TEST REPORT # EMCC-980162EB, 2001-OCT-23

EQUIPMENT UNDER TEST:

Type:	ARS 100-3
Serial Number (ECU):	1999460003
Serial Number (frontend):	7541047395
Equipment Category:	Part 15 Forward-Looking Field Disturbance Sensor, Vehicle Radar System
Manufacturer:	Automotive Distance Control Systems GmbH, A.D.C.
Address:	Kemptener Strasse 99 88131 Lindau (Bodensee) Germany
Phone:	+49-8382-9699-0
Fax:	+49-8382-9699-19

RELEVANT STANDARD: 47 CFR Part 15C - Intentional Radiators, §15.253

MEASUREMENT PROCEDURE USED:

☒ ANSI C63.4-1992 ☐ FCC/OET MP-4 (1987) ☒ IEEE Std C95.3-1991

TEST REPORT PREPARED BY:

Reinhard Sauerschell
EMCC DR. RAŠEK
Moggast 72-74
91320 Ebermannstadt
Germany
Phone: +49 9194 9016
Fax: +49 9194 8125
E-mail: r.sauerschell@emcc.de

TEST PERSONNEL:

Reinhard Sauerschell

HEAD OF LABORATORY:

Winfried Hoffmann

CONTENTS

Page

1 GENERAL INFORMATION

1.1 Purpose

The purpose of this report is to show compliance to the FCC regulations for devices operating under section 15.253 of the Code of Federal Regulations title 47.

1.2 Limits and Reservations

The test results in this report apply only to the particular Equipment Under Test (EUT) as declared in this report.
This test report shall not be reproduced except in full without the written permission of EMCC DR. RAŠEK.

1.3 Test Location

Company Name:	EMCC DR. RAŠEK
Street:	Moggast 72-74
City:	91320 Ebermannstadt
Country:	Germany
Laboratory:	Test Laboratory of EMCC DR. RAŠEK FCC Registration Number: 90566 This site has been fully described in a report submitted to the FCC, and accepted in the letter dated February 09, 2000 Registration Number 90566.
Phone:	+49-9194-9016
Fax:	+49-9194-8125
E-Mail:	emc.cons@emcc.de
Web:	www.emcc.de

1.4 Manufacturer

Company Name:	Automotive Distance Control Systems GmbH, A.D.C.
Street:	Kemptener Strasse 99
City:	88131 Lindau (Bodensee)
Country:	Germany

Name for contact purposes:	Mr Walter Leichte
Phone:	+49-8382-9699-89
Fax:	+49-8382-9699-94
E-mail:	wleichte@adc-gmbh.de

1.5 Dates

Date of receipt of EUT:	CW 39/2001
Test date:	CW 39/2001 and 42/2001

2 PRODUCT DESCRIPTION

2.1 Equipment Under Test (EUT)

Description:	Adaptive Cruise Control Pulse Doppler RADAR System
Device designation:	Part 15 Forward-Looking Field Disturbance Sensor, Vehicle Radar System
Type:	ARS 100-3
No. of units:	two, RADAR frontend, Electronic Control Unit
Serial number (ECU):	1999460003
Serial number (frontend):	7541047395
FCC ID:	OAYARS100-3
Transmit Frequency:	76 to 77 GHz
Type of modulation:	FM – Pulse Doppler
Class of emission (ITU):	52M0P0N
Measurement distance:	0.5 to 150 m
RF power:	200 µW average nominal
Antenna:	Integral
Power:	12.0 VDC (9 to 32 VDC range)

2.2 EUT Peripherals

The EUT was tested connected with
- CAN-bus simulator for start up and initializing purposes,
- standard laboratory DC power supply.

2.3 Mode of Operation During Testing

The equipment under test (EUT) was operated during the tests under the two following conditions:
- normal operation mode,
- CW mode (for test purposes only) for measuring the carrier power.

Normal operation mode appeared after power on automatically.
CW mode was set via the CAN-bus from a PC.

2.4 Modifications Required for Compliance

None

3 TEST RESULTS SUMMARY

Summary of Test Results

Requirement	CFR Section	Report Section	Test Result
Antenna Requirement	15.203	4	Pass
Conducted Emissions	15.207	5	n.a.
Radiated Spurious Emissions	15.209, 15.205(b), 15.253(c)	6	Pass
Power Density Limits (Fundamental)	15.253(b)	6	Pass
Operation within the band, frequency stability	15.253(e)	7	Pass
Radio frequency exposure	15.253(f)	8	Pass

The client has made the determination that EUT Condition, Characterization, and Mode of Operation are representative of production units, and meet the requirements of the specifications referenced herein.

Consistent with Industry practice, measurement and test equipment not directly involved in obtaining measurement results but having an impact on measurements (such as cable loss, antenna factors, etc.) are factored into the "Correction Factor" documented in certain test results. Instrumentation employed for testing meets tolerances consistent with known Industry Standards and Regulations.

The measurements contained in this report were made in accordance with the procedure ANSI C63.4 - 1992 and IEEE Std C95.3-1991. All requirements were found to be within the limits outlined in this report.
The test results in this report apply only to the particular Equipment Under Test (EUT) as declared in this report.

Test Personnel: Reinhard Sauerschell
Issuance Date: 2001-10-23

4 ANTENNA REQUIREMENT

Test Requirement: FCC CFR47, Part 15C

4.1 Regulation

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. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of Part 15C. The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

4.2 Result

Device:	Adaptive Cruise Control Pulse Doppler RADAR System
Type:	ARS 100-3
Serial number (ECU):	1999460003
Serial number (frontend):	7541047395

Antenna is integral.

The EUT meets the requirements of this section.

5 CONDUCTED EMISSIONS

Test Requirement: FCC CFR47, Part 15C

Test Procedure: ANSI C63.4:1992

5.1 Regulation

Section 15.207 (a) For an intentional radiator which is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 450 kHz to 30 MHz shall not exceed 250 microvolts. Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminals.

Section 15.207 (d) Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or make provision for, the use of battery chargers which permit operating while charging, AC adaptors or battery eliminators or that connect to the AC power lines indirectly, obtaining their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.

5.2 Test Equipment

Not applicable.

5.3 Test Procedures

Not applicable.

5.4 Test Results

Device:	Adaptive Cruise Control Pulse Doppler RADAR System
Type:	ARS 100-3
Serial number (ECU):	1999460003
Serial number (frontend):	7541047395

The EUT is powered from a vehicle battery. Therefore - according to Section 15.207 (d) - conducted emissions measurements to demonstrate compliance with the conducted limits are not required.

6 RADIATED EMISSIONS

Test Requirement: FCC CFR47, Part 15C
Test Procedure: ANSI C63.4:1992

6.1 Regulation

Section 15.253 Operation within the bands 46.7-46.9 GHz and 76.0-77.0 GHz.
(a) Operation within the bands 46.7-46.9 GHz and 76.0-77.0 GHz is restricted to vehicle-mounted field disturbance sensors used as vehicle radar systems. The transmission of additional information, such as data, is permitted provided the primary mode of operation is as a vehicle-mounted field disturbance sensor. Operation under the provisions of this section is not permitted on aircraft or satellites.
(b) The radiated emission limits within the bands 46.7-46.9 GHz and 76.0-77.0 GHz are as follows:
(1) If the vehicle is not in motion, the power density of any emission within the bands specified in this section shall not exceed 200 nW/cm² at a distance of 3 meters from the exterior surface of the radiating structure.
(2) For forward-looking vehicle-mounted field disturbance sensors, if the vehicle is in motion the power density of any emission within the bands specified in this section shall not exceed 60 mW/cm² at a distance of 3 meters from the exterior surface of the radiating structure.
(3) For side-looking or rear-looking vehicle-mounted field disturbance sensors, if the vehicle is in motion the power density of any emission within the bands specified in this section shall not exceed 30 mW/cm² at a distance of 3 meters from the exterior surface of the radiating structure.
(c) The power density of any emissions outside the operating band shall consist solely of spurious emissions and shall not exceed the following:
(1) Radiated emissions below 40 GHz shall not exceed the general limits in Section 15.209 of this part.
(2) Radiated emissions outside the operating band and between 40 GHz and 200 GHz shall not exceed the following:
(i) For vehicle-mounted field disturbance sensors operating in the band 46.7-46.9 GHz: 2 pW/cm² at a distance of 3 meters from the exterior surface of the radiating structure.
(ii) For forward-looking vehicle-mounted field disturbance sensors operating in the band 76-77 GHz: 600 pW/cm² at a distance of 3 meters from the exterior surface of the radiating structure.
(iii) For side-looking or rear-looking vehicle-mounted field disturbance sensors operating in the band 76-77 GHz: 300 pW/cm² at a distance of 3 meters from the exterior surface of the radiating structure.
(3) For radiated emissions above 200 GHz from field disturbance sensors operating in the 76-77 GHz band: the power density of any emission shall not exceed 1000 pW/cm² at a distance of 3 meters from the exterior surface of the radiating structure.
(4) For field disturbance sensors operating in the 76-77 GHz band, the spectrum shall be investigated up to 231 GHz.
(d) The provisions in Section 15.35 of this part limiting peak emissions apply.
(e) 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 to +50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

Section 15.35 Measurement detector functions and bandwidths.
(b) On any frequency of frequencies above 1000 MHz, the radiated limits shown are based upon the use of measurement instrumentation employing an average detector function. When average radiated emission measurements are specified in the regulations, including emission measurements below 1000 MHz, there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit for the frequency being investigated unless a different peak emission limit is otherwise specified in the rules in this part, e.g., see § 15.255. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. Measurement of AC power line conducted emissions are performed using a CISPR quasipeak detector, even for devices for which average radiated emission measurements are specified.

Section 15.209 (a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement distance (meters)
0.009–0.490	2400/F(kHz)	300
0.490–1.705	24000/F(kHz)	30
1.705–30.0	30	30
30–88	100	3
88–216	150	3
216–960	200	3
Above 960	500	3

(b) In the emission table above, the tighter limit applies at the band edges.

(c) The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the level of the fundamental emission. For intentional radiators which operate under the provisions of other sections within this part and which are required to reduce their unwanted emissions to the limits specified in this table, the limits in this table are based on the frequency of the unwanted emission and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.

(d) The emission limits shown in the above table are based on measurements employing a CISPR quasi peak detector except for the frequency bands 9–90 kHz, 110–490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.
(e) The provisions in §§ 15.31, 15.33, and 15.35 for measuring emissions at distances other than the distances specified in the above table, determining the frequency range over which radiated emissions are to be measured, and limiting peak emissions apply to all devices operated under this part.

6.2 Radiated Emissions Test, 9 kHz to 30 MHz (Magnetic Field Test)

6.2.1 Test Equipment

Type	Manufacturer/ Model No.	Serial No.	Last Calibration	Next Calibration
Receiver (9 kHz - 1 GHz)	Rohde & Schwarz ESS	825132/015	Oct. 2000	Oct. 2001
Loop Antenna	R&S HFH 2-Z2	892665/004	June 2000	June 2002

6.2.2 Test Procedures

For tabletop equipment, the EUT is placed on a 1 meter by 1.5 meters wide and 0.8 meter high nonconductive table that sits on a flush mounted metal turntable. Floor standing equipment is placed directly on the flush mounted metal turntable. The EUT is connected to its associated peripherals with any excess I/O cabling bundled to approximately 1 meter.

Emissions from the unit are maximized by adjusting the orientation of the receive loop antenna and rotating the EUT on the turntable. Manipulating the system cables also maximizes EUT emissions.

The EUT was tested as a tabletop equipment, connected with CAN-bus simulator and the power supply to provide the 12 VDC operation power.

The test distance was reduced to 1 … 3 m and comparing the results with the calculated 3 m limit by extrapolating the limit by using the square of an inverse linear distance extrapolation factor (40 dB/decade) according to section 15.31 (f) (2).

The tests were performed in normal operation mode. The initial step in collecting radiated data is a peak scan of the measurement range with an EMI test receiver. The significant peaks within a margin of 25 dB to the limit are then measured with quasi-peak detector.
Worst case radiated emissions are listed under chapter: test results.

Radiated Emissions Test Characteristics (magnetic field test)	
Frequency range	9 kHz - 30 MHz
Test distance	1 … 3 m*
Test instrumentation resolution bandwidth	200 Hz (9 kHz - 150 kHz)
	9 kHz (150 kHz - 30 MHz)
Test instrumentation detector	QP
Receive antenna height	1 m
Receive antenna orientation	0 - 360°

* Section 15.31 (f) (2) At frequencies below 30 MHz, measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field. Pending the development of an appropriate measurement procedure for measurements performed below 30 MHz, when performing measurements at a closer distance than

specified, the results shall be extrapolated to the specified distance by either making measurements at a minimum of two distances on at least one radial to determine the proper extrapolation factor or by using the square of an inverse linear distance extrapolation factor (40 dB/decade).

6.2.3 Calculation of Field Strength Limits

Calculation: microvolts/meter to dBµV/m

Specified parameters			
Frequency	Field Strength		Measurement distance
(MHz)	(µV/m)	(dBµV/m)	(meters)
0.009–0.490	266.7-4.9	48.5-13.8	300
0.490–1.705	49.0-14.1	33.8-23.0	30
1.705–30.0	30	29.5	30

6.2.4 Field Strength Calculation

No special calculation for obtaining the field strength in dBµV/m is necessary, because the EMI receiver and the active loop antenna operate as a system, where the reading gives directly the field strength result (dBµV/m). The gain, antenna factors and cable losses are already taken into consideration.

For test distance other than what is specified, but fulfilling the requirements of Section 15.31 (f) (2) the field strength is calculated by adding additionally an extrapolation factor of 40 dB/decade (inverse linear-distance for field strength measurements). The basic equation with a sample calculation is as follows:

FS = RA + DF
where
FS = Field Strength in dBµV/m
RA = Receiver Amplitude in dBµV/m
DF = Distance Extrapolation Factor in dB,
where DF = 20 log (Dtest/Dspec) where Dtest = Test Distance and Dspec = Specified Distance

Assume the tests performed at a reduced Test Distance of 3 m instead of the Specified Distance of 30 m giving a Distance Extrapolation Factor of DF = 40 log(3m/30m) = -40 dB.
Assuming a receiver amplitude of 40.7 dBµV/m is obtained. The distance factor of -40 dB are added, giving a field strength of 0.7 dBµV/m. The 0.7 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 40.7 - 40 = 0.7 [dBµV/m]

Level in µV/m = Common Antilogarithm (0.7/20) = 1.1

6.2.5 Test Results

Device: Adaptive Cruise Control Pulse Doppler RADAR System
Type: ARS 100-3
Serial number (ECU): 1999460003
Serial number (frontend): 7541047395

PRODUCT EMISSIONS QUASI PEAK DATA									
No	Emission Frequency [MHz]	Receiver Mode and Bandwidth [kHz]	Test Distance [m]	Receiver Reading RA [dBµV/m]	Distance Extrapola-tion Factor for 3 m DF [dB]	Result = Corrected Reading FS [dBµV/m]	Spec Limit [dBµV/m]	Margin [dB]	Remarks
1	0.83	10kHz/QP	1	42.0	-40	2.0	29.1	27.1	
2	1.170	10kHz/QP	1	37.9	-40	-2.1	26.3	28.4	
3	1.330	10kHz/QP	1	39.7	-40	-0.3	25.1	25.4	
4	4.835	10kHz/QP	1	36.9	-40	-3.1	29.5	32.6	
5	10.0	10kHz/QP	1	42.0	-40	2.0	29.5	27.5	
6	30.0	10kHz/QP	1	50.1	-40	10.1	29.5	19.4	

The EUT meets the requirements of this section.

Test Personnel: Reinhard Sauerschell

Test Date: 2001-09-27

6.3 Radiated Emissions Test, 30 MHz to 26.5 GHz

6.3.1 Test Equipment

Type	Manufacturer/ Model No.	Serial No.	Last Calibration	Next Calibration
Receiver (30 MHz - 1 GHz)	Rohde & Schwarz ESS	825132/015	Oct. 2000	Oct. 2001
Antenna (30 MHz - 1 GHz)	EMCO 3143	9604-1269	Oct. 2000	April 2002
Receiver (1 GHz - 26.5 GHz)	Rohde & Schwarz ESAI-D ESMI-RF ESMI-B1	833771/008 833827/002 832504/005	June 2000	Dec. 2001
Antenna (1 GHz - 18 GHz)	Schwarzbeck BBHA 9120 D	137	Oct. 1999	Oct. 2001
Standard Gain Horn Antenna (18 GHz - 26.5 GHz)	Mid Century MC 20/31B	1362/86	May 2000	May 2002

6.3.2 Test Procedures

For tabletop equipment, the EUT is placed on a 1 meter by 1.5 meters wide and 0.8 meter high nonconductive table that sits on a flush mounted metal turntable. Floor standing equipment is placed directly on the flush mounted metal turntable. The EUT is connected to its associated peripherals with any excess I/O cabling bundled to approximately 1 meter.

The EUT was tested as a tabletop equipment, connected with CAN-bus simulator and the power supply to provide the 12 VDC operation power.

The tests were performed in normal operation mode.
The initial step in collecting radiated data is a peak scan of the measurement range with an EMI test receiver under closer distances as given in the rule. The significant peaks are then measured with the appropriate distance and detectors.
Worst case radiated emissions are listed under chapter: test results.

Radiated Emissions Test Characteristics	
Frequency range	30 MHz - 26,500 MHz
Test distance	3 m
Test instrumentation resolution bandwidth	120 kHz (30 MHz - 1,000 MHz)
	1 MHz (1,000 MHz - 26,500 MHz)
Test instrumentation detector	QP (30 MHz - 1,000 MHz)
	AV (1,000 MHz - 26,500 MHz)
Receive antenna scan height	1 m - 4 m
Receive antenna polarization	Vertical/Horizontal

6.3.3 Calculation of Field Strength Limits

Calculation: microvolts/meter to dBµV/m

Frequency	Field Strength		Measurement distance	Remarks
(MHz)	(microvolts/meter)	(dBµV/m)	(meters)	
30–88	100	40	3	
88–216	150	43.5	3	
216–960	200	46	3	
960-26,500	500	54	3	

6.3.4 Average Correction Factor

NOTE: All AV measurements were performed using the test receiver's average detector and the max. hold facility; the average value measured directly without the necessity of additional correction factor.

6.3.5 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF
where
FS = Field Strength in dBµV/m
RA = Receiver Amplitude in dBµV
AF = Antenna Factor in dB(1/m)
CF = Cable Attenuation Factor in dB

Assume a receiver reading of 23.5 dBµV is obtained. The Antenna Factor of 7.4 dB(1/m) and a Cable Factor of 1.1 dB are added, giving a field strength of 32 dBµV/m. The 32 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 23.5 + 7.4 + 1.1 = 32 [dBµV/m]

Level in µV/m = Common Antilogarithm (32/20) = 39.8

6.3.6 Test Results

Device: Adaptive Cruise Control Pulse Doppler RADAR System
Type: ARS 100-3
Serial number (ECU): 1999460003
Serial number (frontend): 7541047395

PRODUCT EMISSIONS DATA 15.205 BANDS											
No	Emission Frequency [MHz]	Receiver Mode and Bandwidth [kHz]	Test Distance [m]	Receiver Reading RA [dBµV]	Correction Factor AF+CF [dB(1/m)]	Distance Extrapola-tion Factor DF [dB]	Result = Corrected Reading FS [dBµV/m]	Spec Limit [dBµV/m]	Polari-zation Ant	Margin [dB]	Remark
1	12,711	1000, PK	3	18.3	40.3	0	58.6	74	v	15.4	
		1000, AV	3	12.4	40.3	0	52.7	54	v	1.3	

The EUT meets the requirements of this section.

Test Personnel: Reinhard Sauerschell

Test Date: 2001-10-18

6.4 Radiated Emissions Test, 26.5 GHz to 231 GHz (outside the operating band)

6.4.1 Test Equipment

Type	Manufacturer/ Model No.	Serial No.	Last Calibration	Next Calibration
Receiver (26.5 GHz - 110 GHz) Waveguide Mixer LO Amplifier	Rohde & Schwarz ESAI-D ESMI-RF ESMI-B1 R&S/Tektronix FS-Z40/WM782A FS-Z60/WM782U FS-Z75/WM782V FS-Z110/WM782W R&S, FS-Z30	 833771/008 833827/002 832504/005 840448/007 840449/001 840450/005 840451/005 775850/002	June 2000	Dec. 2001
Standard Gain Horn Ant.	FMI/Pro N 2224-25	49	May 2000	May 2002
Standard Gain Horn Ant.	FMI/ProN 2424-25	30	May 2000	May 2002
Standard Gain Horn Ant	Electrof./Tho WG25-25	001	May 2000	May 2002
Standard Gain Horn Ant.	Electrof./Tho WG27-25	001	May 2000	May 2002
Spectrum Analyzer	Tektronix 2755A1	B 010245		
Waveguide Mixer	Tektronix WM 490 F	B 020970		
Waveguide Mixer	Tektronix WM 490 G	B 020958		
Waveguide Transition	Tektronix 119-1728-00	678B/0567		
Diplexer	Textronix 015-0385-00	003/900		
Standard Gain Horn Ant.	FMI/Pro N 2824-25	24	May 2000	May 2002
Standard Gain Horn Ant.	FMI/Pro N 3024-25	001	May 2000	May 2002
Standard Gain Horn Ant.	Electrof./Tho WR-3	001	May 2000	May 2002

6.4.2 Test Procedures

The basic test setups and procedures are the same as for the tests 30 MHz to 26.5 GHz. Above 26.5 GHz additional external mixers have to be used, which means additional correction factors.
Due to high mixer loss at very high frequencies the distance between the EUT and the test antenna was reduced to very low values (some cm) to detect any emissions.
The operating band 76 GHz to 77 GHz was excluded, but nevertheless up to 100 MHz into the band the emissions were checked in respect of the frequency error test (refer to chapter 7).

Radiated Emissions Test Characteristics	
Frequency range	26,500 MHz - 231,000 MHz
Test distance	0.01 - 3 * m
Test instrumentation resolution bandwidth	1 MHz
Test instrumentation detector	PK
Receive antenna scan height	no height scan performed due to high gain antenna
Receive antenna polarization	Vertical/Horizontal

* According to Section 15.31 (f) (1): At frequencies at or above 30 MHz, measurements may be performed at a distance other than what is specified provided: measurements are not made in the near field except where it can be shown that near field measurements are appropriate due to the characteristics of the device; and it can be demonstrated that the signal levels needed to be measured at the distance employed can be detected by the measurement equipment. (...) When performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade (inverse linear-distance for field strength measurements; inverse-linear-distance-squared for power density measurements).

6.4.3 Calculations of Spurious Emissions Limits

Frequency	Field Strength		Measurement distance	Remarks
(MHz)	(microvolts/meter)	(dBµV/m)	(meters)	
26,500 – 40,000	500	54	3	

Frequency	Power Density		Measurement distance	Remarks
(MHz)	pW/cm²	dBm/cm²	(meters)	
40,000 – 200,000	600	-62.2	3	
> 200,000	1000	-60.0	3	

6.4.4 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Mixer Loss. The basic equation with a sample calculation is as follows:

FS = RA + AF + ML
where
FS = Field Strength in dBµV/m
RA = Receiver Amplitude in dBµV
AF = Antenna Factor in dB(1/m)
ML = Mixer Loss in dB

Assume a receiver reading of 10.2 dBµV is obtained. The Antenna Factor of 38.8 dB(1/m) and a Mixer Loss of 22 dB are added, giving a field strength of 71 dBµV/m. The 71 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 10.2 + 38.8 + 22 = 71 [dBµV/m]

Level in µV/m = Common Antilogarithm (71/20) = 3,548

For test distance other than what is specified, but fulfilling the requirements of Section 15.31 (f)(1) the field strength is calculated by adding additionally an extrapolation factor of 20 dB/decade (inverse linear-distance for field strength measurements). The basic equation with a sample calculation is as follows:

FS = RA + AF + ML + DF
where
FS = Field Strength in dBµV/m
RA = Receiver Amplitude in dBµV
AF = Antenna Factor in dB(1/m)
ML = Mixer Loss in dB
DF = Distance Extrapolation Factor in dB,
where DF = 20 log (Dtest/Dspec) where Dtest = Test Distance and Dspec = Specified Distance.

Assume the tests performed at a reduced Test Distance of 1 m instead of the Specified Distance of 3 m giving a Distance Extrapolation Factor of DF = 20 log(1m/3m) = -9.5 dB.
Assuming a receiver reading of 10.2 dBµV is obtained. The Antenna Factor of 38.3 dB(1/m), the Mixer Loss of 22 dB and the Distance Factor of -9.5 dB are added, giving a field strength of 61.5 dBµV/m. The 61.5 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 10.2 + 38.8 + 22 - 9.5 = 61.5 [dBµV/m]

Level in µV/m = Common Antilogarithm (61.5/20) = 1,188

6.4.5 Power Density Calculation

The power density is calculated by using the reading, mixer loss, effective aperture of the antenna and distance correction factor (20 dB/dec relation).
The basic calculation is similar as described in the chapter above with the difference, that the result is the power density:

FS = RA + ML + DF - A
where
FS = Field Strength in dBµV/m
RA = Receiver Amplitude in dBµV
ML = Mixer Loss in dB
DF = Distance Extrapolation Factor in dB,
A = effective Antenna Aperture in dB/cm²
where DF = 20 log (Dtest/Dspec) where Dtest = Test Distance and Dspec = Specified Distance, and A = 10 log (effective Antenna Aperture in cm²).

6.4.6 Test Results

Device: Adaptive Cruise Control Pulse Doppler RADAR System
Type: ARS 100-3
Serial number (ECU): 1999460003
Serial number (frontend): 7541047395

PRODUCT EMISSIONS DATA, **26.5 GHz < f < 40 GHz**											
No	Emission Frequency [MHz]	Receiver Mode and Bandwidth [kHz]	Test Distance [m]	Receiver Reading RA [dBµV]	Antenna Factor AF [dB(1/m)]	Mixer Loss ML [dB]	Distance Extrapolation Factor DF [dB]	Result = Corrected Reading FS [dBµV/m]	Spec Limit [dBµV/m]	Polarization Eut/Ant	Margin [dB]
No emissions detected (noise only)											

PRODUCT EMISSIONS DATA, **f > 40 GHz**											
No	Emission Frequency [MHz]	Receiver Mode and Bandwidth [kHz]	Test Distance [m]	Receiver Reading RA [dBm]	Mixer Loss ML [dB]	Distance Extrapolation Factor DF [dB]	Eff. Antenna Area A [dB/cm²]	Result = Corrected Reading FS [dBm/cm²]	Spec Limit [dBm/cm²]	Polarization Ant	Margin [dB]
1	76,000	1000/PK	1	<-98 *	31	-9.5	5.8	<-82.3	-62.2	h/v	>20.1
2	77,000	1000/PK	1	<-96 *	31	-9.5	5.8	<-80.3	-62.2	h/v	>18.1
3	76,100	1000/PK	1	<-98 *	31	-9.5	5.8	<-82.3	-62.2	h/v	>20.1
4	76,900	1000/PK	1	<-96 *	31	-9.5	5.8	<-80.3	-62.2	h/v	>18.1

NOTES: * noise only

The EUT meets the requirements of this section.

Test Personnel: Reinhard Sauerschell

Test Date: 2001-09-25

Radiated Emissions Test within the Band, 76.0 GHz to 77.0 GHz

6.4.7 Test Equipment

Type	Manufacturer/ Model No.	Serial No.	Last Calibration	Next Calibration
Receiver (26.5 GHz - 110 GHz) Waveguide Mixer LO Amplifier	Rohde & Schwarz ESAI-D ESMI-RF ESMI-B1 R&S/Tektronix FS-Z40/WM782A FS-Z60/WM782U FS-Z75/WM782V FS-Z110/WM782W R&S, FS-Z30	 833771/008 833827/002 832504/005 840448/007 840449/001 840450/005 840451/005 775850/002	June 2000	Dec. 2001
Stand. Gain Horn Ant	FMI/ProN 27240-10	24	May 2000	May 2002

6.4.8 Test Procedures

Refer to chapter 6.4.2.

Radiated Emissions Test Characteristics	
Frequency range	76,000 MHz - 77,000 MHz
Test distance	3 m
Test instrumentation resolution bandwidth	1 MHz
Test instrumentation detector	PK
Receive antenna scan height	no height scan performed due to high gain antenna
Receive antenna polarization	Vertical/Horizontal

6.4.9 Calculations of Power Density Limits

Frequency	Power Density		Measurement distance	Remarks
(MHz)	µW/cm²	dBm/cm²	(meters)	
76,000 MHz - 77,000 MHz	60	-12.2	3	in motion
76,000 MHz - 77,000 MHz	0.2	-37.0	3	not in motion

6.4.10 Power Density Calculation

Refer to appropriate chapter above.

6.4.11 Test Results

Device: Adaptive Cruise Control Pulse Doppler RADAR System
Type: ARS 100-3
Serial number (ECU): 1999460003
Serial number (frontend): 7541047395

PRODUCT EMISSIONS DATA											
No	Emission Frequency [MHz]	Receiver Mode and Bandwidth [kHz]	Test Distance [m]	Receiver Reading RA [dBm]	Mixer Loss ML [dB]	Distance Extrapolation Factor DF [dB]	Eff. Antenna Area A [dB/cm²]	Result = Corrected Reading [dBm/cm²]	Spec Limit [dBm/cm²]	Margin [dB]	NOTES
1	76,309	1000/PK	3	-80	31	0	-9.1	-39.9	-37.0	2.9	1,2,3,4,5,6
2	76,509	1000/PK	3	-56.9	31	0	-9.1	-16.8	-12.2	4.6	1,2,5,7

NOTES: 1: Polarization of test antenna: copolarized with EUT sensor,
2: in motion state,
3: not in motion state,
4: normal operation mode (pulse mode),
5: CW mode,
6: LO,
7: carrier

The EUT meets the requirements of this section.

Test Personnel: Reinhard Sauerschell

Test Date: 2001-09-24

7 OPERATION WITHIN THE BAND, FREQUENCY STABILITY

Test Requirement: FCC CFR47, Part 15C
Test Procedure: ANSI C63.4:1992

7.1 Regulation

Section 15.253 Operation within the bands 46.7-46.9 GHz and 76.0-77.0 GHz.
(e) 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 to +50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

7.2 Test Equipment

Type	Manufacturer/ Model No.	Serial No.	Last Calibration	Next Calibration
Receiver (26.5 GHz - 110 GHz) Waveguide Mixer LO Amplifier	Rohde & Schwarz ESAI-D ESMI-RF ESMI-B1 R&S/Tektronix FS-Z40/WM782A FS-Z60/WM782U FS-Z75/WM782V FS-Z110/WM782W R&S, FS-Z30	 833771/008 833827/002 832504/005 840448/007 840449/001 840450/005 840451/005 775850/002	June 2000	Dec. 2001
Stand. Gain Horn Ant	FMI/ProN 27240-10	24	May 2000	May 2002
Climatic Test Unit	Heraeus Vötsch VLK 07/90	29143	March 2001	March 2002
True RMS Digital Multimeter	Hewlett-Packard 3478A	2301A17492	March 2001	March 2002
Programmable Power Source	R&S NGPE40	451292/0529		

7.3 Test Procedures

The EUT was installed in a climatic chamber, where the temperature was changed in 10°C steps from –20° C to +50° C. The frequency was measured under normal operation mode (pulse mode) by variation the input voltage (10.0 VDC, 12.0 VDC, 16.0 VDC, as declared by the manufacturer). The frequency stability is the variation of the average frequency of the two measured –10 dB points of the pulse spectrum over temperature and voltage referred to the value at normal temperature (20°C) and normal voltage (12 VDC).

7.4 Test Results

Device: Adaptive Cruise Control Pulse Doppler RADAR System
Type: ARS 100-3
Serial number (ECU): 1999460003
Serial number (frontend): 7541047395

Temperature	Input Voltage	Frequ. of lower –10dB point	Frequ. of upper –10dB point	Calc. Mid Frequency	Drift
C	Volt	MHz	MHz	MHz	MHz
-20 °C	12	76508.9	76512.9	76510.9	63.7
	10.0	76508.9	76513.0	76510.9	63.7
	16.0	76509.0	76513.0	76511.0	63.8
-10 °C	12	76493.3	76497.5	76495.4	48.1
	10.0	76493.3	76497.5	76495.4	48.2
	16.0	76493.4	76497.6	76495.5	48.2
0 °C	12	76476.7	76481.3	76479.0	31.8
	10.0	76477.1	76481.6	76479.4	32.1
	16.0	76477.3	76481.8	76479.6	32.3
10 °C	12	76474.0	76478.7	76476.4	29.1
	10.0	76474.1	76478.9	76476.5	29.2
	16.0	76474.1	76479.0	76476.5	29.3
20 °C	12	76444.5	76450.0	76447.2	0.0
	10.0	76446.6	76452.1	76449.3	2.1
	16.0	76448.3	76453.7	76451.0	3.8
30 °C	12	76454.1	76459.1	76456.6	9.4
	10.0	76453.6	76458.6	76456.1	8.9
	16.0	76453.2	76458.2	76455.7	8.5
40 °C	12	76444.6	76449.7	76447.2	-0.1
	10.0	76443.8	76448.8	76446.3	-0.9
	16.0	76443.1	76448.1	76445.6	-1.7
50 °C	12	76422.5	76427.4	76424.9	-22.3
	10.0	76421.1	76426.2	76423.7	-23.6
	16.0	76419.6	76424.7	76422.1	-25.1
Maximum frequency error [MHz]:			-25.1 / +63.8		

Compared with the results in chapter 6.4.6 and 6.5.5, the EUT meets the requirements of this section.

Test Personnel: Reinhard Sauerschell

Test Date: 2001-10-18 to 2001-10-19

8 RADIO FREQUENCY EXPOSURE

Test Requirement: FCC CFR47, Part 15C
Test Procedure: IEEE Std C95.3-1991

8.1 Regulation

Section 15.253 Operation within the bands 46.7-46.9 GHz and 76.0-77.0 GHz.
(f) Regardless of the power density levels permitted under this section, devices operating under the provisions of this section are subject to the radio frequency radiation exposure requirements specified in § 1.1307(b), § 2.1091 and § 2.1093 of this chapter, as appropriate. Applications for equipment authorization of devices operating under this section must contain a statement confirming compliance with these requirements for both fundamental emissions and unwanted emissions. Technical information showing the basis for this statement must be submitted to the Commission upon request.

§ 2.1091 Radiofrequency radiation exposure evaluation: mobile devices.
(a) Requirements of this section are a consequence of Commission responsibilities under the National Environmental Policy Act to evaluate the environmental significance of its actions. See subpart I of part 1 of this chapter, in particular § 1.1307(b).
(b) For purposes of this section, a mobile device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons. In this context, the term ''fixed location'' means that the device is physically secured at one location and is not able to be easily moved to another location. Transmitting devices designed to be used by consumers or workers that can be easily relocated, such as wireless devices associated with a personal computer, are considered to be mobile devices if they meet the 20 centimeter separation requirement.

(c) Mobile devices that operate in the Cellular Radiotelephone Service, the Personal Communications Services, the Satellite Communications Services, the General Wireless Communications Service, the Wireless Communications Service, the Maritime Services and the Specialized Mobile Radio Service authorized under subpart H of part 22 of this chapter, part 24 of this chapter, part 25 of this chapter, part 26 of this chapter, part 27 of this chapter, part 80 of this chapter (ship earth stations devices only) and part 90 of this chapter are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use if they operate at frequencies of 1.5 GHz or below and their effective radiated power (ERP) is 1.5 watts or more, or if they operate at frequencies above 1.5 GHz and their ERP is 3 watts or more. Unlicensed personal communications service devices, unlicensed millimeter wave devices and unlicensed NII devices authorized under §15.253, § 15.255, and subparts D and E of part 15 of this chapter are also subject to routine environmental evaluation for RF exposure prior to equipment authorization or use if their ERP is 3 watts or more or if they meet the definition of a portable device as specified in § 2.1093
(b) requiring evaluation under the provisions of that section. All other mobile and unlicensed transmitting devices are categorically excluded from routine environmental evaluation for RF exposure prior to equipment authorization or use, except as specified in §§ 1.1307(c) and 1.1307(d) of this chapter. Applications for equipment authorization of mobile and unlicensed transmitting devices subject to routine environmental evaluation must contain a statement confirming compliance with the limits specified in paragraph (d) of this section as part of their application. Technical information showing the basis for this statement must be submitted to the Commission upon request.

(d) The limits to be used for evaluation are specified in § 1.1310 of this chapter. All unlicensed personal communications service (PCS) devices and unlicensed NII devices shall be subject to the limits for general population/uncontrolled exposure.
(1) For purposes of analyzing mobile transmitting devices under the occupational/controlled criteria specified in § 1.1310 of this chapter, timeaveraging provisions of the guidelines may be used in conjunction with typical maximum duty factors to determine maximum likely exposure levels.
(2) Timeaveraging provisions may not be used in determining typical exposure levels for devices intended for use by consumers in general population/uncontrolled environments as defined in § 1.1310 of this chapter. However, ‘‘sourcebased’’ timeaveraging based on an inherent property or dutycycle of a device is allowed. An example of this is the determination of exposure from a device that uses digital technology such as a timedivision multipleaccess (TDMA) scheme for transmission of a signal. In general, maximum average power levels must be used to determine compliance.
(3) If appropriate, compliance with exposure guidelines for devices in this section can be accomplished by the use of warning labels and by providing users with information concerning minimum separation distances from transmitting structures and proper installation of antennas.
(4) In some cases, e.g., modular or desktop transmitters, the potential conditions of use of a device may not allow easy classification of that device as either mobile or portable (also see § 2.1093). In such cases, applicants are responsible for determining minimum distances for compliance for the intended use and installation of the device based on evaluation of either specific absorption rate (SAR), field strength or power density, whichever is most appropriate.

§ 1.1307 Actions that may have a significant environmental effect, for which Environmental Assessments (EAs) must be prepared.
(b) In addition to the actions listed in paragraph (a) of this section, Commission actions granting construction permits, licenses to transmit or renewals thereof, equipment authorizations or modifications in existing facilities, require the preparation of an Environmental Assessment (EA) if the particular facility, operation or transmitter would cause human exposure to levels of radiofrequency radiation in excess of the limits in §§ 1.1310 and 2.1093 of this chapter. Applications to the Commission for construction permits, licenses to transmit or renewals thereof, equipment authorizations or modifications in existing facilities must contain a statement confirming compliance with the limits unless the facility, operation, or transmitter is categorically excluded, as discussed below. Technical information showing the basis for this statement must be submitted to the Commission upon request.

§ 1.1310 Radiofrequency radiation exposure limits.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm²)	Averaging time (minutes)
1500–100,000	-	-	1.0	30

8.2 Test Equipment

Type	Manufacturer/ Model No.	Serial No.	Last Calibration	Next Calibration
Receiver (26.5 GHz - 110 GHz) Waveguide Mixer LO Amplifier	Rohde & Schwarz ESAI-D ESMI-RF ESMI-B1 R&S/Tektronix FS-Z40/WM782A FS-Z60/WM782U FS-Z75/WM782V FS-Z110/WM782W R&S, FS-Z30	 833771/008 833827/002 832504/005 840448/007 840449/001 840450/005 840451/005 775850/002	June 2000	Dec. 2001
Stand. Gain Horn Ant	FMI/ProN 27240-10	24	May 2000	May 2002
Standard Gain Horn Ant.	Millitech SGH-10-RP000	128	May 2000	May 2002
Standard Gain Horn Ant.	Electrof./Tho WG27-25	001	May 2000	May 2002

8.3 Test Procedures

The radiation in the band 76 GHz to 77 GHz GHz was tested with standard gain horn antennas at a distance of 0.2 m to the surface of the EUT.
Two operation modes were checked:
- vehicle in motion (carrier on, pulse mode),
- vehicle not in motion (carrier off).

The surface of the EUT was scanned with the antennas. Max. levels were detected in the copolarized plane of the antenna of EUT.
Emissions outside the band are negligible.

8.4 Calculations of Power Density Limits

Frequency	Power Density		Remarks
(MHz)	mW/cm²	dBm/cm²	
1,500 to 100,000	1.0	0	

8.5 Power Density Calculation

Refer to appropriate chapter above.

8.6 Test Results

Device: Adaptive Cruise Control Pulse Doppler RADAR System
Type: ARS 100-3
Serial number (ECU): 1999460003
Serial number (frontend): 7541047395

PRODUCT EMISSIONS DATA											
No	Emission Frequency [MHz]	Receiver Mode and Bandwidth [kHz]	Test Distance [m]	Receiver Reading RA [dBm]	Mixer Loss ML [dB]	Distance Extrapolation Factor DF [dB]	Eff. Antenna Area A [dB/cm²]	Result = Corrected Reading [dBm/cm²]	Spec Limit [dBm/cm²]	Margin [dB]	NOTES
1	76,486	1000/PK	0.2	-52.3	31	0	-9.1	-12.2	0	12.2	1,2,4,7
2	76,486	1000/PK	0.2	-45.2	31	0	-9.1	-5.1	0	5.1	1,2,5,7
3	76,312	1000/PK	0.2	-51.2	31	0	4.9	-25.1	0	25.1	1,3,5,6

NOTES: 1: Polarization of test antenna: copolarized with EUT sensor,
2: in motion state,
3: not in motion state,
4: normal operation mode (pulse mode),
5: CW mode,
6: LO,
7: carrier

The EUT meets the requirements of this section.

Test Personnel: Reinhard Sauerschell

Test Date: 2001-09-24 to 2001-09-25

9 MISCELLANEOUS COMMENTS AND NOTES

None.

10 LIST OF ANNEXES

Following annexes are separated parts from this test report.

Description	Pages
Annex 1: Photographs of test setups	5
Annex 2: Photographs of equipment under test (EUT), external views	9
Annex 3: Photographs of equipment under test (EUT), internal views	9