ANTENNA TEST REPORT

Test Place

Company Name	UL Japan, Inc. Ise EMC Lab.
Address	4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 Japan
Telephone Number	+81-596-24-8999

Equipment Under Test (EUT)

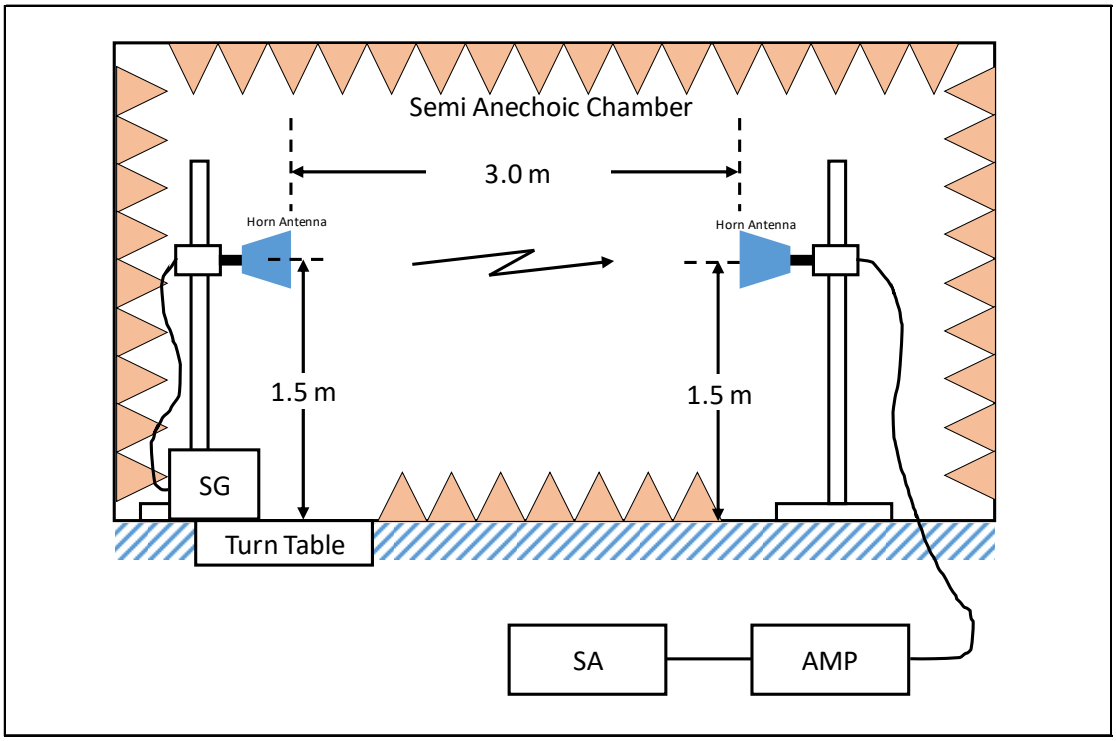
Description	BLE ECU
Manufacturer	DENSO CORPORATION
Model Number	17EAE
Frequency of Operation	2400 MHz to 2483.5 MHz
Antenna Type	Inverted F or Loop Antenna

Test Procedure

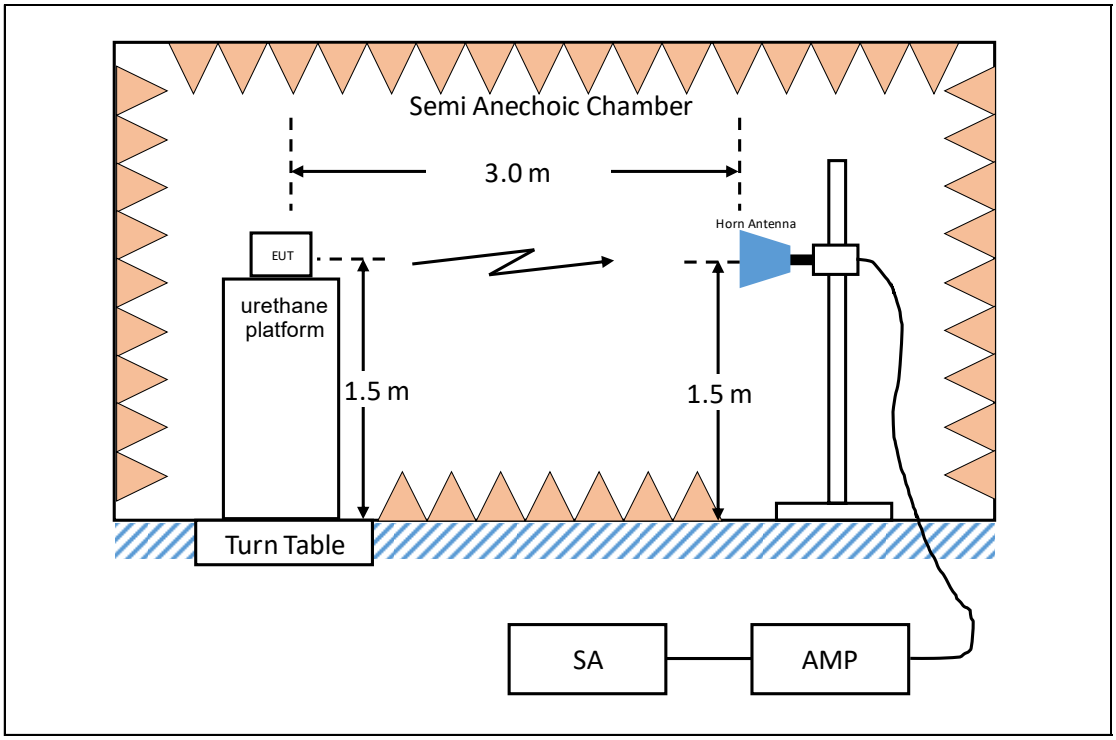
Test configuration	EUT was placed on a platform of nominal size, 0.5 m by 0.5 m, raised 1.5 m above the conducting ground plane. The measurements were performed for both vertical and horizontal antenna polarization with the Spectrum Analyzer. The setup are shown in Figure 1.
Test procedure	Step 1 The tests have been measured in semi anechoic chamber at the distance of 3 m between the Substitution Antenna and the measuring Antenna, both Antennas were placed for the height 1.5 m. The Substitution Antenna has been connected to the Signal Generator. Step 2 The output power of the Signal Generator was setting value calculated by compensating the finite difference in the Antenna gain of Substitution Antenna. Step 3 The electric field strength at the distance of 3 m is received via the measurement antenna, and the reference value at that time is measured with a spectrum analyzer. Step 4 The measurements were performed for both vertical and horizontal antenna polarization. Step 5 Exchanged the Substitution Antenna to the EUT, with the EUT set to CW. Step 6 The EUT was rotated a full revolution and recorded the electric field strength for each degree. Step 7 Calculate and record the EIRP from the difference from the value recorded in Step 6 to the value recorded in Step 3. Step 8 The measurement in steps 5 to 7 repeated with both vertical and horizontal antenna polarization, each position of XY, YZ and ZX-plane of EUT. Step 9 Then the results of Step 8 were recorded. Step 10 Calculate the difference between step 9 and the Output Power of EUT, and recorded the calculated results.

Figure 1: Test Setup

Setup for step 1 to 4



Setup after step 5



SG: Signal Generator
SA: Spectrum Analyzer
AMP: Pre Amplifier

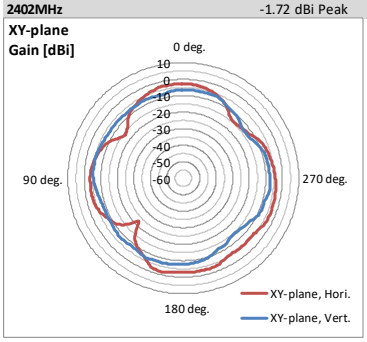
Test Data

Antenna Pattern and Gain

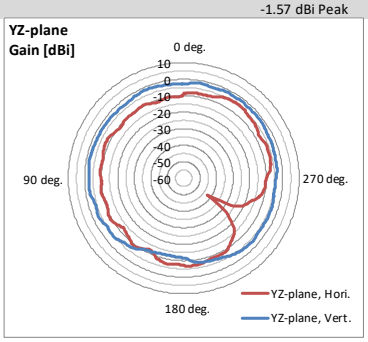
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.2
Date	August 22, 2024
Temperature / Humidity	22 deg. C / 65 % RH
Engineer	Yuichiro Yamazaki
Test Sample / Antenna	EU (1) / Inverted F (Var.2) Antenna

Antenna pattern (Top view)

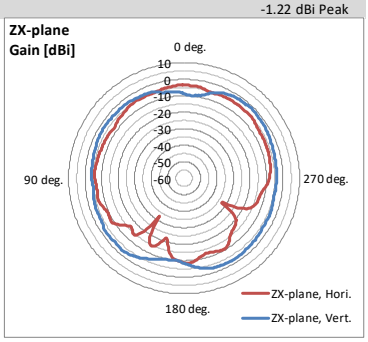
2402MHz



-1.72 dBi Peak

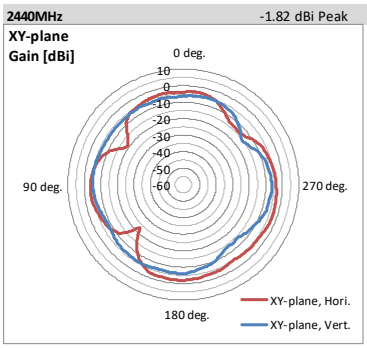


-1.57 dBi Peak

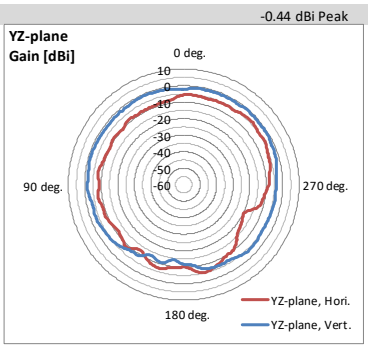


-1.22 dBi Peak

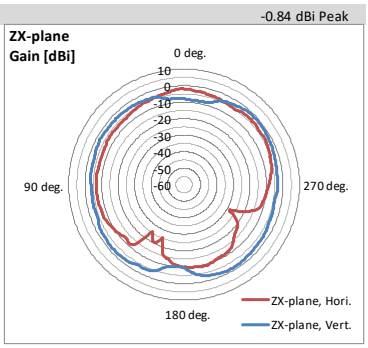
2440MHz



-1.82 dBi Peak

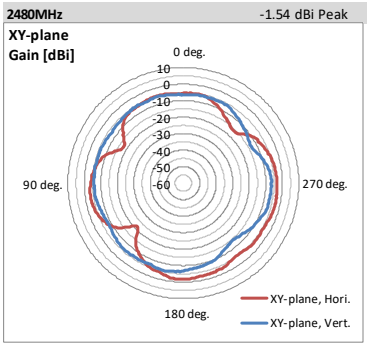


-0.44 dBi Peak

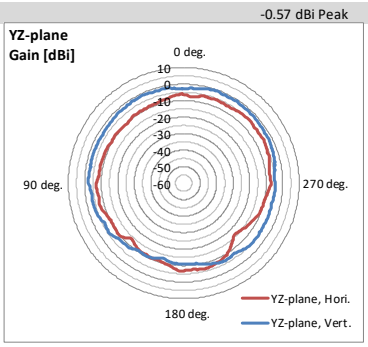


-0.84 dBi Peak

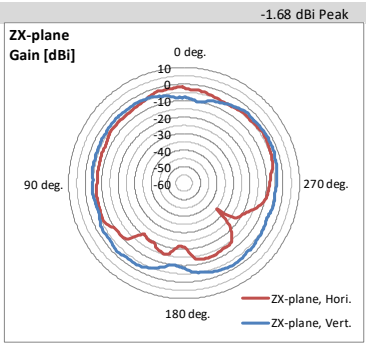
2480MHz



-1.54 dBi Peak



-0.57 dBi Peak



-1.68 dBi Peak

Antenna gain [UNIT: dBi]

Peak

Frequency [MHz]	2402.0	2440.0	2480.0
Peak gain	-1.22	-0.44	-0.57

Average (角度1度毎の値を真値平均した結果)

Frequency [MHz]		2402.0	2440.0	2480.0
XY-plane	Hori.	-5.24	-5.08	-5.41
	Vert.	-8.00	-7.20	-7.19
	Avg (H/V)	-6.41	-6.02	-6.21
YZ-plane	Hori.	-8.73	-7.86	-8.07
	Vert.	-3.59	-3.02	-3.72
	Avg (H/V)	-5.44	-4.80	-5.37
ZX-plane	Hori.	-7.47	-6.79	-6.80
	Vert.	-3.74	-3.34	-4.12
	Avg (H/V)	-5.22	-4.73	-5.26
Total		-5.66	-5.14	-5.59

Hori. : Horizontal
Vert. : Vertical

Average : Result of averaging the true value of the value of each degree of angle.

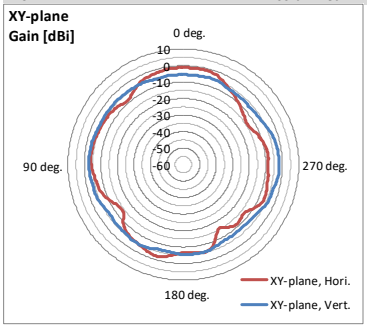
Yellow highlighted area: Maximum Antenna Gain [dBi]

Antenna Pattern and Gain

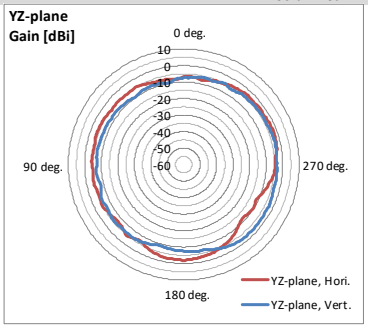
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.2
Date	August 22, 2024
Temperature / Humidity	22 deg. C / 65 % RH
Engineer	Yuichiro Yamazaki
Test Sample / Antenna	EU (2) / Loop Antenna

Antenna pattern (Top view)

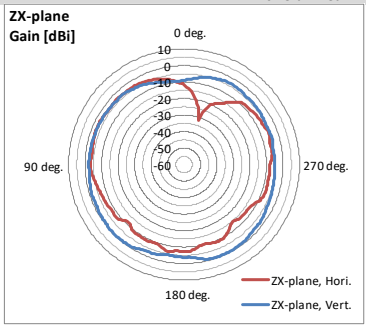
2402MHz



-1.00 dBi Peak

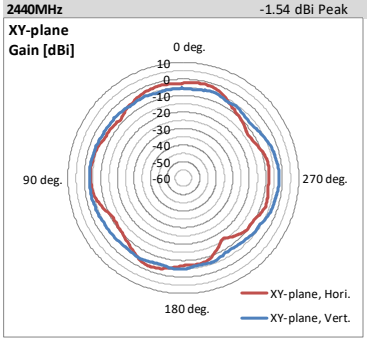


-1.90 dBi Peak

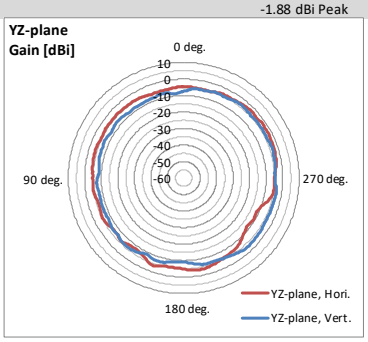


-0.28 dBi Peak

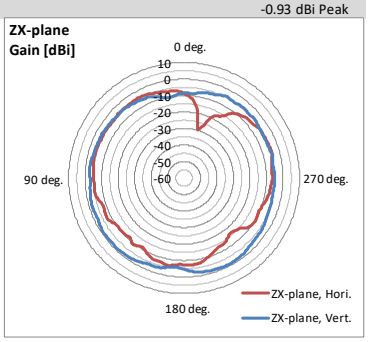
2440MHz



-1.54 dBi Peak

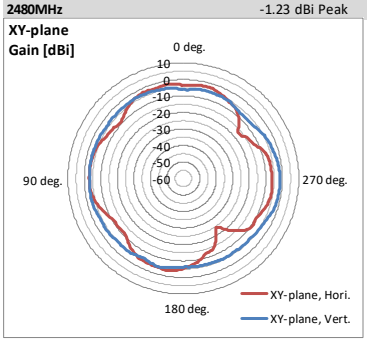


-1.88 dBi Peak

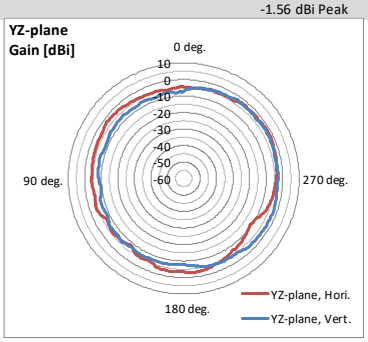


-0.93 dBi Peak

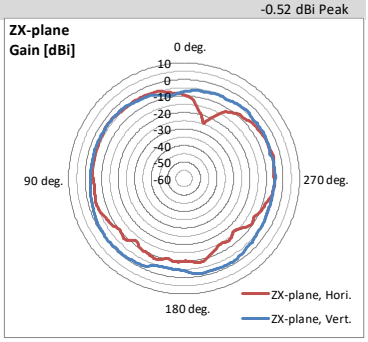
2480MHz



-1.23 dBi Peak



-1.56 dBi Peak



-0.52 dBi Peak

Antenna gain [UNIT: dBi]

Peak

Frequency [MHz]	2402.0	2440.0	2480.0
Peak gain	-0.28	-0.93	-0.52

Average (角度1度毎の値を真値平均した結果)

Frequency [MHz]		2402.0	2440.0	2480.0
XY-plane	Hori.	-5.64	-5.92	-5.87
	Vert.	-4.72	-4.75	-4.14
	Avg (H/V)	-5.15	-5.30	-4.92
YZ-plane	Hori.	-4.83	-4.83	-4.23
	Vert.	-5.48	-5.72	-5.01
	Avg (H/V)	-5.14	-5.25	-4.60
ZX-plane	Hori.	-6.89	-7.19	-6.95
	Vert.	-3.03	-3.68	-3.54
	Avg (H/V)	-4.54	-5.09	-4.92
Total		-4.94	-5.21	-4.81

Hori. : Horizontal
Vert. : Vertical

Average : Result of averaging the true value of the value of each degree of angle.

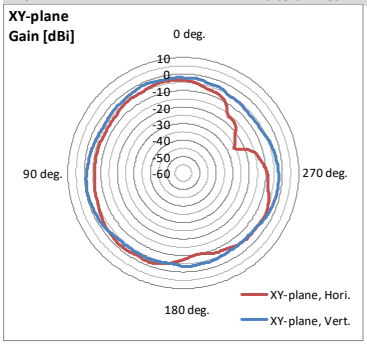
Yellow highlighted area: Maximum Antenna Gain [dBi]

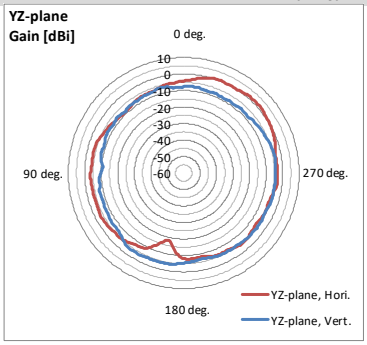
Antenna Pattern and Gain

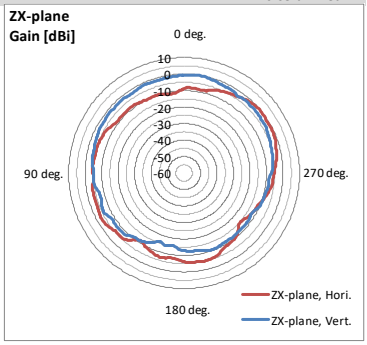
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.2
Date	August 22, 2024
Temperature / Humidity	22 deg. C / 65 % RH
Engineer	Yuichiro Yamazaki
Test Sample / Antenna	EU (8) / Inverted F (Var.1) Antenna

Antenna pattern (Top view)

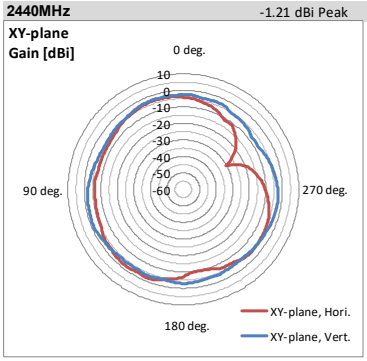
2402MHz

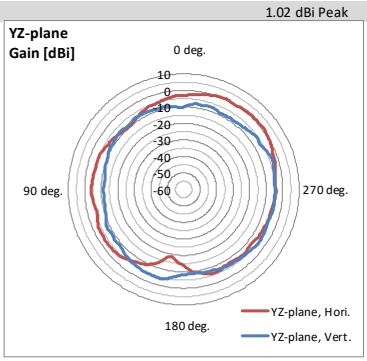


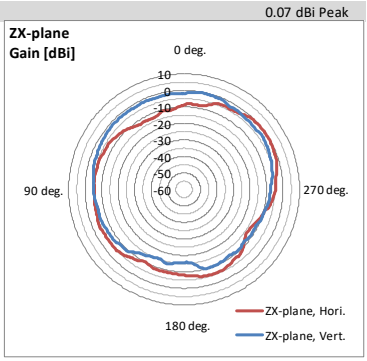




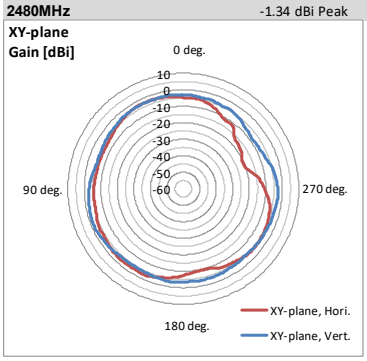
2440MHz

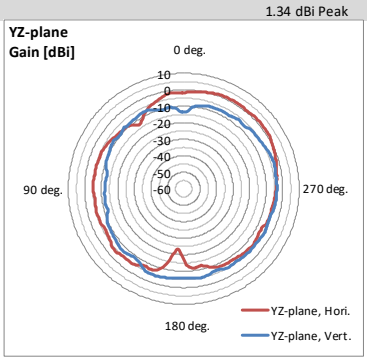


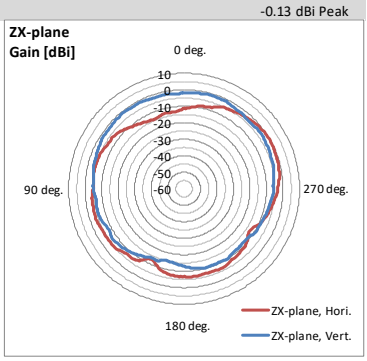




2480MHz







Antenna gain [UNIT: dBi]

Peak

Frequency [MHz]	2402.0	2440.0	2480.0
Peak gain	1.44	1.02	1.34

Average

Frequency [MHz]		2402.0	2440.0	2480.0
XY-plane	Hori.	-5.64	-5.72	-5.61
	Vert.	-3.19	-3.63	-3.75
	Avg (H/V)	-4.24	-4.55	-4.58
YZ-plane	Hori.	-3.69	-3.93	-3.63
	Vert.	-6.18	-6.84	-6.60
	Avg (H/V)	-4.76	-5.15	-4.86
ZX-plane	Hori.	-5.46	-5.55	-5.41
	Vert.	-4.58	-4.75	-4.57
	Avg (H/V)	-5.00	-5.13	-4.97
Total		-4.65	-4.93	-4.80

Hori. : Horizontal
Vert. : Vertical

Average : Result of averaging the true value of the value of each degree of angle.

Yellow highlighted area: Maximum Antenna Gain [dBi]

Test Instruments

Test Equipment

Test Item	LIMS ID	Description	Manufacturer	Model	Serial	Last Calibration Date	Cal Int
APG	142004	AC2_Semi Anechoic Chamber(NSA)	TDK	Semi Anechoic Chamber 3m	DA-06902	2023/12/12	24
APG	244707	Thermo-Hygrometer	HIOKI E.E. CORPORATION	LR5001	231202102	2024/01/25	12
APG	141542	Digital Tester	Fluke Corporation	FLUKE 26-3	78030611	2024/08/06	12
APG	142228	Measure, Tape, Steel	KOMELON	KMC-36	-	-	-
APG	142006	AC2_Semi Anechoic Chamber(SVSWR)	TDK	Semi Anechoic Chamber 3m	DA-06902	2023/04/17	24
APG	141512	Horn Antenna 1-18GHz	Schwarzbeck Mess-Elektronik OHG	BBHA9120D	254	2023/10/17	12
APG	141978	Spectrum Analyzer	Keysight Technologies Inc	E4448A	MY46180899	2024/05/09	12
APG	141580	MicroWave System Amplifier	Keysight Technologies Inc	83017A	MY39500779	2024/03/08	12
APG	246001	Microwave Cable	Huber+Suhner	SF103/11PC35/ 11PC35/1000mm / SF126E/5000mm	800673(1m) / 610204(5m)	2024/03/06	12
APG	141892	Signal Generator	Keysight Technologies Inc	E8257D	US49280311	2023/11/24	12
APG	214065	Microwave cable	Huber+Suhner	SF-126E/11PC35/ 11PC35/10000	550489/126E	2024/01/22	12
APG	141514	Horn Antenna 1-18GHz	Schwarzbeck Mess-Elektronik OHG	BBHA9120D	01611	2024/06/25	12
APG	141420	Attenuator	Weinschel Associates	WA56-10	56100307	2024/05/22	12
APG	141398	Microwave Cable 1G-40GHz	Suhner	SUCOFLEX102	30813/2	2024/05/27	12

***Hyphens for Last Calibration Date and Cal Int (month) are instruments that Calibration is not required (e.g. software), or instruments checked in advance before use.**

The expiration date of the calibration is the end of the expired month.
As for some calibrations performed after the tested dates, those test equipment have been controlled by means of an unbroken chains of calibrations.

All equipment is calibrated with valid calibrations. Each measurement data is traceable to the national or international standards.

Test item: APG: Antenna Pattern and Gain