

## TEST REPORT

Test Report No.: 1-1622/20-01-16-A

BNetzA-CAB-02/21-102

### Testing Laboratory

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**Accredited Testing Laboratory:**

The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2018-03) by the Deutsche Akkreditierungsstelle GmbH (DAkkS). The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate starting with the registration number: D-PL-12076-01.

### Applicant

**Caterpillar Inc.**

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IL 61629 Peoria / United States of America  
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### Manufacturer

Caterpillar Inc.  
100 N.E. Adams Street  
IL 61629 Peoria / United States of America

### Test Standard/s

**FCC - Title 47 CFR  
Part 15: 2021-08**

FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices

**ANSI C63.4: 2014-06**

American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

### Test Item

**Kind of test item:** Subsystem  
**Model name:** Caterpillar PL444 (NA)  
detailed information see chapter 6.1 and 6.2 of this test report



This test report is electronically signed and valid without handwritten signature. The public keys can be requested at the test laboratory to verify the electronic signatures.

### Test report authorised:

Jens Hennemann  
Lab Manager  
Electromagnetic Compatibility & Acoustics

### Test performed:

Holger Medrow  
Testing Manager  
Electromagnetic Compatibility & Acoustics

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## 2 General information

### 2.1 Notes and disclaimer

The test results of this test report relate exclusively to the test item specified in this test report. CTC advanced GmbH does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item.

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The present test report can only be used for the sDOC procedure in the USA if the „Responsible Party“ (located in USA) or an official of the responsible party confirms the report in writing, as designated in FCC§2.938.

This test report is electronically signed and valid without handwritten signature. For verification of the electronic signatures, the public keys can be requested at the testing laboratory.

## 2.2 Application details

Date of receipt of order: 2021-03-05  
Date of receipt of test item: 2021-08-31  
Start of test<sup>1)</sup>: 2021-08-31  
End of test<sup>1)</sup>: 2021-08-31  
Person(s) present during the test: Mr. Gollasch

<sup>1)</sup> Date of each measurement, if not shown in the plot, can be requested. Dates are stored in the measurement software.

## 3 Test standard/s:

Test Standard	Test Standard Description
<b>FCC - Title 47 CFR Part 15: 2021-08</b>	FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices
<b>ANSI C63.4: 2014-06</b>	American National Standard for Methods of Measurement of Radio- Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
<b>ICES-003, Issue 6: 2017-04</b>	Interference-Causing Equipment Standard Digital Apparatus

## 4 Test Environment

Temperature: 15°C – 35°C  
Relative humidity content: 30 % - 60 %  
Air pressure: 860 – 1060 hPa  
Power supply of measurement equipment: 230 V / 50 Hz

## 5 Test Laboratories sub-contracted

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## 6 Information about Test Conditions

### 6.1 Test Item

<b>Kind of test item</b> :	<b>Subsystem</b>		
<b>Type identification</b> :	Caterpillar PL444 (NA)		
<b>Equipment classification:</b>	Equipment for vehicular use		
<b>Environment classification:</b>	Residential, commercial and light industry		
<b>Supply voltage</b> :	9 - 32V DC		
<b>Ports</b> : (maximum cable lengths declared by manufacturer)	<b>Description</b>	<b>Direction</b>	<b>Length</b>
	multi function port	In-/output	< 3m
<b>Is mounting position / usual operating position defined?</b>			No
<b>Additional information:</b>			
- this is a class B digital device: the instructions furnished the user shall include a statement according to §15.105 of the used FCC rules - the build in radio parts are not part of this test report and already tested FCC ID: PQMPL444			

### 6.2 EUT: Type, S/N etc. and Short Descriptions Used in this Test Report

short description*)	EUT	Type	S/N serial number	HW hardware status	SW software status
<b>EUT A</b>	Caterpillar subsystem	PL444(NA)	210812011006004Z	A3C09188501 00 PL444 (NA)	LEAP 21.1.0.0

\*) EUT short description is used to simplify the identification of the EUT in this test report.

### 6.3 EUT Set-up(s)

EUT set-up no.*)	Combination of EUT and AE	Remarks
<b>set. 1</b>	EUT A	---

\*) EUT set-up no. is used to simplify the identification of the EUT set-up in this test report.

### 6.4 EUT Operating Modes

EUT operating mode no.*)	Description of operating modes	Additional information
<b>op. 1</b>	Powered, active and radio idle	---

\*) EUT operating mode no. is used to simplify the test report.

## 7 Summary of Test Results

- ☒ No deviations from the technical specifications were ascertained  
☐ There were deviations from the technical specifications ascertained

### 7.1 Emission

#### 7.1.1 Enclosure

EMI Phenomenon	Frequency range	Basic standard	Result
Radiated Interference Field Strength	30 - 1000 MHz	FCC Part 15 Class B	passed
Radiated Interference Field Strength	> 1 GHz	FCC Part 15 Class B	passed

#### 7.1.2 AC Mains Power Input/Output Ports

EMI Phenomenon	Frequency range	Basic standard	Result
Conducted interference voltage	0,15– 30 MHz	FCC Part 15 Class B	NA7

#### Remarks:

NA1	Not tested because not required by used standard
NA2	Test not applicable because port does not exists
NA3	Test not applicable because port only for services
NA4	Test not applicable because port lengths not longer than 3m
NA5	Not tested because not required by customer
NA6	Not tested because used frequency < 108 MHz
NA7	Not tested because the device is for vehicular use

## 7.2 Measurement and Test Set-up

Note: The test configuration is in accordance with the requirements given in the standards in point 3

## 7.3 Measurement uncertainty

The uncertainty of the measurement equipment fulfils CISPR 16 and the related European and national standards.

The semi anechoic chamber fulfils the requirements of CISPR 16-1 (ANSI C63.4) for a test volume of 4m Ø.

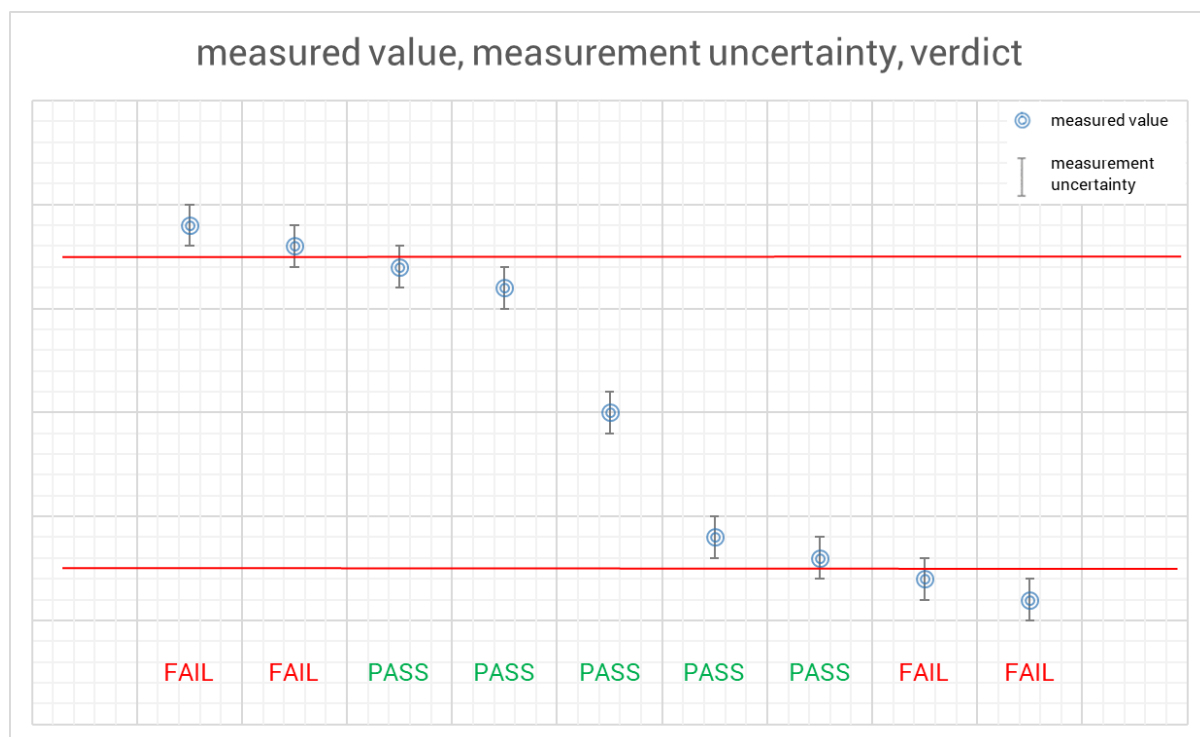
The table below shows the measurement uncertainties for each measurement method. The expended uncertainty (k=2 or 95%) was calculated with worst case values.

Measurement Method	Frequency area Impulse duration time	Description	Expanded uncertainty (k=2 or 95%)
<b>Radiated Emission FCC part 15 B, ANSI C63.4</b>	30 MHz – 18 GHz	- / -	± 4.28 dB
<b>Conducted Emission FCC part 15 B, ANSI C63.4</b>	9 kHz – 30 MHz	- / -	± 3.49 dB

## 7.4 Reporting statements of conformity – decision rule

Only the measured values related to their corresponding limits will be used to decide whether the equipment under test meets the requirements of the test standards listed in chapter 3.

The measurement uncertainty is mentioned in this test report, see chapter above, but is not taken into account - neither to the limits nor to the measurement results. Measurement results with a smaller margin to the corresponding limits than the measurement uncertainty have a potential risk of more than 5% that the decision might be wrong."



## 8 Detailed test results - Emission

### 8.1 Electromagnetic Radiated Emissions (Distance 10 m)

#### 8.1.1 Instrumentation for Test (see equipment list)

F 1	F 2	F 4b	F 5	F 6	F 7	F 8	F 28				
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#### 8.1.2 Test Plan

<b>EUT set-up</b>	set 1		
<b>Operating mode</b>	<b>Application</b>	<b>Limit</b>	<b>Result</b>
op 1	Enclosure	FCC part 15 B Class B	passed

**Remarks:** Powered by external power supply (24V DC)

#### 8.1.3 Radiated Limits

Frequency- range	FCC part 15 B Class B	FCC part 15 B Class A
30 MHz – 88 MHz	30 dB $\mu$ V/m	39,1 dB $\mu$ V/m
88 MHz – 216 MHz	33,5 dB $\mu$ V/m	43,5 dB $\mu$ V/m
216 MHz – 960 MHz	36 dB $\mu$ V/m	46,4 dB $\mu$ V/m
above 960 MHz	44 dB $\mu$ V/m	49,5 dB $\mu$ V/m
	* This values are recalculated from the class B limits at 3 m antenna distance in §15.109 (g 2) of the FCC rules	

#### 8.1.4 Calibration Information

Device	Serial number	Internal Number	Calibration valid until	Calibration interval
ESR 3	1316.3003K03-102587-ct	300005771	12 / 2021	12 month
Trilog Antenna	9163-1029	300005379	08 / 2023	24 month

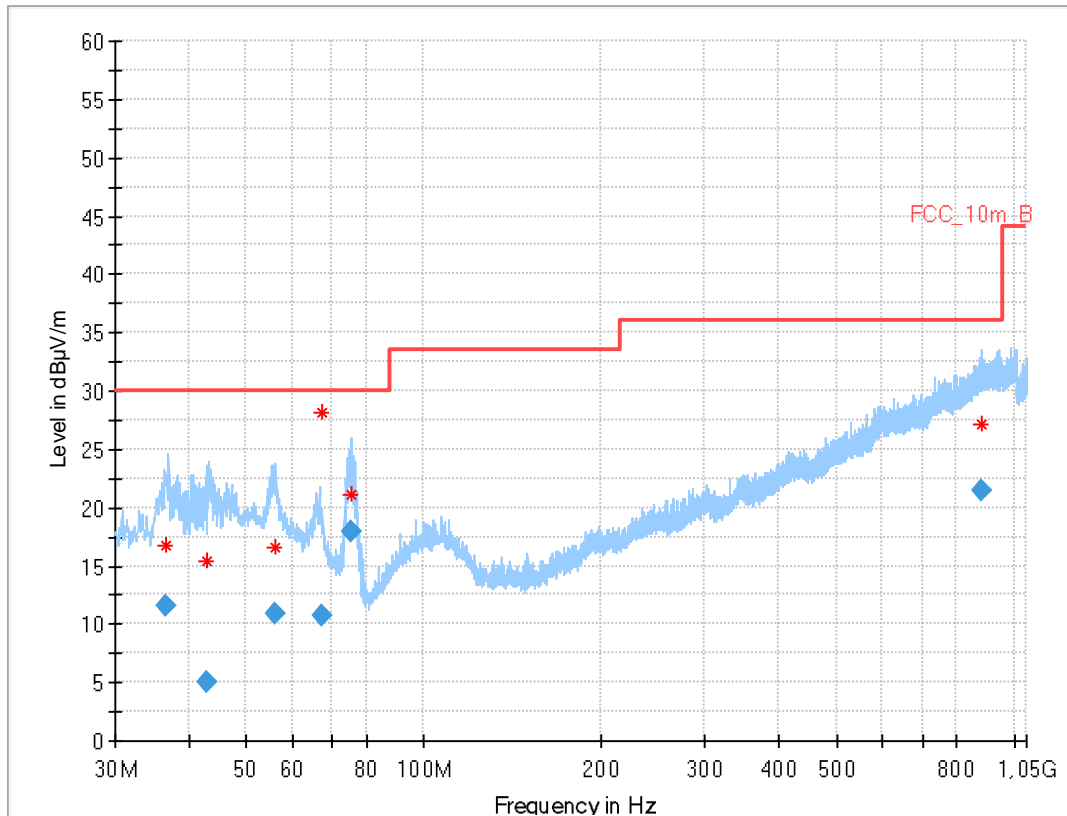
**Remarks:**  
System check of all relevant devices and the chamber (weekly)



## 8.1.5 Test Results

### Common Information

EUT: PL444(NA)  
 Serial number: 210812011006004Z  
 Test description: FCC part 15 B class B 10m  
 Operating condition: powered  
 Operator name: MED  
 Comment: DC: 24 V



### Final\_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
36.547	11.54	30.0	18.5	1000	120.0	200.0	V	-35	14
43.035	5.02	30.0	25.0	1000	120.0	200.0	V	151	15
55.922	10.96	30.0	19.0	1000	120.0	169.0	V	45	16
67.050	10.76	30.0	19.2	1000	120.0	391.0	V	210	12
75.132	17.85	30.0	12.2	1000	120.0	355.0	V	27	9
878.240	21.50	36.0	14.5	1000	120.0	200.0	V	242	25

## 8.1.6 Hardware Set-up

### Subrange 1

<b>Frequency Range:</b>	30 MHz - 2 GHz
<b>Receiver:</b>	ESR 3 [ESR 3] @ GPIB0 (ADR 20), SN 1316.3003K03/102587, FW 3.46 SP1
<b>Signal Path:</b>	without Notch FW 1.0
<b>Antenna:</b>	VULB 9163
<b>Antenna Tower:</b>	Tower [EMCO 2090 Antenna Tower] @ GPIB0 (ADR 8), FW REV 3.12
<b>Turntable:</b>	Turntable [EMCO Turntable] @ GPIB0 (ADR 9), FW REV 3.12
<b>Software version:</b>	EMC32 V10.59.0

### 8.1.7 Sequence of testing

#### Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, a nonconducting table with 0.8 m height is used, which is placed on the ground plane.
- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 10 m or 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

#### Premeasurement

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height changes from 1 m to 3 m.
- At each turntable position, antenna polarization and height the analyzer sweeps three times in peak to find the maximum of all emissions.

#### Final measurement

- The final measurement is performed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximize the peaks by changing turntable position  $\pm 45^\circ$  and antenna height between 1 and 4 m.
- The final measurement is done with quasi-peak detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement with marked maximum final results and the limit is stored.

### 8.1.8 Signal strength calculation

Calculation formula:

$$SS = U_R + CL + AF$$

List of abbreviations:

SS	▶	signal strength
$U_R$	▶	voltage at the receiver
CL	▶	loss of the cable
AF	▶	antenna factor

List with correction factors:

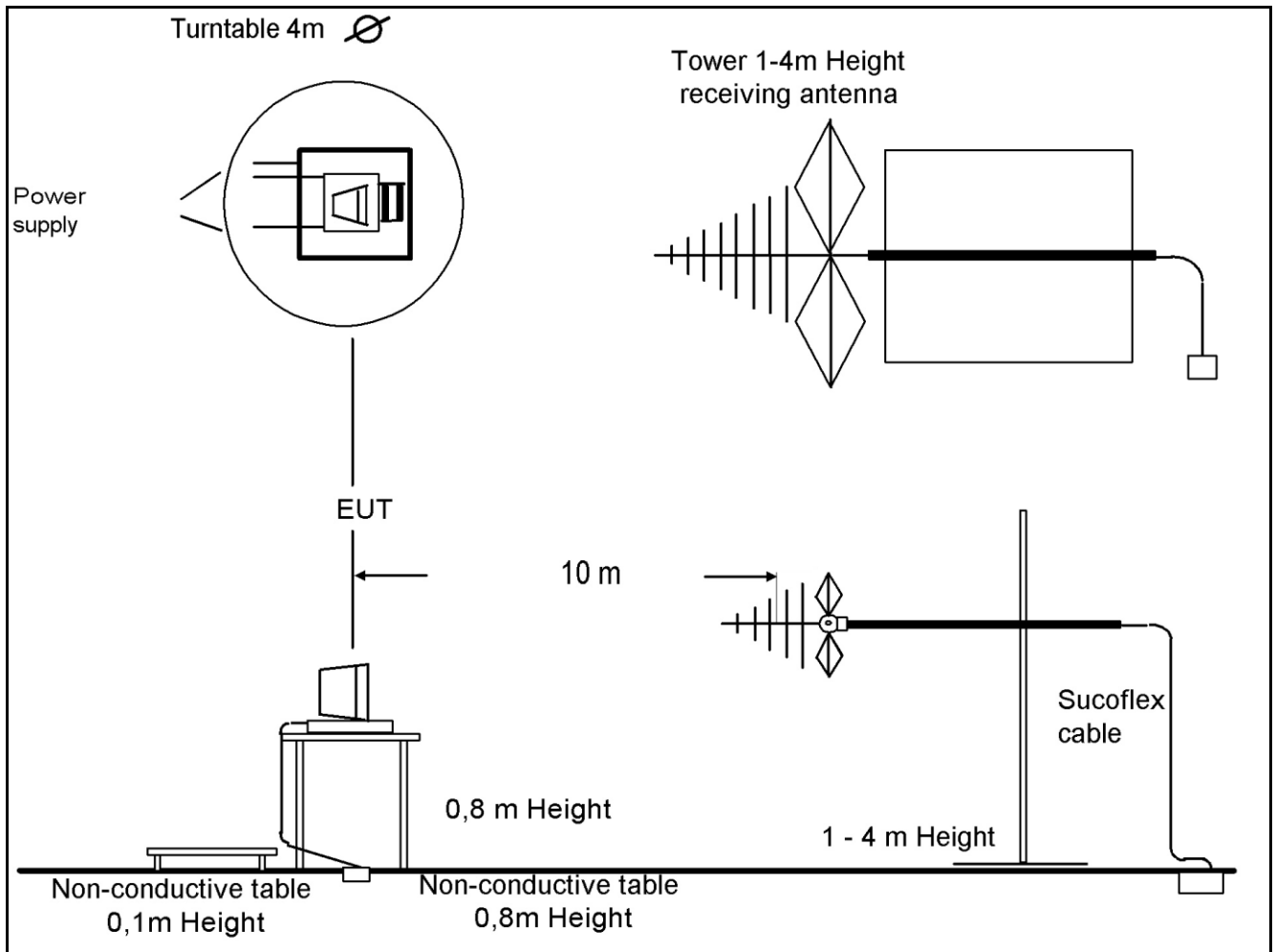
Frequency [MHz]	CL [dB]	AF [1/m]
30,000	0,20	12,30
100,000	0,60	11,30
200,000	1,10	10,60
300,000	1,30	13,20
400,000	1,60	15,30
500,000	1,90	16,80
600,000	2,00	18,80
700,000	2,20	20,30
800,000	2,30	21,50
900,000	2,40	22,80
1000,000	2,50	23,30

Example calculation:

For example at 500,000 000 MHz the measured Voltage ( $U_R$ ) is 12,35 dB $\mu$ V, the loss of the cable (CL) is 1,90 dB and the antenna factor (AF) is 16,80 dB ( $m^{-1}$ ) the final result will be calculated:

$$SS [dB\mu V/m] = 12,35 [dB\mu V] + 1,90 [dB] + 16,80 [dB (m^{-1})] = \underline{31,05 [dB\mu V/m] (35,69 \mu V/m)}$$

### 8.1.9 Test Set-up



## 8.2 Electromagnetic Radiated Emissions (Distance 5 m)

### 8.2.1 Instrumentation for Test (see equipment list)

F 1	F 6	F 28	F 30	F 32	F 33						
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### 8.2.2 Test Plan

<b>EUT set-up</b>	set 1		
<b>Operating mode</b>	<b>Application</b>	<b>Limit</b>	<b>Result</b>
op 1	Enclosure	FCC part 15 B Class B	passed

<b>Remarks:</b>	The measured values are recalculated from 5m to 3m distance Powered by external power supply (24V DC)
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### 8.2.3 Radiated Limits

Frequency- range	47CFR15: (FCC part 15 B) Class B	47CFR15: (FCC part 15 B) Class A *
above 1GHz	54 dBµV/m	59,5 dBµV/m
		* This values are recalculated from the class A limits at 10 m antenna distance in §15.109 (g 2) of the FCC rules.

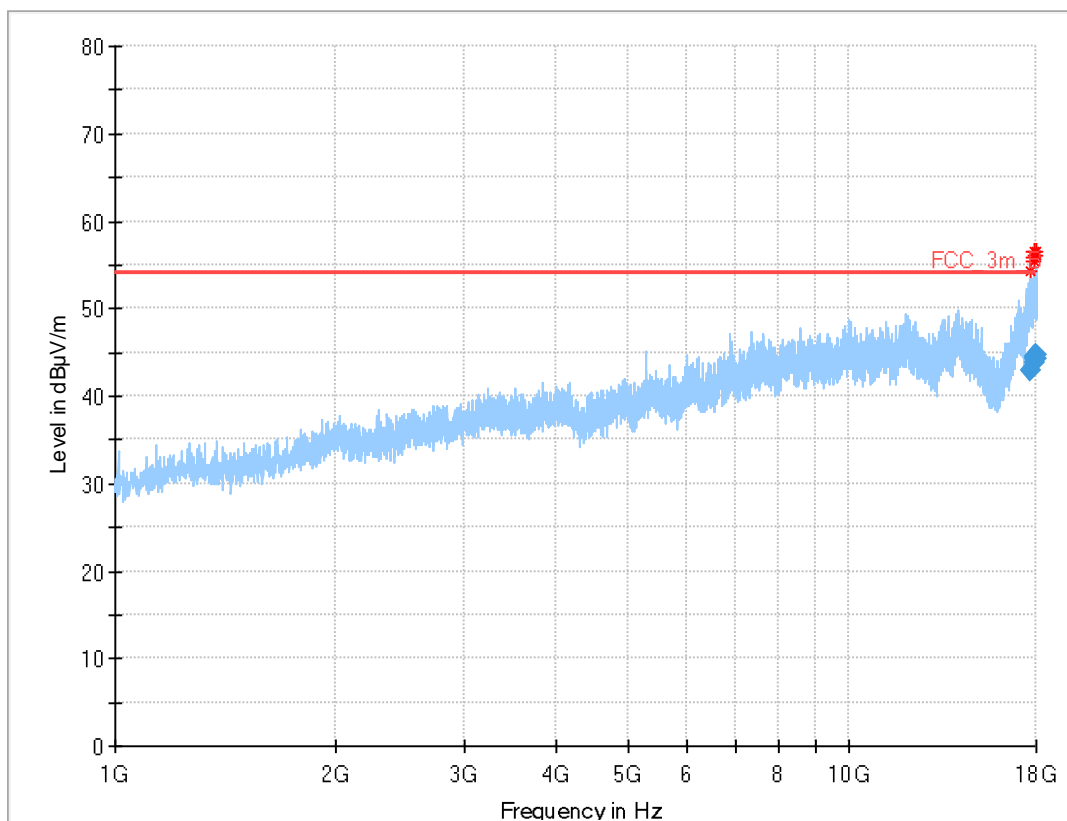
### 8.2.4 Calibration Information

Device	Serial number	Internal Number	Calibration valid until	Calibration interval
<b>FSU 26</b>	200809	300003874	12/2021	12 month
<b>Horn Antenna</b>	9107-3697	300001605	03/2023	24 month
Remarks: System check of all relevant devices and the chamber (weekly)				

## 8.2.5 Test Results

### Common Information

EUT: PL444(NA)  
 Serial number: 210812011006004Z  
 Test description: FCC part 15 B class B  
 Operating condition: powered  
 Operator name: MED  
 Comment: DC: 24 V



### Final Result

Frequency (MHz)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
17685.394	42.89	54.0	11.1	1000	1000.0	V	325	17	
17861.724	43.71	54.0	10.3	1000	1000.0	H	182	19	
17894.021	44.32	54.0	9.7	1000	1000.0	V	107	19	
17894.678	44.39	54.0	9.6	1000	1000.0	H	101	19	
17979.009	44.34	54.0	9.7	1000	1000.0	V	260	20	
17995.351	44.62	54.0	9.4	1000	1000.0	H	231	20	

## 8.2.6 Hardware Set-up

### Subrange 1

<b>Frequency Range:</b>	1 GHz - 18 GHz
<b>Receiver:</b>	FSU 26 [FSU 26] @ GPIB0 (ADR 17), SN 200809/026, FW 4.71
<b>Signal Path:</b>	1_18_EN FW 1.0
<b>Antenna:</b>	Horn Antenna EMCO 3115
<b>Turntable:</b>	Turntable [EMCO Turntable] @ GPIB0 (ADR 9), FW REV 3.12
<b>Software version:</b>	EMC32 V10.59.0

1



## 8.2.7 Sequence of testing

### Setup

- The Equipment was setup to simulate a typical usage like described in the user manual / or described by manufacturer.
- If the EUT is a tabletop system, a nonconducting table with 0,8 m height is used, which is placed on the ground plane.
- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
- Auxiliary equipment and cables were positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- The measurement distance is: (see ANSI C 63.4)  
< 18 GHz = 5 m  
The EUT was set into operation.

### Premeasurement

- The turntable rotates continuous from 0° to 360°
- The antenna is polarized vertical and horizontal.
- In accordance to the antenna beam and the size of the EUT the antenna height changes in 30 cm steps, start at 1 meter. If it is not possible to tilt the emissions will be checked with a manually tilted antenna from top side.
- The analyzer scans quickly to find the maximum emissions of the EUT

### Final measurement

- The final measurement will be performed with minimum the six highest peaks (depends on emissions and number of measured points below 1 GHz)
- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position ( $\pm 45^\circ$ ).
- The final measurement will be done with AV (Average / see ANSI C 63.4) detector
- The final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit, and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

## 8.2.8 Signal strength calculation

### Calculation formula:

$$SS = U_R + CL + AF + PA + DC$$

### List of abbreviations:

SS	▶	signal strength
$U_R$	▶	voltage at the receiver
CL	▶	loss of the cable and gain of the preamp
AF	▶	antenna factor
DC	▶	distance correction (results measured on 5 m calculated to 3 m)

List with correction factors: column CL in table contains cable factor and preamplifier correction

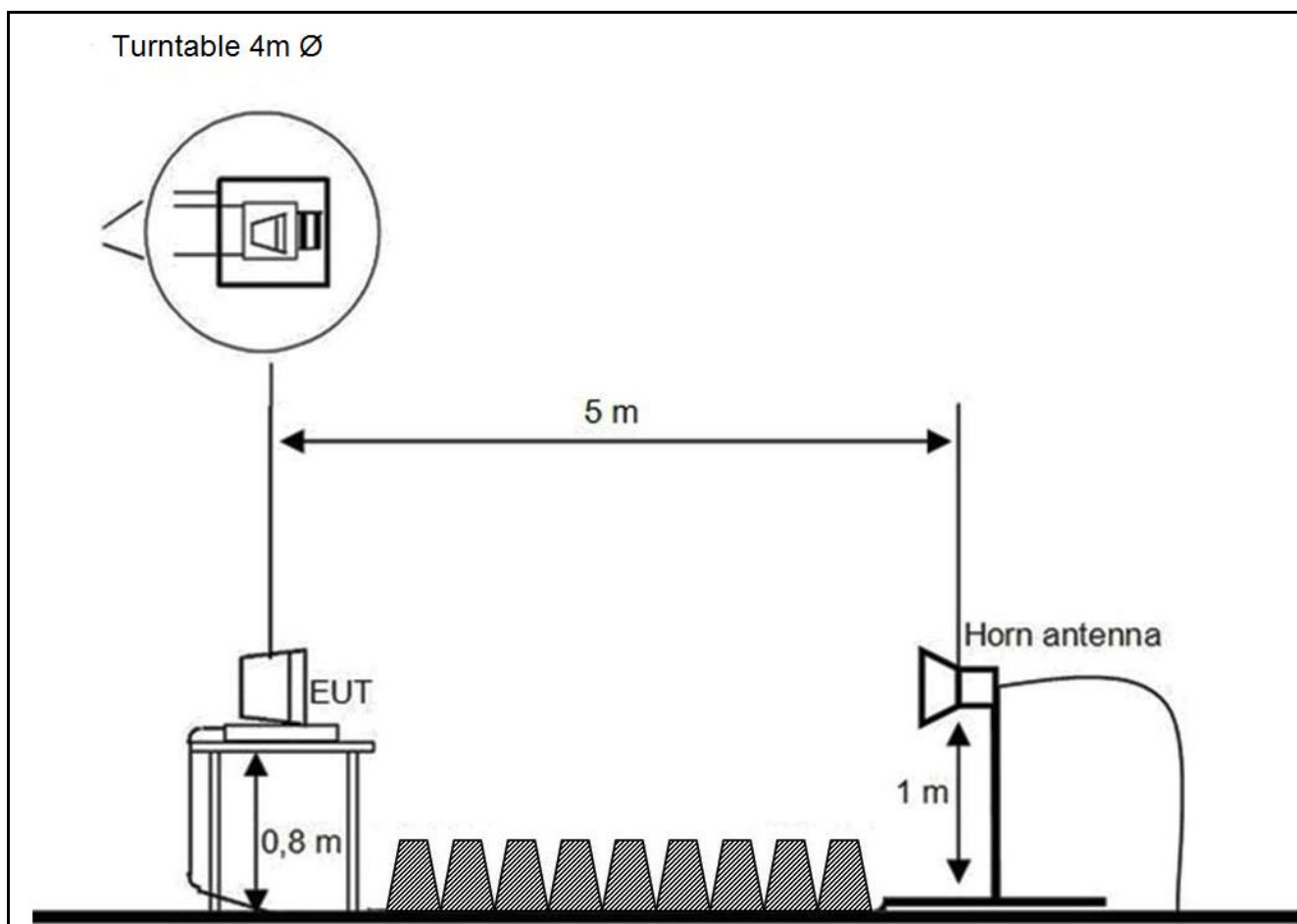
Frequency [GHz]	CL [dB]	AF [dB1/m]	DC [dB]
1,000	-35,50	24,40	4,40
1,500	-35,20	25,10	4,40
2,000	-35,10	27,40	4,40
2,500	-35,00	28,50	4,40
3,000	-34,70	30,20	4,40
3,500	-34,80	31,20	4,40
4,000	-35,00	32,60	4,40
4,500	-34,90	32,50	4,40
5,000	-34,80	33,40	4,40
5,500	-34,35	34,10	4,40
6,000	-34,00	34,40	4,40
6,500	-33,50	34,50	4,40
7,000	-33,10	35,50	4,40
7,500	-33,40	36,50	4,40
8,000	-33,80	36,90	4,40
8,500	-33,75	37,20	4,40
9,000	-33,70	37,40	4,40
9,500	-33,50	37,50	4,40
10,000	-33,40	37,90	4,40
11,000	-35,90	38,30	4,40
12,000	-34,40	39,10	4,40
13,000	-37,30	39,30	4,40
14,000	-36,20	41,30	4,40
15,000	-36,90	40,10	4,40
16,000	-34,90	37,60	4,40
17,000	-35,60	40,80	4,40
18,000	-35,70	45,70	4,40

### Example calculation:

For example at 4,000 000 000 GHz the measured Voltage ( $U_R$ ) is 46,13 dB $\mu$ V, the loss of the cable (CL) is -35,00 dB, the antenna factor (AF) is 32,60 dB(m-1) and the distance correction (DC) is 4,40 dB the final result will be calculated:

$$SS \text{ [dB}\mu\text{V/m]} = 46,13 \text{ [dB}\mu\text{V]} + (-35,00) \text{ [dB]} + 32,60 \text{ [dB(m-1)]} + 4,4 \text{ [dB]} = 48,13 \text{ [dB}\mu\text{V/m]} \text{ (202,53 } \mu\text{V/m)}$$

## 8.2.9 Test Set-up



## 9 Test equipment and ancillaries used for tests

To simplify the identification of the test equipment and/or ancillaries which were used, the reporting of the relevant test cases only refer to the test item number as specified in the table below.

No.	Instrument/Ancillary	Manufacturer	Type	Serial-No.	Internal identification
<b>Radiated emission in chamber F</b>					
F-1	Control Computer	F+W		2934939v001	300005258
F-2	Trilog-Antenna	Schwarzbeck	VULB 9163	9163-1029	300005379
F-3a	Amplifier	Veritech Microwave Inc.	0518C-138	- / -	- / -
F-4b	Switch	Netgear	GS108P	26V12A3H50336	300000368
F-5	EMI Test receiver	R&S	ESR	1316.3003K03-102587-ct	300005771
F-6	Turntable Interface-Box	EMCO / ETS-LINDGREN	Model 105637	44583	300003747
F-7	Tower/Turntable Controller	EMCO / ETS-LINDGREN	Model 2090	64672	300003746
F-8	Tower	EMCO / ETS-LINDGREN	Model 2175	64762	300003745
F-9	Ultra Notch-Filter Rejected band Ch. 62	WRCD		9	
<b>Radiated immunity in chamber F</b>					
F-10	Control Computer	F+W		2934939v001	300005258
F-11	Signal Generator	R&S	SMB 100A	1406.6000k02-113856	300005266
F-13	RF-Amplifier	Bonn	BLWA 0860-250/100D	035491	300003210
F-14	Stacked Logper Antenna	Schwarzbeck	STLP9128 E	9128 E 013	300003408
F-14a	Bicon-Antenna	EMCO	3109	8906-2309	300000575
F-14b	Bicon-Antenna	Schwarzbeck	Balun VHBD 9134 elements BBFA 9146	3011 0057	300005385
F-15	RF-Amplifier	ar	1000LM20	20562	-/-
F-16	Directional Coupler	ar	DC7144A	312786	300003411
F-16a	Directional coupler	emv	DC 2000	9401-1677	300000592
F-18	Power Meter	R&S	NRP2	104973	300005114
F-19	Power sensor	R&S	NRP-Z91	103332	300005114-1
F-20	Power sensor	R&S	NRP-Z91	103333	300005114-2
F-28	Power Supply	Hewlett Packard	6032 A	2920 A 04466	300000580
F-35	RF- Amplifier	Bonn	BLMA 2060-5	097392A	300003908
F-36	Stacked Microwave Log.-Per. Antenna	Schwarzbeck	STLP9149	9149-044	300003919
<b>Radiated emission in chamber F &gt; 1GHz</b>					
F-29	Horn antenna	Schwarzbeck	BBHA 9120 B	188	300003896
F-30	Amplifier	ProNova	0518C-138	005	F 024
F-31	Amplifier	Miteq	42-00502650-28-5A	1103782	300003379
F-32	Horn antenna	EMCO	3115	9107-3697	300001605
F-33	Spectrum Analyzer	R&S	FSU26	200809	300003874
F-34	Loop antenna	EMCO	6502	8905-2342	300000256

## 10 Observations

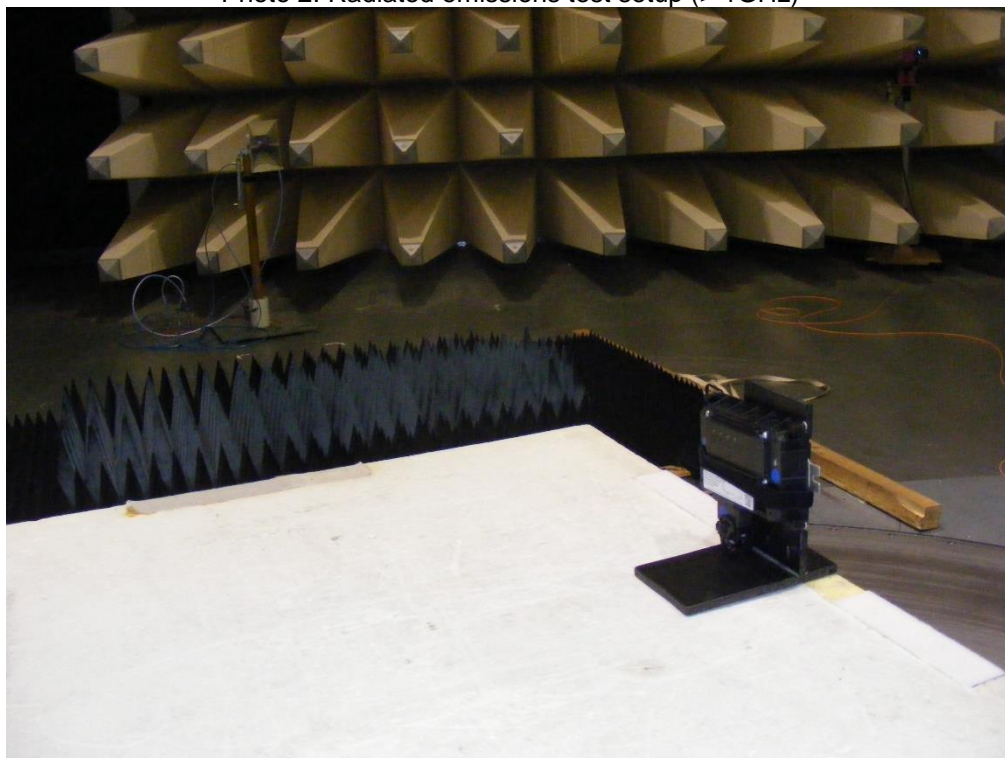
No observations, exceeding those reported with the single test cases, have been made.

## Annex A Photographs of the test set-up

Photo 1: Radiated emissions test setup (< 1GHz)



Photo 2: Radiated emissions test setup (> 1GHz)





## Annex B Photographs of the EUT

Photo 3: EUT A, front side

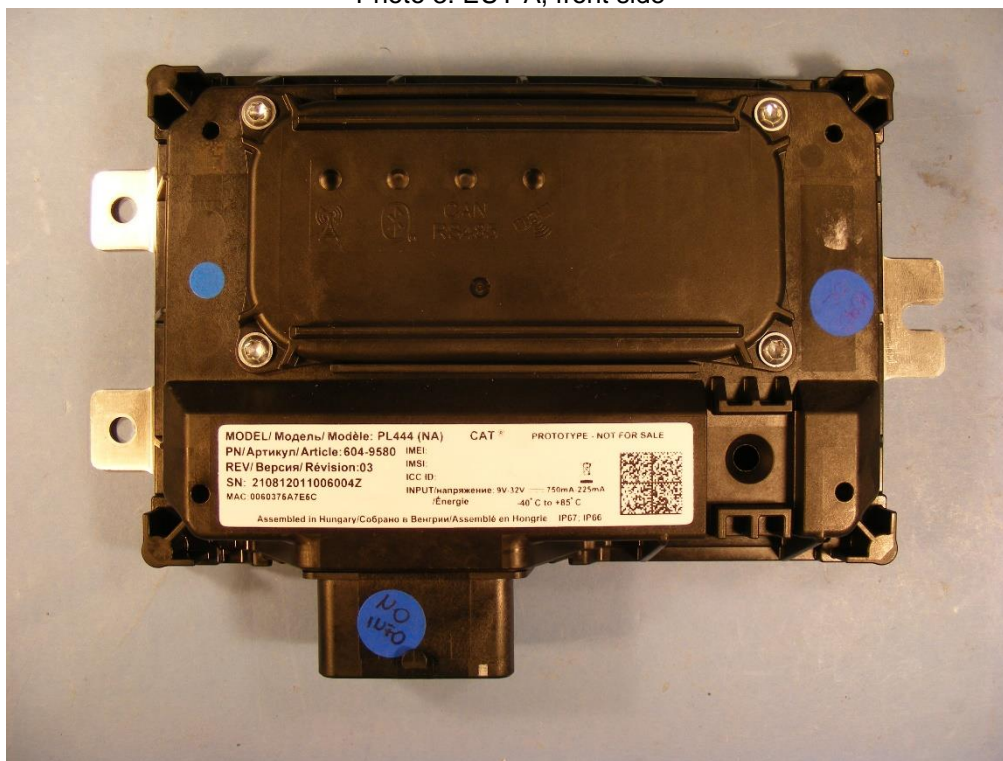


Photo 4: EUT A, rear side

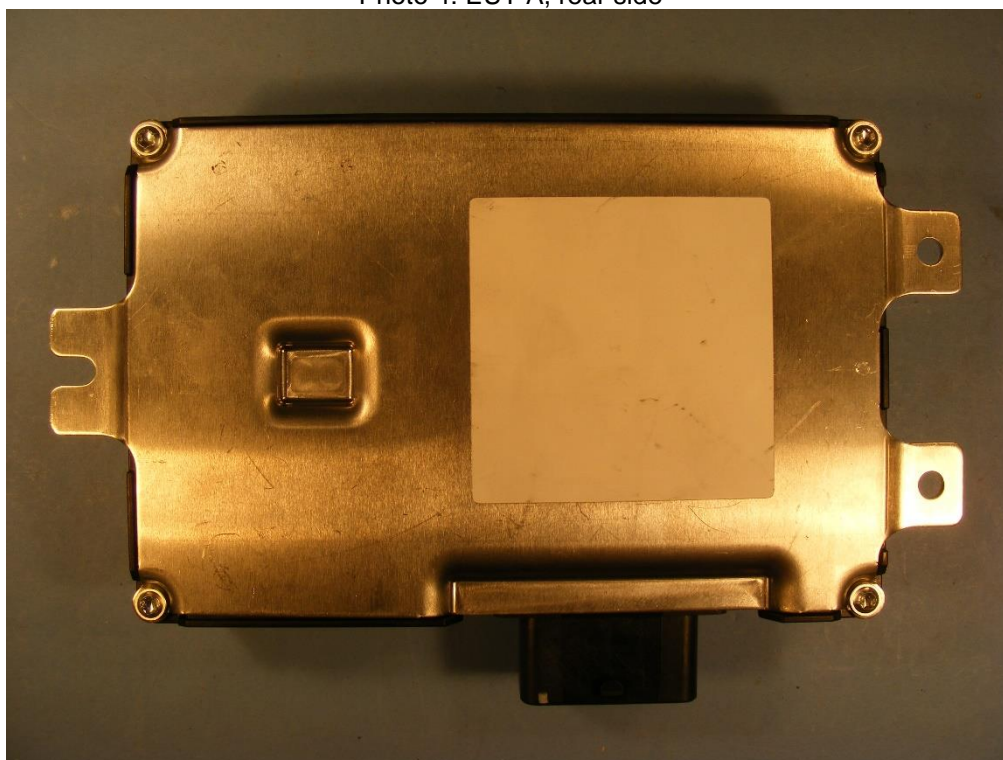


Photo 5: EUT A, port

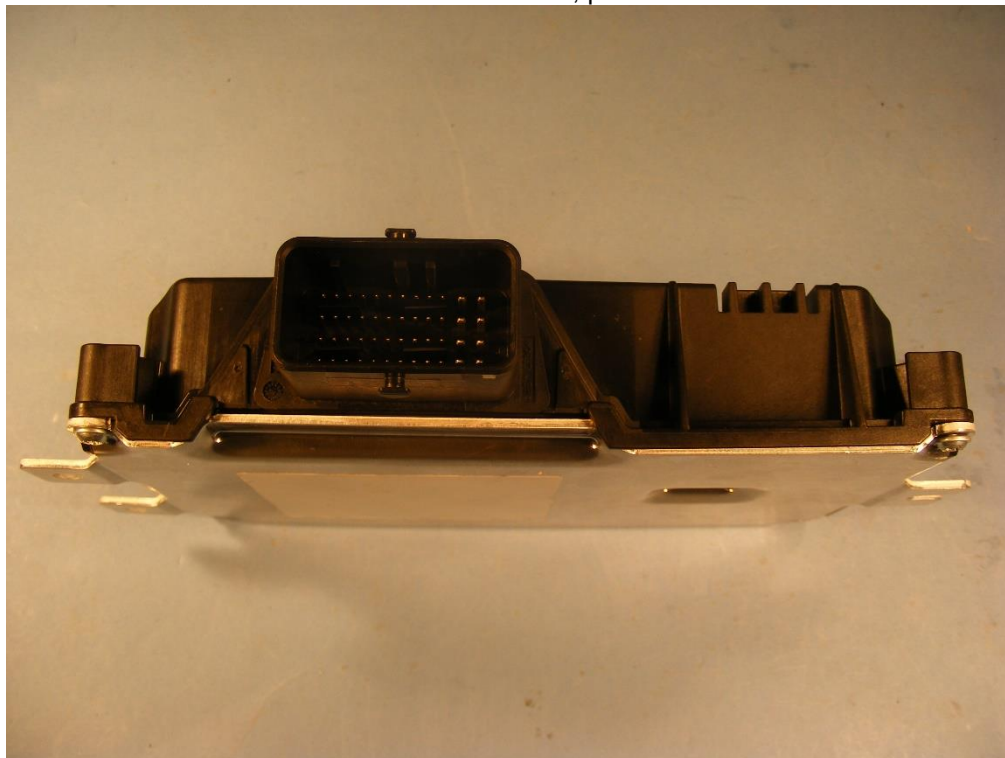
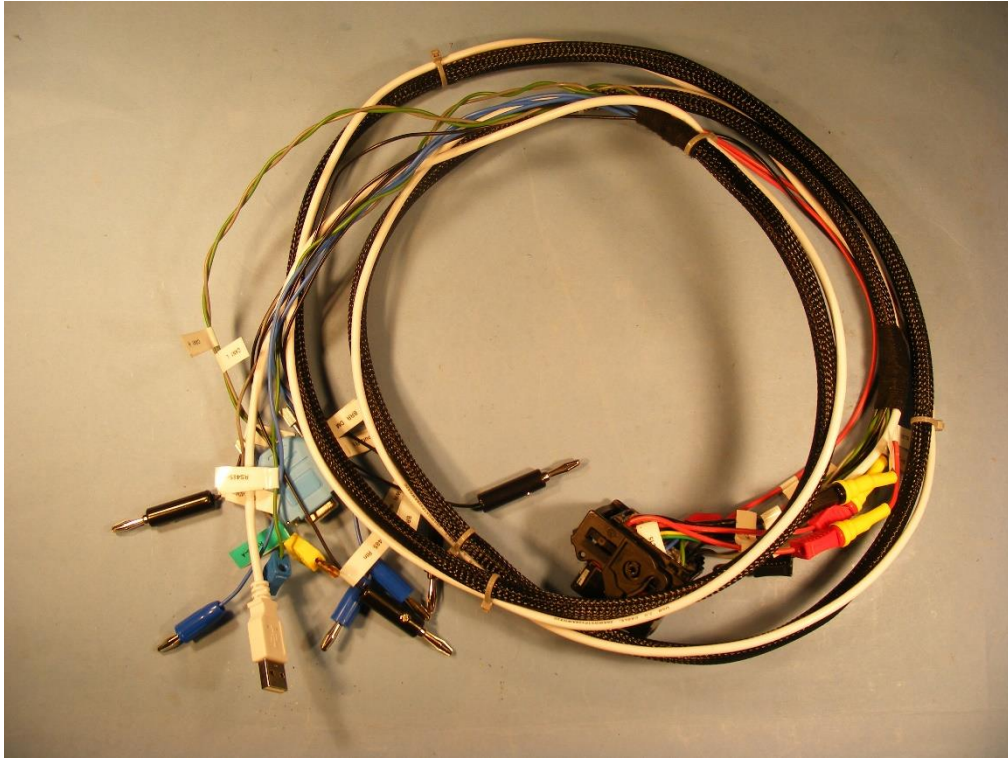


Photo 6: EUT A, label





Photo 7: EUT A, harness



**Annex C Document history**

Version	Applied changes	Date of release
- / -	Initial release	2021-09-22
-A	Editorial changes	2021-10-04

This test report replaces the test report 1-1622/20-01-16 and dated 2021-09-22

**Annex D Further information****Glossary**

DUT	-	Device under Test
EMC	-	Electromagnetic Compatibility
EUT	-	Equipment under Test
FCC	-	Federal Communication Commission
FCC ID	-	Company Identifier at FCC
HW	-	Hardware
IC	-	Industry Canada
Inv. No.	-	Inventory number
N/A	-	not applicable
S/N	-	Serial Number
SW	-	Software