirmed before each testing.

2.3 Measurement Uncertainty

Table 3: Emission Measurement Uncertainty

Measurement Type	Frequency	Uncertainty
Conducted Emission on Power Ports	150kHz - 30MHz	±2.0dB
Radiated Emission – Semi Anechoic Chamber	30MHz - 1GHz	±3.8dB at 3m ±5.0dB at 10m
	1GHz - 40GHz	±4.5dB at 3m
Radiated Emission (MMW)	40GHz - 50GHz	±4.6dB
	50GHz - 75GHz	±5.0dB
	75GHz - 110GHz	±5.0dB
	110GHz - 220GHz	±5.3dB
	220GHz - 243GHz	±5.7dB

Note:

The measurement instrumentation uncertainty (MIU) was determined according to CISPR 16-4-2. All MIU values mentioned in the above table are smaller than the uncertainty budgets specified by CISPR 16-4-2, therefore compliance for all emission measurements is deemed to occur if no measured disturbance level exceeds the disturbance limit.

3. General Product Information

3.1 Product Function and Intended Use

The **EUT** (**E**quipment **U**nder **T**est) is a 60GHz band FMCW sensor modules. The modules are incorporating an Infineon's 60GHz radar sensor IC and a MCU for control and signal processing. The modules have one Tx and three Rx antennas which can simultaneously get both a distance and its position (angle) information with high special resolution.

Note: Both models NJR4652F2S1 and NJR4652F2S2 are electrically identical. Chirp parameters are only customized by each firmware.

3.2 Ratings and System Details

Peak e.i.r.p. Power:	+5.63dBm (Chirp Disable)
Antenna gain:	+5.0dBi
Antenna type:	Pattern antenna (printed on PCB)
Antenna mounting type:	Internal
Frequency range:	61.00 - 61.50GHz
Nominal Frequency:	61.02 – 61.48GHz
Number of channels:	1
Modulation type:	FMCW with Pulse
FCC classification:	DXX (Part 15 Low Power Transceiver, Rx Verified)
Input Voltage:	DC 5.0V
Typical Nominal Voltage:	DC 5.0V
Input Current:	185mA
Protection Class:	III
Test voltage:	DC 5.0V (For EUT) AC 120V (For AC Adapter) **(*)**
Test frequency:	60Hz (For AC Adapter) **(*)**

Note:
(*) One off-the-shelf AC Adapter was used.

3.3 Noise Generating and Noise Suppressing Parts

The highest frequency generated or used by the EUT is 61.48GHz for fundamental component as intentional radiator portion.

3.4 Submitted Documents and Information

Following document has been submitted by the client:

Instruction for the testing

Following information provided in this test report has been submitted by the client:

- client name and address;
- EUT identification, ratings, system details, and description of product function and intended use;
- information related to noise generating and noise suppressing parts (if any).

4. Test Setup and Operation Modes

4.1 Test Methodology

The test methodology used is based on the requirements of 47 CFR Part 15, sections 15.31, 15.33, 15.35, 15.205, 15.207, 15.209 and 15.255.

The test methods, which have been used, are based on ANSI C63.10.

For details, see under each test item.

4.2 Operation Modes

The operation modes used for testing are:

A. Transmitting at the lowest frequency Channel (61.02GHz) with the highest Duty Cycle.

B. Transmitting at the middle frequency Channel (61.25GHz) with the highest Duty Cycle.

C. Transmitting at the highest frequency Channel (61.48GHz) with the highest Duty Cycle.

D1. Transmitting at the chirp active (FMCW1) with the actual operational Duty Cycle.

D2. Transmitting at the chirp active (FMCW8) with the actual operational Duty Cycle.

D3. Transmitting at the chirp active (FMCW16) with the actual operational Duty Cycle.

The operation modes are coupled with the following configurations:

1. Model NJR4652F2S1
2. Model NJR4652F2S2 **(*)**

Note:

(*) One chirp setting, D1 is only available at this model.

Both models NJR4652F2S1 and NJR4652F2S2 are electrically identical. Chirp parameters are only customized by each firmware.

For FCC, as per requirement of the §15.31(c), a frequency sweep (i.e. chirp) was disable during testing. Above listed modes A to C were applied as test mode.

For ISED, a chirp was enable during testing. Above listed operation modes D1 to D3 were applied. (Test data for ISED are covered by the separate test report.)

Regarding the details of each chirp parameter, refer to the submitted operational descriptions of the EUT.

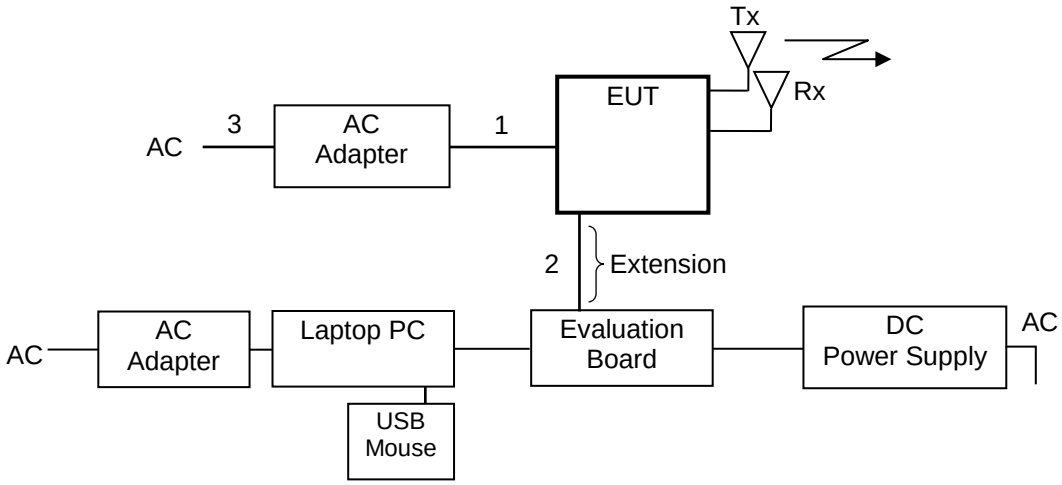
4.3 Physical Configuration for Testing

The EUT was tested on a stand-alone basis and the test system was configured in a typical fashion (as a customer would normally use it).

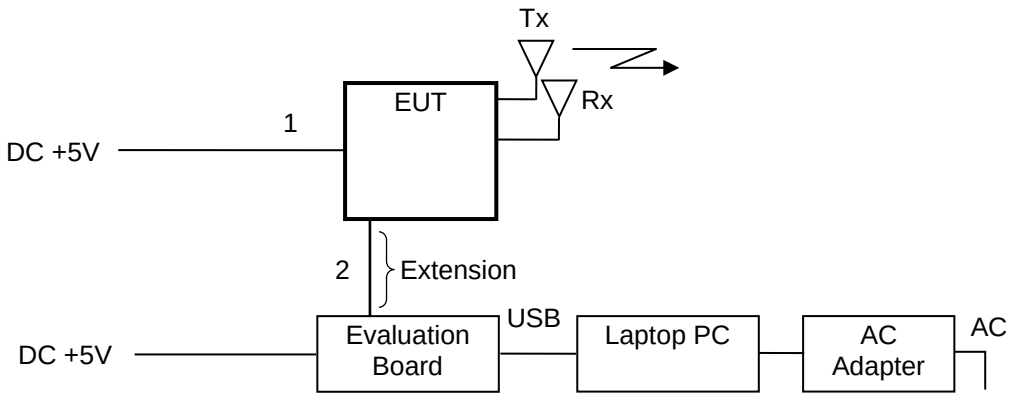
The justification and manipulation of cables and equipment in order to simulate a worst-case behavior of the test setup has been carried out as prescribed in ANSI C63.10.

Figure 1: Block Diagram

For AC Power Line Conducted Emission of Transmitter



For Other Test Items of Transmitter



Note: Laptop PC and its AC Adapter were used for initial test setup purpose only.

Table 4: Interfaces present on the EUT

No.	Interface	Cable Length for Testing, Shielding	Interface Classification
1.	DC cable	2.6m, Un-shielded	DC input power port **(*)**
2.	UART	2.9m, Un-shielded	Signal port **(*)**
3.	AC cable (AC Adapter)	1.0m, Un-shielded	AC input power port

Note:

(*) The EUT is directly plugged onto an end user's PCB. In order to enable testing as Stand-alone configuration, these interface cables were extended for testing purpose.

For more details, refer to section: Photographs of the Test Set-Up.
Test samples were used with the following serial number under listed in the next table.

Table 5: Serial Number

Model	Serial Number	LDO	Remarks
NJR4652F2S1	#1	Type A	Highest e.i.r.p value was observed.
	#2		
	#3	Type B	
NJR4652F2S2	#5	Type A	
	#7	Type B	

Note:

Two types of LDO are used at their mass-productions on the models. By the preliminary test in the section 5.2.4, the sample expected the highest EIRP was identified. Hence, the serial number #1 was mainly tested in this test report. #2 was used at the Frequency Stability and AC power line conducted emission.

4.4 Test Software

The EUT was provided by the manufacturer with suitable software to allow operation in all the required modes.

Software used for testing are:

- NJR4652_PresenceDetection_CommandControl_001, version 1.0.0.0 by Nisshinbo Micro Devices Inc.
- NJR4652_SmartEntrance_CommandControl_001, version 1.0.0.0 by Nisshinbo Micro Devices Inc.

These software were running on the laptop computer connected to the EUT. It was used to enable the test operation modes listed in section 4.2 as appropriate.

4.5 Special Accessories and Auxiliary Equipment

The product has been tested together with the following additional accessories:

1. Product: AC Adapter for EUT
   Manufacturer: UNIFIVE
   Model: UNI318-0530
   Rated Voltage: AC 100-240V
   Input Current: 0.4A
   Frequency: 50/60Hz
   Output Voltage: DC 5.0V
   Output Current: 3.0A
   Protection Class: II
   Serial Number: L12-0430880

2. Product: Laptop PC
   Manufacturer: Lenovo
   Model: ThinkPad L560
   Rated Voltage: DC 20V
   Input Current: Un-specified
   Protection Class: III
   Serial Number: B028858

3. Product: AC Adapter for Laptop PC
   Manufacturer: Lenovo
   Model: ADLX45NCC2A
   Rated Voltage: AC 100-240V
   Input Current: 1.3A
   Frequency: 50-60Hz
   Rated Voltage: DC 20V
   Output Current: 2.25A
   Protection Class: II
   Serial Number: 8SSA10E75794C1SG73W2583 REV:100

4. Product: USB Mouse
   Manufacturer: Lenovo
   Model: MO28UOB
   Rated Voltage: DC 5V
   Input Current: 100mA
   Protection Class: III
   Serial Number: 8SSM50G45918G68E1715

5. Product: Evaluation Board
   Manufacturer: Nisshinbo Micro Devices Inc.
   Model: R4652K-100-2.0
   Rated Voltage: DC 5V
   Protection Class: III
   Serial Number: Un-specified

6. Product: Extension Board
   Manufacturer: Nisshinbo Micro Devices Inc.
   Model: NJR4652K-100-2.0
   Rated Voltage: N/A
   Serial Number: Un-specified

Note: Extension Board does not have any electrical component on its PCB.

4.6 Countermeasures to achieve Compliance

No additional measures were employed to achieve compliance.

5. Test Results RADIO

5.1 Technical Requirements

5.1.1 Supply Voltage Requirements

RESULT: **Pass**

Requirements:

FCC §15.31(e)

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

Verdict:

The EUT has an internal voltage regulator to supply the RF circuit. Hence it complies with the supply voltage requirements.

5.1.2 Antenna Requirements

RESULT: **Pass**

Requirements:

FCC §15.203

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

Verdict:

The antenna is permanently attached to the PCB board and is not able to be replaced. Hence it complies with the antenna requirements.

5.1.3 Restricted Bands of Operation

RESULT: **Pass**

Requirements:

FCC §15.205 (d)(4) and §15.255(d)

Any equipment operated under the provisions of §15.255 is exempt from the requirements of this section 15.205.

Verdict:

The EUT operation frequency range is 61.00 - 61.50GHz as a fixed field disturbance sensor. Therefore only spurious emissions may be found in the restricted bands below 40GHz, and the EUT complies with the restricted frequency band requirement.

5.2 Radiated Measurements

5.2.1 Duty Cycle

RESULT: **Reference**

Date of testing:	2022-06-01, 2022-06-02, 2022-06-03
Ambient temperature:	23, 20, 22°C
Relative humidity:	48, 59, 58%
Atmospheric pressure:	1004, 1005, 1003hPa
Test mode applied:	A, B, C
Test configuration applied:	1

Requirements:

N/A, this test item was performed as reference.

Test procedure:

ANSI C63.10-2013 §7.5, §9.10 and §9.11

Table 6: Duty Cycle during testing

Mode	On Time Duration [us]	Period of the one frame [ms]	Measured Duty Cycle [%]	Remark
A	-/-	-/-	100	Test mode (Continuous Tx)
B	-/-	-/-	100	Test mode (Continuous Tx)
C	-/-	-/-	100	Test mode (Continuous Tx)

Table 7: Duty Cycle Correction Factor

Mode	Measured Duty Cycle [%]	Possible highest Duty Cycle [%]	DCCF [dB]	Remark
A	100	21.84	-13.21	See Note **(*)**
B	100	21.84	-13.21	See Note **(*)**
C	100	21.84	-13.21	See Note **(*)**

Note: **(*)** For Mode A to C, each **D**uty **C**ycle **C**orrection **F**actor (hereinafter, DCCF) was calculated with the possible highest duty cycle of the EUT by the following formula;

DCCF = 20 × Log_{10} (Duty Cycle), where Duty Cycle is in dimensionless.

The calculated DCCF may only be applied to a spurious emission that is temporally related to the fundamental emission. See the section 4.1.4.2.4, Average value of pulsed emissions of ANSI C63.10-2013.

Figure 2: Duty Cycle, Mode A, model NJR4652F2S1

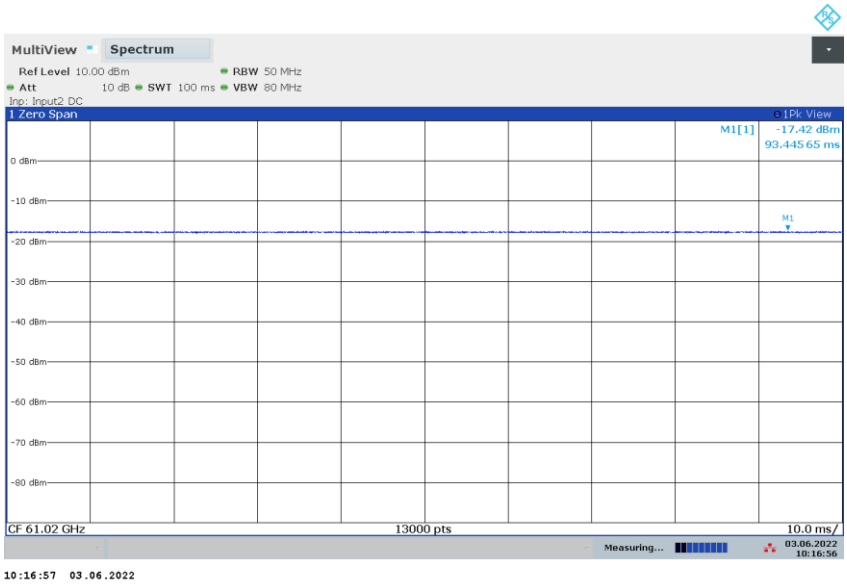


Figure 3: Duty Cycle, Mode B, model NJR4652F2S1

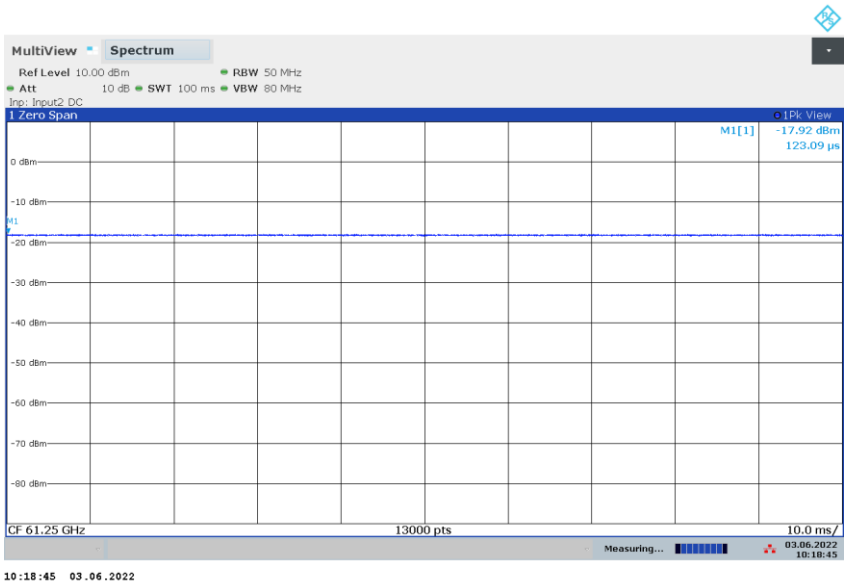


Figure 4: Duty Cycle, Mode C, model NJR4652F2S1

5.2.2 20dB Bandwidth

RESULT: **Pass**

Date of testing:	2022-06-01, 2022-06-02, 2022-06-03
Ambient temperature:	23, 20, 22°C
Relative humidity:	48, 59, 58%
Atmospheric pressure:	1004, 1005, 1003hPa
Measurement distance:	1m
Kind of test site:	Semi Anechoic Chamber
Test mode applied:	A, C
Test configuration applied:	1

Requirements:

FCC §15.215(c)

The 20dB bandwidth of the emission shall be contained within the frequency band (61.00 - 61.50GHz) designated in the rule section under which the equipment is operated.

Test procedure:

ANSI C63.10 §6.9.2

The EUT was placed on non-conductive table raised 80cm above the ground plane in a semi-anechoic chamber.

20dB bandwidth was measured with a horn antenna connected to a spectrum analyzer with peak detector and Max Hold.

Markers were placed at the lowest and highest intersections of the trace with a 20dBc line to obtain the value of the emission bandwidth.

Note:
This 20dB Bandwidth was calculated from a pair of measurement data at a lower side of the Lowest Channel (mode A) and at a higher side of the Highest Channel (mode C) in accordance with the 2021 TCBC workshop materials.

Table 8: 20dB Bandwidth Edge Frequencies

Mode	20dB Bandwidth Edge Side	Edge Frequency [GHz]	Limit [GHz]	Margin [MHz]
A	Lower side	61.01919455	61.00	19.194554
	Higher side	61.01919469	-/-	-/-
C	Lower side	61.47899742	-/-	-/-
	Higher side	61.47899792	61.50	21.0020803
20dB Bandwidth [MHz] (*)		459.803366		

Note: **(*)** This 20dB Bandwidth was calculated by a lower side of the Lowest Channel and a higher side of the Highest Channel in accordance with the 2021 TCBC workshop materials.

Table 9: 20dB Bandwidth

Mode	20dB Bandwidth (*) [Hz]	RBW (Hz)	Remark
A	139.08	50	**Reference plots**
C	500.7	200	**Reference plots**

Note: **(*)** As these 20dB Bandwidth measurement data were used for a calculation, therefore, they are reference data.

Figure 5: 20dB Bandwidth, Mode A

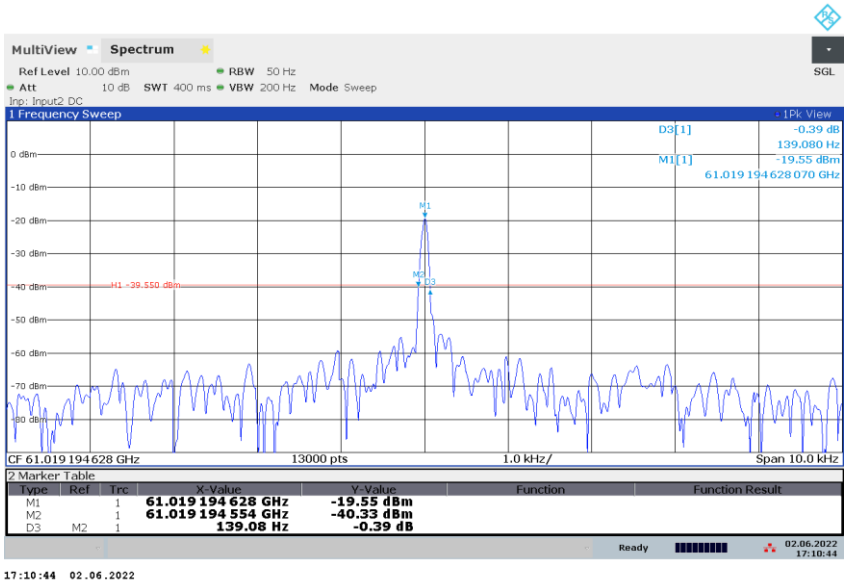
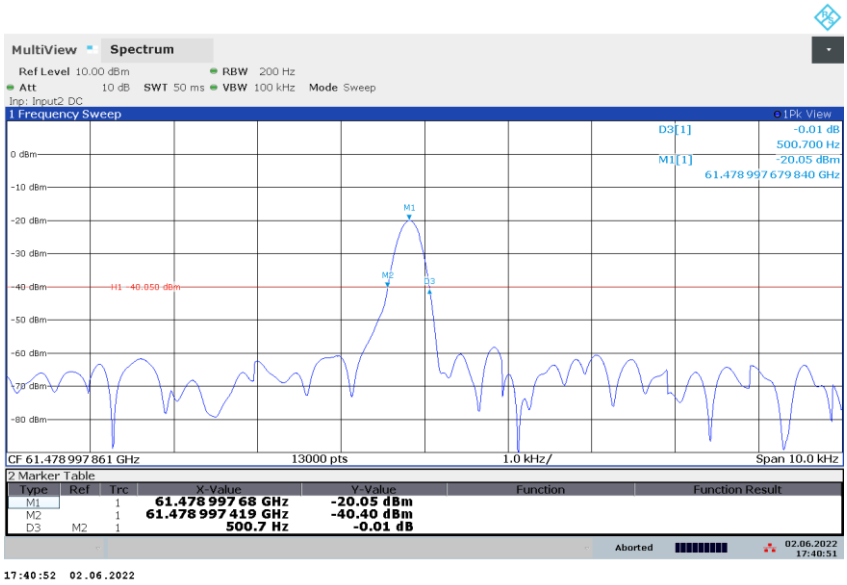


Figure 6: 20dB Bandwidth, Mode C



5.2.3 99% Bandwidth

RESULT: **Reference**

Date of testing:	2022-06-01, 2022-06-02, 2022-06-03
Ambient temperature:	23, 20, 22°C
Relative humidity:	48, 59, 58%
Atmospheric pressure:	1004, 1005, 1003hPa
Measurement distance:	1m
Kind of test site:	Semi Anechoic Chamber
Test mode applied:	D1, D2, D3
Test configuration applied:	1

RSS-Gen §6.7 and §8.11

The 99% bandwidth shall be reported and shall lie entirely outside the restricted bands and the prohibited TV bands of 54-72MHz, 76-88MHz, 174-216MHz, 470-608MHz and 614-806MHz, unless otherwise indicated.

Test procedure:

ANSI C63.10 §6.9.3

The EUT was placed on non-conductive table raised 80cm above the ground plane in a semi-anechoic chamber.

99% bandwidth was measured with a horn antenna connected to a spectrum analyzer with the following settings:

- RBW = 5MHz, VBW = 20MHz, Sample detector with Max Hold

Markers were placed at the lowest and highest intersections of the trace by 99% OBW function to obtain the value of the emission bandwidth.

Note: This test item is not relevant to FCC testing.

Table 10: 99% Bandwidth Edge Frequencies

Mode	99% Bandwidth Edge Side	Edge Frequency [GHz]	Limit [GHz]	Margin [MHz]
D1	Lower side	61.0195404	61.00	19.5404
	Higher side	61.4793200	61.50	20.6800
D2	Lower side	61.0205710	61.00	20.5710
	Higher side	61.4787811	61.50	21.2189
D3	Lower side	61.0190247	61.00	19.0247
	Higher side	61.4798601	61.50	20.1399

Table 11: 99% Bandwidth

Mode	99% Bandwidth [MHz]	RBW (MHz)	Ratio	Remark
D1	459.779683342	5	1.09%	
D2	458.210036134	5	1.09%	
D3	460.835423954	5	1.08%	Widest 99OBW

Note: Ratio was calculated in order to confirm its RBW setting at each measurement (i.e. 1% to 5%).
Gray shading data is the widest 99% OBW in this test report.

Figure 7: 99% Bandwidth, Mode D1

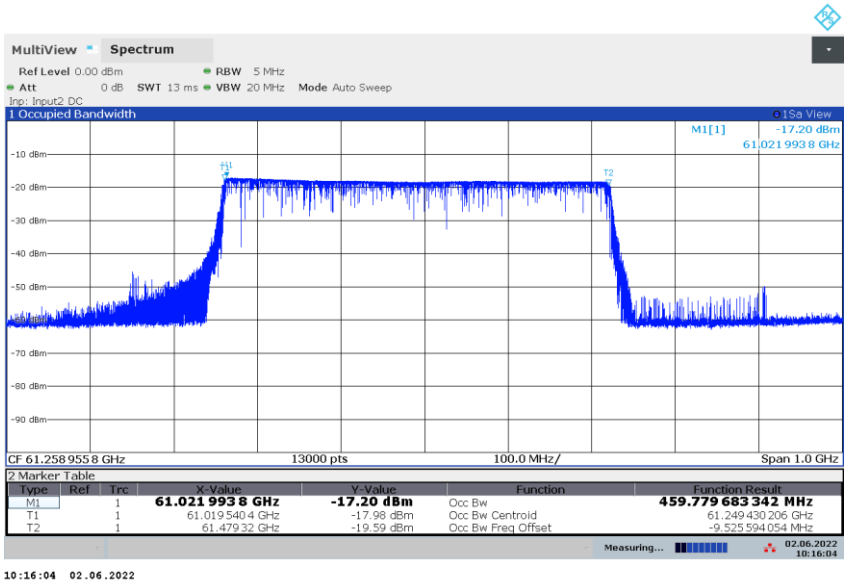


Figure 8: 99% Bandwidth, Mode D2

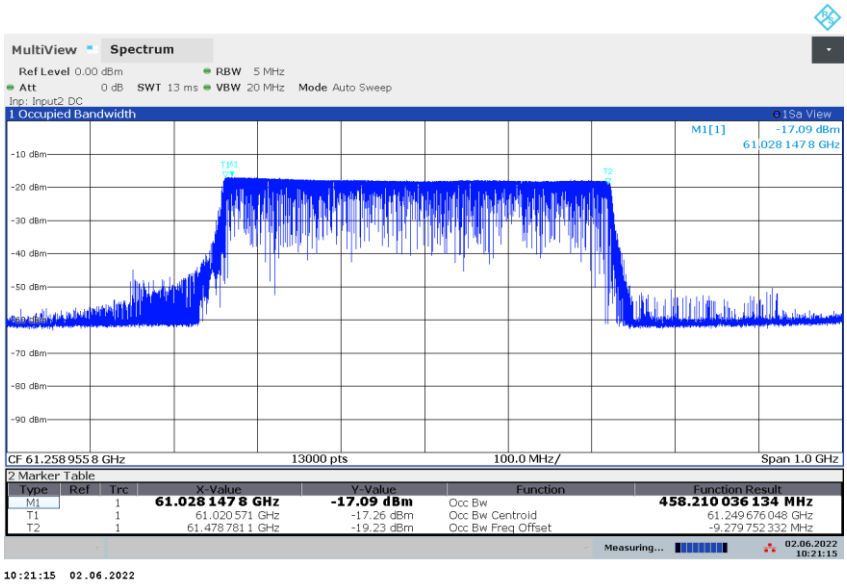
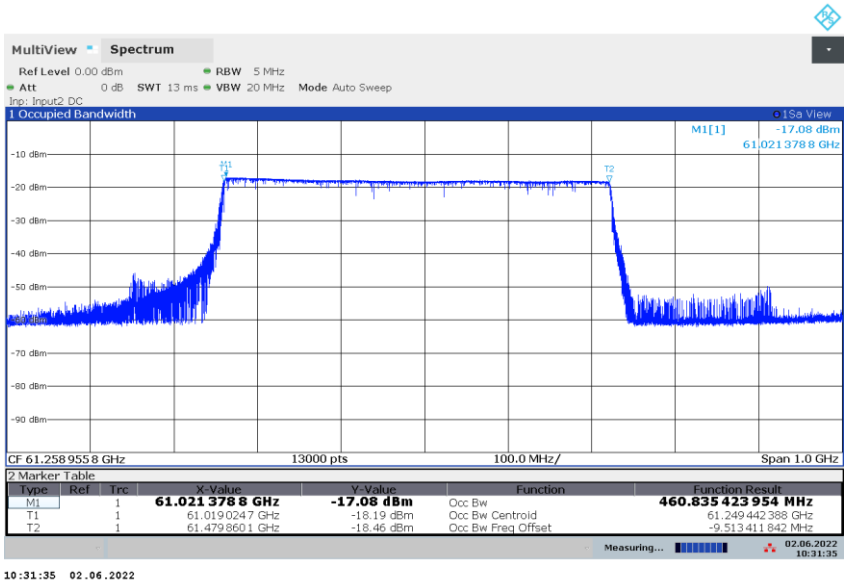


Figure 9: 99% Bandwidth, Mode D3



5.2.4 Radiated e.i.r.p. Power

RESULT: **Pass**

Date of testing:	2022-06-01, 2022-06-02, 2022-06-03
Ambient temperature:	23, 20, 22°C
Relative humidity:	48, 59, 58%
Atmospheric pressure:	1004, 1005, 1003hPa
Measurement distance:	1m
Kind of test site:	Semi Anechoic Chamber
Test mode applied:	A, B, C
Test configuration applied:	1, 2

Requirements:

FCC §15.255 (c)(2), (c)(4)

For fixed field disturbance sensors that occupy 500 MHz or less of bandwidth and that are contained wholly within the frequency band 61.0-61.5 GHz, the average power of any emission, measured during the transmit interval, shall not exceed 40 dBm, and the peak power of any emission shall not exceed 43 dBm.

Test procedure:

ANSI C63.10 §9.11

The EUT was placed on a non-conductive table raised 80cm above the ground plane for the fundamental measurements. Measurements were made at a distance of 1m.

Preliminary measurements were performed in order to determine the worst position where highest emission level was observed. A spectrum analyzer was used with peak detector and Max Hold. The EUT was manually rotated 360° in front of Rx antenna.

As per the § 9.11 e) and f), the following substitution method was applied.

Each pair of Peak and Average voltages of the fundamental emission was recorded by a Digital Storage Oscilloscope (DSO).

A Signal Generator (SG) was connected to the instrumentation system instead of the Rx antenna. A frequency was adjusted to the center frequency occupied by EUT. A level of the SG was tuned until the same voltage was obtained. Unmodulated CW signal was used.

Without changing any settings, connect the port to a mm-wave Power Meter. Then, the each corresponding power was measured and was recorded.

The maximum Peak and Average field strengths of the fundamental were calculated at the test distance (1m), using with the Equation (19) and with the each Peak and Average substitution power at the input to the instrumentation system.

Equation (19): $E = 126.8 - 20\log(\lambda) + P - G$

where

E is the field strength of the emission at the measurement distance, in dBµV/m

P is the power measured at the output of the test antenna, in dBm

λ is the wavelength of the emission under investigation [$300/f_{MHz}$], in m

G is the gain of the test antenna, in dBi

The Peak and Average EIRP were calculated from the measured peak and average field strength using the Equation (22).

Equation (22): $EIRP = E + 20\log(d_{MEAS}) - 104.7$

where

EIRP is the equivalent isotropically radiated power, in dBm

E_{Meas} is the field strength of the emission at the measurement distance, in dBµV/m

d_{Meas} is the measurement distance, in m

Table 12: Radiated Peak e.i.r.p. Power, model NJR4652F2S1

Mode	Frequency [GHz]	Reading Value on DSO PK [mV]	P [dBm]	G [dBi]	d_{Meas} [m]	Peak EIRP [dBm]	Peak Limit [dBm]	Margin [dB]
A	61.020	4.0200	-39.47	23.17	1.0	5.63	43.0	37.37
B	61.250	3.1500	-39.61	23.17	1.0	5.52	43.0	37.48
C	61.480	2.7500	-40.07	23.17	1.0	5.09	43.0	37.91

Note: Field strength of the fundamental, E_{Meas} in dBµV/m is calculated by the following Equation:

$E_{Meas} = 126.8 - 20 \times Log_{10} (\lambda) + P - G$ [dBuV/m]

EIRP of the fundamental, in dBm is calculated by the following Equation:

$EIRP = E_{Meas} + 20 \times Log_{10} (d_{Meas}) – 104.7$ [dBm]

Gray shading data is the highest Peak EIRP in this test report.

Table 13: Radiated Average e.i.r.p. Power, model NJR4652F2S1

Mode	Frequency [GHz]	Reading Value on DSO AV [mV]	P [dBm]	G [dBi]	d_{Meas} [m]	Average EIRP [dBm]	Average Limit [dBm]	Margin [dB]
A	61.020	3.9126	-39.69	23.17	1.0	5.41	40.0	34.59
B	61.250	3.0454	-39.87	23.17	1.0	5.26	40.0	34.74
C	61.480	2.6147	-40.45	23.17	1.0	4.71	40.0	35.29

Note: Field strength of the fundamental, E_{Meas} in dBµV/m is calculated by the following Equation:

$E_{Meas} = 126.8 - 20 \times Log_{10} (\lambda) + P - G$ [dBuV/m]

EIRP of the fundamental, in dBm is calculated by the following Equation:

$EIRP = E_{Meas} + 20 \times Log_{10} (d_{Meas}) – 104.7$ [dBm]

Table 14: Radiated Peak e.i.r.p. Power, model NJR4652F2S2

Mode	Frequency [GHz]	Reading Value on DSO PK [mV]	P [dBm]	G [dBi]	d_{Meas} [m]	Peak EIRP [dBm]	Peak Limit [dBm]	Margin [dB]
A	61.020	3.8200	-39.92	23.17	1.0	5.18	43.0	37.82
B	61.250	3.1500	-39.61	23.17	1.0	5.52	43.0	37.48
C	61.480	2.7800	-40.00	23.17	1.0	5.16	43.0	37.84

Note: Field strength of the fundamental, E_{Meas} in dBµV/m is calculated by the following Equation:

$E_{Meas} = 126.8 - 20 \times Log_{10} (\lambda) + P - G$ [dBuV/m]

EIRP of the fundamental, in dBm is calculated by the following Equation:

$EIRP = E_{Meas} + 20 \times Log_{10} (d_{Meas}) – 104.7$ [dBm]

Table 15: Radiated Average e.i.r.p. Power, model NJR4652F2S2

Mode	Frequency [GHz]	Reading Value on DSO AV [mV]	P [dBm]	G [dBi]	d_{Meas} [m]	Average EIRP [dBm]	Average Limit [dBm]	Margin [dB]
A	61.020	3.7183	-40.12	23.17	1.0	4.98	40.0	35.02
B	61.250	3.0267	-39.96	23.17	1.0	5.17	40.0	34.83
C	61.480	2.6585	-40.36	23.17	1.0	4.80	40.0	35.20

Note: Field strength of the fundamental, E_{Meas} in dBµV/m is calculated by the following Equation:

$E_{Meas} = 126.8 - 20 \times Log_{10} (\lambda) + P - G$ [dBuV/m]

EIRP of the fundamental, in dBm is calculated by the following Equation:

$EIRP = E_{Meas} + 20 \times Log_{10} (d_{Meas}) – 104.7$ [dBm]

Table 16: Preliminary test

Model	Serial Number	LDO	Mode	Reading Value on DSO [mV]		Remark
				Peak	Average	
NJR4652F2S1	#1	Type A	A	**4.0200**	**3.9126**	**Highest**
	#3	Type B	A	3.7900	3.6754	
NJR4652F2S2	#5	Type A	A	3.8200	3.7183	
	#7	Type B	A	3.9900	3.8859	

Note:
Two types of LDO are used at their mass-productions on the models. By the preliminary test, the sample which is expected the highest EIRP power was identified. The serial number #1 was fully tested in this test report.

5.2.5 Radiated Spurious Emissions of Transmitter

RESULT: **Pass**

Date of testing:	2022-06-03, 2022-06-06, 2022-06-07 2022-06-08
Ambient temperature:	22, 21, 20, 23°C
Relative humidity:	58, 59, 57, 53%
Atmospheric pressure:	1003, 1000, 997, 108hPa
Frequency range:	9kHz - 200GHz
Measurement distance:	3m below 1GHz 3m above 1GHz 1m above 40GHz
Kind of test site:	Semi Anechoic Chamber
Test mode applied:	A, B, C
Test configuration applied:	1

Requirements:

FCC §15.209, §15.255(d).

Radiated emissions below 40GHz shall not exceed the general limits.

Between 40GHz and 200GHz, the level of these emissions shall not exceed 90 pW/cm^2 at a distance of 3 meters (i.e. equivalent to EIRP of -9.9dBm).

Test procedure:

ANSI C63.10 §9.12, 9.13 (6.6 through 6.6)

1) For below 40GHz

The EUT was placed on a non-conductive table. The table height was 0.8m for measurements below 1GHz and was 1.5m for measurements from 1 to 40GHz.

Before final measurements of radiated emissions were performed, the EUT was scanned to determine its emission spectrum profile. The physical arrangement of the test system, the associated cabling and the EUT orientation (X, Y, Z) were varied in order to ensure that maximum emission amplitudes were attained.

The spectrum was examined from 9kHz to 40GHz. Final radiated emission measurements were made at 3m distance below 40GHz.

At each frequency selected for final measurement, the EUT was rotated 360° and the antenna was raised and lowered from 1 to 4m in order to determine the emission's maximum level. Measurements were taken using both horizontal and vertical antenna polarizations.

For emissions between 30MHz and 1GHz, measurements were performed with a receiver operating in the CISPR quasi-peak detection mode. The receiver's 6dB bandwidth was set to 120kHz. For emissions above 1GHz, measurements were performed with a spectrum analyzer using the following settings: for peak field strength: RBW = 1MHz & VBW = 3MHz; for average field strength: RBW = 1MHz & VBW = 10Hz.

Absorbers have been placed on the floor between the EUT and the measuring antenna for testing above 1 to 40GHz.

The highest emission amplitudes relative to the appropriate limit were recorded in this report. Emissions other than those mentioned are small or not detectable.

No spurious emission was found in the range from 9kHz to 30MHz at 3m measurement distance.

2) Above 40GHz to 200GHz

The same test setup mentioned in the section 5.2.4 was applied for the range.

Final radiated emission measurements were made at 1m distance.

As per the section 9.12 of ANSI C63.10, measurements were performed with a spectrum analyzer using the following settings: RBW = 1MHz & VBW = 3MHz; power average detector with max hold.

As per the Annex G of ANSI C63.10, G.5.2 was applied.

The highest emission amplitudes relative to the appropriate limit were recorded in this report. Emissions other than those mentioned are small or not detectable.

No spurious emission was found in the range from 110 to 200MHz at the closer distance of 0.3m than 1m measurement distance. The second and third harmonics components were not found in the range from 40 to 200GHz.

Table 17: Radiated Emission, Quasi Peak Data, 30MHz - 1GHz, Horizontal and Vertical Antenna Orientations, Mode A

Freq. [MHz]	EUT / Antenna Orientation	Reading QP [dBµV]	Factor [dB(1/m)]	Level QP [dBµV/m]	Limit [dBµV/m]	Margin QP [dB]	Height [cm]	Angle [°]
48.061	X/V	45.5	-20.7	24.8	40.0	15.2	100	5
49.152	X/H	38.3	-20.7	17.6	40.0	22.4	389	127
96.098	X/V	49.5	-25.9	23.6	43.5	19.9	100	129
144.163	X/H	41.3	-20.8	20.5	43.5	23.0	228	142
167.736	X/V	37.2	-21.2	16.0	43.5	27.5	100	183
238.648	X/H	41.6	-22.2	19.4	46.0	26.6	138	182
900.062	X/V	37.1	-8.1	29.0	46.0	17.0	239	109

Note: Level QP = Reading QP + Factor dB(uV/m) = 20 × Log_{10}(uV/m)

Table 18: Radiated Emission, Average Data, 1 - 40GHz, Horizontal and Vertical Antenna Orientations, Mode A

Freq. [MHz]	EUT / Antenna Orientation	Reading AV [dBµV]	Factor [dB(1/m)]	Level AV [dBµV/m]	Limit [dBµV/m]	Margin AV [dB]	Height [cm]	Angle [°]
1499.747	X/V	41.4	-17.4	24.0	54.0	30.0	196	214
7407.564	X/V	39.2	-3.8	35.4	54.0	18.6	122	182
12619.345	X/V	37.4	-5.2	32.2	54.0	21.8	190	184
19368.110	X/V	37.6	-10.7	26.9	54.0	27.1	100	4
24667.278	X/V	40.0	-11.1	28.9	54.0	25.1	151	96
30509.600	X/V	70.8	-21.3	49.5	54.0	4.5 **(*)**	190	324

Note: Level AV = Reading AV + Factor dB(uV/m) = 20 × Log_{10}(uV/m)

(*) DCCF factor was not considered.

(*) The measured result is below the specification limit by a margin less than the measurement uncertainty; it is therefore not possible to determine compliance at a level of confidence of 95%. However, the measured result indicates a high probability that the tested product complies with the specification limit.

Table 19: Radiated Emission, Peak Data, 1 - 40GHz, Horizontal and Vertical Antenna Orientations, Mode A

Freq. [MHz]	EUT / Antenna Orientation	Reading PK [dBµV]	Factor [dB(1/m)]	Level PK [dBµV/m]	Limit [dBµV/m]	Margin PK [dB]	Height [cm]	Angle [°]
1499.747	X/V	57.2	-17.4	39.8	74.0	34.2	196	214
7407.564	X/V	53.1	-3.8	49.3	74.0	24.7	122	182
12619.345	X/V	51.5	-5.2	46.3	74.0	27.7	190	184
19368.110	X/V	51.8	-10.7	41.1	74.0	32.9	100	4
24667.278	X/V	54.1	-11.1	43.0	74.0	31.0	151	96
30509.600	X/V	74.0	-21.3	52.7	74.0	21.3	190	324

Note: Level PK = Reading PK + Factor, dB(uV/m) = 20 × Log_{10}(uV/m)

Table 20: Radiated Emission, Average Data, 1 - 40GHz, Horizontal and Vertical Antenna Orientations, Mode B

Freq. [MHz]	EUT / Antenna Orientation	Reading AV [dBµV]	Factor [dB(1/m)]	Level AV [dBµV/m]	Limit [dBµV/m]	Margin AV [dB]	Height [cm]	Angle [°]
1499.360	X/V	41.4	-17.4	24.0	54.0	30.0	198	142
7430.324	X/V	39.2	-3.8	35.4	54.0	18.6	108	181
12615.606	X/V	37.5	-5.2	32.3	54.0	21.7	207	185
24667.856	X/V	39.9	-11.1	28.8	54.0	25.2	143	96
30624.570	X/V	71.3	-21.0	50.3	54.0	3.7 **(*)**	199	321

Note: Level AV = Reading AV + Factor, dB(uV/m) = 20 × Log_{10}(uV/m)

(*) DCCF factor was not considered.

(*) The measured result is below the specification limit by a margin less than the measurement uncertainty; it is therefore not possible to determine compliance at a level of confidence of 95%. However, the measured result indicates a high probability that the tested product complies with the specification limit.

Table 21: Radiated Emission, Peak Data, 1 - 40GHz, Horizontal and Vertical Antenna Orientations, Mode B

Freq. [MHz]	EUT / Antenna Orientation	Reading PK [dBµV]	Factor [dB(1/m)]	Level PK [dBµV/m]	Limit [dBµV/m]	Margin PK [dB]	Height [cm]	Angle [°]
1499.360	X/V	58.2	-17.4	40.8	74.0	33.2	198	142
7430.324	X/V	52.9	-3.8	49.1	74.0	24.9	108	181
12615.606	X/V	51.5	-5.2	46.3	74.0	27.7	207	185
24667.856	X/V	53.7	-11.1	42.6	74.0	31.4	143	96
30624.570	X/V	74.5	-21.0	53.5	74.0	20.5	199	321

Note: Level PK = Reading PK + Factor, dB(uV/m) = 20 × Log_{10}(uV/m)

Table 22: Radiated Emission, Average Data, 1 - 40GHz, Horizontal and Vertical Antenna Orientations, Mode C

Freq. [MHz]	EUT / Antenna Orientation	Reading AV [dBµV]	Factor [dB(1/m)]	Level AV [dBµV/m]	Limit [dBµV/m]	Margin AV [dB]	Height [cm]	Angle [°]
1499.907	X/V	41.8	-17.4	24.4	54.0	29.6	193	250
7390.532	X/V	39.1	-3.8	35.3	54.0	18.7	100	200
12615.664	X/V	37.4	-5.2	32.2	54.0	21.8	170	179
24778.606	X/V	39.9	-11.3	28.6	54.0	25.4	152	130
30739.490	X/V	69.9	-20.7	49.2	54.0	4.8 **(*)**	187	321

Note: Level AV = Reading AV + Factor, dB(uV/m) = 20 × Log_{10}(uV/m)

(*) DCCF factor was not considered.

Table 23: Radiated Emission, Peak Data, 1 - 40GHz, Horizontal and Vertical Antenna Orientations, Mode C

Freq. [MHz]	EUT / Antenna Orientation	Reading PK [dBµV]	Factor [dB(1/m)]	Level PK [dBµV/m]	Limit [dBµV/m]	Margin PK [dB]	Height [cm]	Angle [°]
1499.907	X/V	58.8	-17.4	41.4	74.0	32.6	193	250
7390.532	X/V	53.2	-3.8	49.4	74.0	24.6	100	200
12615.664	X/V	51.2	-5.2	46.0	74.0	28.0	170	179
24778.606	X/V	53.9	-11.3	42.6	74.0	31.4	152	130
30739.490	X/V	73.5	-20.7	52.8	74.0	21.2	187	321

Note: Level PK = Reading PK + Factor, dB(uV/m) = 20 × Log_{10}(uV/m)

Table 24: Radiated Emission, Average Data, above 40GHz, Horizontal and Vertical Antenna Orientations, Mode A

Freq. [GHz]	EUT / Antenna Orientation	Reading AV [dBm]	L_P [dB]	Level EIRP [dBm]	Limit [dBm]	Margin AV [dB]
49.799550	X/V	-103.35	66.44	-36.91	-9.9	27.01
49.809550	X/H	-105.38	66.45	-38.93	-9.9	29.03
71.067410	X/V	-91.80	69.53	-22.27	-9.9	12.37
71.383910	X/H	-91.84	69.57	-22.27	-9.9	12.37

Note: Level EIRP (AV) = Reading AV + L_P

All relevant factors of a pre-amplifier gain, a cable loss, a conversion factor of harmonics mixer, an antenna gain are included in the Reading AV value.

L_P is the free-space propagation path loss, in dB and is calculated by the following formula;

– $L_P = 20 \times \text{Log}_{10}(F) + 20 \times \text{Log}_{10}(d) - 27.5$,

where d = measurement distance in m

where F = measurement center frequency in MHz

Table 25: Radiated Emission, Average Data, above 40GHz, Horizontal and Vertical Antenna Orientations, Mode B

Freq. [GHz]	EUT / Antenna Orientation	Reading AV [dBm]	L_P [dB]	Level EIRP [dBm]	Limit [dBm]	Margin AV [dB]
42.130330	X/H	-105.45	64.99	-40.46	-9.9	30.56
49.874150	X/V	-103.32	66.46	-36.86	-9.9	26.96
71.236660	X/V	-91.96	69.55	-22.41	-9.9	12.51
71.344910	X/H	-91.01	69.57	-21.44	-9.9	11.54

Note: Level EIRP (AV) = Reading AV + L_P

All relevant factors of a pre-amplifier gain, a cable loss, a conversion factor of harmonics mixer, an antenna gain are included in the Reading AV value.

L_P is the free-space propagation path loss, in dB and is calculated by the following formula;

– $L_P = 20 \times \text{Log}_{10}(F) + 20 \times \text{Log}_{10}(d) - 27.5$,

where d = measurement distance in m

where F = measurement center frequency in MHz

Table 26: Radiated Emission, Average Data, above 40GHz, Horizontal and Vertical Antenna Orientations, Mode C

Freq. [GHz]	EUT / Antenna Orientation	Reading AV [dBm]	L_P [dB]	Level EIRP [dBm]	Limit [dBm]	Margin AV [dB]
42.743520	X/H	-104.58	65.12	-39.46	-9.9	29.56
49.862850	X/V	-103.76	66.46	-37.30	-9.9	27.40
71.146910	X/H	-91.72	69.54	-22.18	-9.9	12.28
71.215410	X/V	-91.49	69.55	-21.94	-9.9	12.04

Note: Level EIRP (AV) = Reading AV + L_P

All relevant factors of a pre-amplifier gain, a cable loss, a conversion factor of harmonics mixer, an antenna gain are included in the Reading AV value.

L_P is the free-space propagation path loss, in dB and is calculated by the following formula;

– $L_P = 20 \times \text{Log}_{10}(F) + 20 \times \text{Log}_{10}(d) - 27.5$,

where d = measurement distance in m

where F = measurement center frequency in MHz

5.2.6 Frequency Stability

RESULT: **Pass**

Date of testing:	2022-06-15, 2022-06-20, 2022-06-21
Ambient temperature:	22, 20, 23°C
Relative humidity:	59, 69, 58%
Atmospheric pressure:	1009, 1001, 1004hPa
Kind of test site:	Environment Test Chamber
Temperature range:	-20 to +70°C **(*)**
Temperature step:	10°C
Voltage variations:	85%, 115% to Nominal Voltage 85%, DC +4.25V 115%, DC +5.5V **(**)**
Test mode applied:	A, C
Test configuration applied:	1

Requirements:

FCC §15.255 (f)

Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the temperature range −20°C to + 50°C with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

(*) As the maximum operating temperature is +70°C, the highest temperature was selected at +70°C.
(**) As the maximum rated input voltage of the product is DC 5.5V, the highest voltage variation was 5.5V.

Test procedure:

ANSI C63.10 §9.14

1) The EUT was placed inside an Environment Test Chamber to perform bandwidth measurements. The temperature chamber has a small window that permits locating the receive antenna near the EUT.
2) It was set with the EUT at ambient temperature of 20°C and voltage source set to the EUT nominal operating voltage, a spectrum of the fundamental was recorded by the spectrum analyzer.
3) Power supply to the EUT was varied between 85% and 115% of nominal voltage, and a frequency excursion of the fundamental were recorded.
4) Temperature setting was raised to 70°C, while keeping the power supply at 100% nominal setting. A frequency excursion of the fundamental was recorded.

5) Repeat step 4) at each 10°C increment down to −20°C.

Regarding a measurement procedure for 20dB bandwidth measurement, see the section 5.2.2 of this test report.

Regarding a measurement procedure for 99% bandwidth measurement, see the section 5.2.3 of this test report.

Table 27: Frequency Tolerance, mode A and mode C

Temp. [°C]	Voltage [V]	Lower side of mode A			Higher side of mode C			Calculated Center Frequency [GHz]
		Measured Frequency F_L [GHz]	Limit [GHz]	Margin [MHz]	Measured Frequency F_U [GHz]	Limit [GHz]	Margin [MHz]	
70	5.00	61.02076402	61.00	20.764	61.48054677	61.50	19.453	61.25066
60	5.00	61.01994704	61.00	19.947	61.47976417	61.50	20.236	61.24986
50	5.00	61.01946024	61.00	19.460	61.47924532	61.50	20.755	61.24935
40	5.00	61.01902558	61.00	19.026	61.47883005	61.50	21.170	61.24893
30	5.00	61.01895715	61.00	18.957	61.47875076	61.50	21.249	61.24885
20	5.50	61.01900392	61.00	19.004	61.47880673	61.50	21.193	61.24891
20	5.00	61.01906829	61.00	19.068	61.47885292	61.50	21.147	61.24896
20	4.25	61.01919319	61.00	19.193	61.47898931	61.50	21.011	61.24909
10	5.00	61.01927593	61.00	19.276	61.47908877	61.50	20.911	61.24918
0	5.00	61.01960207	61.00	19.602	61.47939029	61.50	20.610	61.24950
-10	5.00	61.01997253	61.00	19.973	61.47977719	61.50	20.223	61.24987
-20	5.00	61.02031545	61.00	20.315	61.48011652	61.50	19.883	61.25022

Note:
Center Frequency was calculated by the following;
Center Frequency = $(F_H+F_L)/2$

5.3 Conducted Measurements

5.3.1 Conducted Peak Output Power

RESULT: **Pass**

Date of testing:	2022-06-01, 2022-06-02, 2022-06-03
Ambient temperature:	23, 20, 22°C
Relative humidity:	48, 59, 58%
Atmospheric pressure:	1004, 1005, 1003hPa
Measurement distance:	1m
Kind of test site:	Semi Anechoic Chamber
Test mode applied:	A, B, C
Test configuration applied:	1, 2

Requirements:

FCC §15.255 (e)

Except as specified paragraph (e)(1) of §15.255, the peak transmitter conducted output power shall not exceed 500 mW.

Test procedure:

ANSI C63.10 §9.11

Conducted Peak Output Power is calculated from the Radiated Peak e.i.r.p. Power reported in the section 5.2.4 of this test report.

The EUT was placed on non-conductive table raised 80cm above the ground plane in a semi-anechoic chamber.

In additions, 6dB bandwidth was measured with a horn antenna connected to a spectrum analyzer with the following settings:

- RBW = 100kHz, VBW = 300kHz, peak detector with Max Hold

Markers were placed at the lowest and highest intersections of the trace with a 6dBc line to obtain the value of the emission bandwidth.

Table 28: Conducted Peak Output Power, model NJR4652F2S1

Mode	Frequency [GHz]	Peak e.i.r.p. Level [dBm]	Tx Antenna Gain [dBi]	Peak Cond. Level [dBm]	Peak Limit [dBm]	Margin [dB]
A	61.020	5.63	5.0	0.63	26.9	26.3
B	61.250	5.52	5.0	0.52	26.9	26.4
C	61.480	5.09	5.0	0.09	26.9	26.8

Note: Conducted Peak Output Power is calculated by the Peak EIRP power with Tx Antenna gain of the EUT.

Gray shading data is the highest E-field strength in this test report.

Table 29: Conducted Peak Output Power, model NJR4652F2S2

Mode	Frequency [GHz]	Peak e.i.r.p. Level [dBm]	Tx Antenna Gain [dBi]	Peak Cond. Level [dBm]	Peak Limit [dBm]	Margin [dB]
A	61.020	5.18	5.0	0.18	26.9	26.7
B	61.250	5.52	5.0	0.52	26.9	26.4
C	61.480	5.16	5.0	0.16	26.9	26.7

Note: Conducted Peak Output Power is calculated by the Peak EIRP power with Tx Antenna gain of the EUT.

Table 30: 6dB Bandwidth (Chirp Disable), model NJR4652F2S1

Mode	6dB Bandwidth Edge Side	Edge Frequency [GHz]	Limit [GHz]	Margin [MHz]
A	Lower side	61.019112196	61.00	19.112196
	Higher side	61.019278923	-/-	-/-
C	Lower side	61.478918429	-/-	-/-
	Higher side	61.479080952	61.50	20.919048
6dB Bandwidth [MHz] (*)		459.968756 > 100 [MHz]		

Note: **(*)** The 6dB Bandwidth was calculated by a lower side of the Lowest Channel and a higher side of the Highest Channel in accordance with the 2021 TCBC workshop materials (KDB Sharing).

Figure 10: 6dB Bandwidth, Mode A

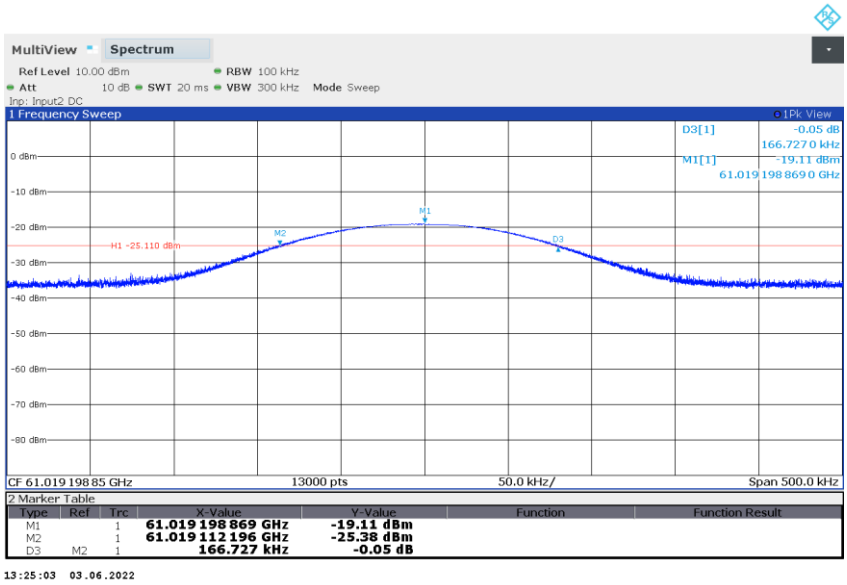
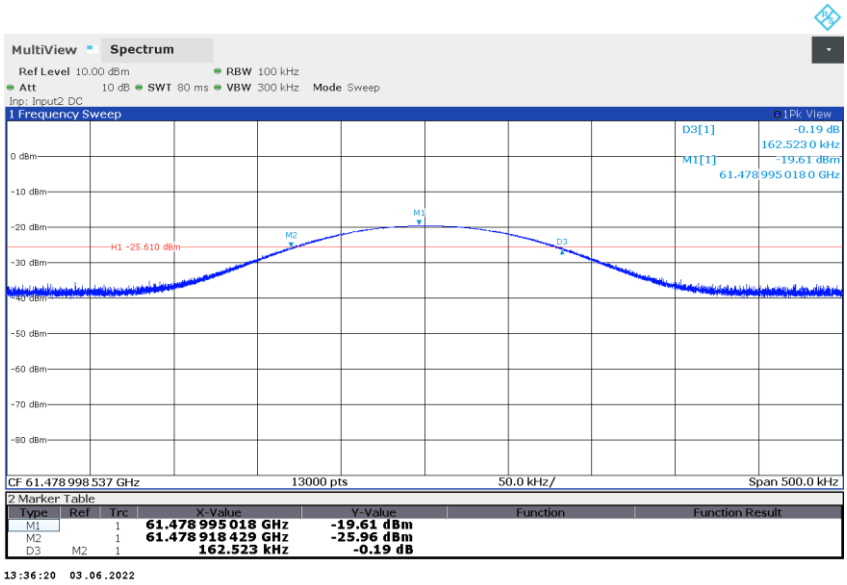


Figure 11: 6dB Bandwidth, Mode C



5.4 AC Power Line Conducted Measurements

5.4.1 AC Power Line Conducted Emission of Transmitter

RESULT: **Pass**

Date of testing:	2022-07-05, 2022-07-06
Ambient temperature:	19, 24°C
Relative humidity:	66, 65%
Atmospheric pressure:	1005, 1001hPa
Frequency range:	0.15 - 30MHz
Equipment classification:	Class B
Kind of test site:	Shielded Room
Test mode applied:	A, B, C
Test configuration applied:	1

Requirements:

FCC §15.207

The AC power line conducted emission on any frequency within the band 150kHz to 30MHz shall not exceed the limits specified in FCC §15.207.

Test procedure:

ANSI C63.10 §6.2

The EUT was placed on a wooden table raised 80cm above the reference ground plane. A vertical conducting plane of the screened room was located 40cm to the rear of the EUT. The AC adapter of the EUT was connected to a Line Impedance Stabilization Network (LISN).

The physical arrangement of the test system and associated cabling was varied to determine the effect on the EUT's emissions in amplitude and frequency in order to ensure that maximum emission amplitudes were attained.

The measurements were performed with a receiver operating in the CISPR quasi-peak and average detection modes. The receiver’s 6dB bandwidth was set to 9kHz.

Pre-checks have been performed in the above mentioned operation modes to determine which mode produces the highest emission level, final measurements were performed for the worst case operation mode C and the mode D1.

The highest emission amplitudes relative to the appropriate limit were recorded in this report. Emissions other than those mentioned are small or not detectable.

Table 31: AC Power Line Conducted Emission, 0.15 - 30MHz, Quasi Peak and Average Data, Phase N (N) and L1 (L), Mode C

Freq. [MHz]	Phase	Reading QP [dBµV]	Reading AV [dBµV]	Factor [dB]	Level QP [dBµV]	Level AV [dBµV]	Limit QP [dBµV]	Limit AV [dBµV]	Margin QP [dB]	Margin AV [dB]
0.3200	N	31.2	23.2	9.7	40.9	32.9	59.7	49.7	18.8	16.8
4.8570	N	15.0	5.7	10.1	25.1	15.8	56.0	46.0	30.9	30.2
16.4000	N	20.3	13.4	10.6	30.9	24.0	60.0	50.0	29.1	26.0
23.8350	N	16.2	13.5	10.8	27.0	24.3	60.0	50.0	33.0	25.7
0.3190	L1	31.4	23.0	9.7	41.1	32.7	59.7	49.7	18.6	17.0
5.0210	L1	13.0	3.0	10.1	23.1	13.1	60.0	50.0	36.9	36.9
16.4790	L1	20.8	14.6	10.5	31.3	25.1	60.0	50.0	28.7	24.9
23.8350	L1	15.6	12.9	10.7	26.3	23.6	60.0	50.0	33.7	26.4

Note: Level QP = Reading QP + Factor, Level AV = Reading AV + Factor

Table 32: AC Power Line Conducted Emission, 0.15 - 30MHz, Quasi Peak and Average Data, Phase N (N) and L1 (L), Mode C

Freq. [MHz]	Phase	Reading QP [dBµV]	Reading AV [dBµV]	Factor [dB]	Level QP [dBµV]	Level AV [dBµV]	Limit QP [dBµV]	Limit AV [dBµV]	Margin QP [dB]	Margin AV [dB]
0.3220	N	30.7	22.9	9.7	40.4	32.6	59.7	49.7	19.3	17.1
0.6680	N	15.3	6.8	9.7	25.0	16.5	56.0	46.0	31.0	29.5
16.4070	N	20.0	13.7	10.6	30.6	24.3	60.0	50.0	29.4	25.7
23.8350	N	16.8	14.1	10.8	27.6	24.9	60.0	50.0	32.4	25.1
0.3230	L1	30.9	23.7	9.7	40.6	33.4	59.6	49.6	19.0	16.2
1.0510	L1	14.7	6.8	9.8	24.5	16.6	56.0	46.0	31.5	29.4
15.4810	L1	20.8	15.6	10.5	31.3	26.1	60.0	50.0	28.7	23.9
23.8340	L1	16.1	13.5	10.7	26.8	24.2	60.0	50.0	33.2	25.8

Note: Level QP = Reading QP + Factor, Level AV = Reading AV + Factor

LDO Type B (Serial number #3) was additionally tested in this test item.

7. List of Tables

8. List of Figures

9. List of Photographs

– End of test report –