

TEST REPORT # EMCC-990004EA, 2002-07-15

EQUIPMENT UNDER TEST:

Trade Name: KILN Data Transmitter
Model: KILN Data Transmitter
Serial No: None
Equipment Category: Transmitter
Manufacturer: SMARTCO GmbH
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RELEVANT STANDARD: 47 CFR Part 15C - Intentional Radiators

MEASUREMENT PROCEDURE USED:

ANSI C63.4-1992 FCC/OET MP-4 (1987) Other

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TEST OF SMARTCO GMBH MODEL KILN DATA TRANSMITTER TO 47 CFR PART 15C - INTENTIONAL RADIATORS

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TEST OF SMARTCO GMBH MODEL KILN DATA TRANSMITTER TO 47 CFR PART 15C - INTENTIONAL RADIATORS

1 GENERAL INFORMATION

1.1 Purpose

The purpose of this report is to show compliance to the FCC regulations for unlicensed devices operating under section 15.249 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.
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1.4 Manufacturer

Company Name: SMARTCO GmbH
Street: Konrad-Horschuch-Str. 57
City: 73660 Urbach
Country: Germany
Name for contact purposes: Mr Martin Gläser
Phone: +49-7181-87063
Fax: +49-7181-89542
E-mail: smartco@compuserve.com

1.5 Dates

Date of receipt of EUT: CW 26/2002
Test date: CW 26/2002

2 PRODUCT DESCRIPTION

2.1 Equipment Under Test (EUT)

Device: Remote control (RF) transmitter
Model: KILN Data Transmitter
Serial Number: None
Application: Wireless data acquisition system for kiln control systems
Power: 3.6 V Lithium AA battery
Transmit Frequency: 916.5 MHz, one RF channel
Modulation: On-off-keying (OOK)
Oscillator Frequencies: 3.6864 MHz (microcontroller), 916.5 MHz (transmit module)
Antenna: internal, integral
Interface ports: none
Variants: none

FCC-ID: NP6TXKILN-I

The EUT measures the moisture and/or temperature of wood in a drykiln. The transmit module gets the readings at 2400 Baud (serial) from the microcontroller and sends them to at least one receiver inside the kiln.

Readings are transmitted automatically in regular time intervals (one pulse package of 35ms length approximately every 20 seconds).

The maximum duty cycle of the EUT referred to one pulse package is 67% (as declared by the manufacturer). It follows that the worst case on time in any 100 ms time window is an on time of $67\% \times 35 \text{ ms} = 23.45 \text{ ms}$.

2.2 EUT Peripherals

The EUT was tested as stand-alone device.¹

2.3 Mode of Operation During Testing

The operation mode during testing had the following differences to normal operation mode:

- transmission of pulse packages every 500ms instead of every 20s (increased transmission rate),
- microcontroller permanently active.

2.4 Modifications Required for Compliance

None.

¹ Radiated emissions test in the frequency range 30 MHz - 1 GHz: the EUT was measured together with its corresponding receiver "KILN Data Collector"

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3 TEST RESULTS SUMMARY

Summary of Test Results Transmitter, model KILN Data Transmitter

Requirement	CFR Section	Report Section	Test Result
Antenna Requirement	15.203	4	Pass
Conducted Emissions	15.207	6	*
Field Strength Limits (Fundamental and Harmonics)	15.249	5	Pass
Radiated Spurious Emissions	15.209, 15.249	5	Pass

* Not required, the EUT is battery powered and there is no provision for connection to the mains.

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 all applicable Public Notices received prior to the date of testing. All emissions from the device 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: Klaus Pfister
Issuance Date: 2002-07-15

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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: Remote Control (RF) Transmitter

Transmitter Model: KILN Data Transmitter

Antenna is directly soldered on the PCB.

The EUT meets the requirements of this section.

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5 RADIATED EMISSIONS TEST

Test Requirement: FCC CFR47, Part 15C

Test Procedure: ANSI C63.4:1992

5.1 Regulation

15.249(a) The field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental frequency (MHz)	Field strength of fundamental (millivolts/meter)	Field strength of harmonics (microvolts/meter)
902 - 928 MHz	50	500
2400 - 2483.5 MHz	50	500
5725 - 5875 MHz	50	500
24.0 - 24.25 GHz	250	2500

(b) Field strength limits are specified at a distance of 3 meters.

(c) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

(d) As shown in §15.35(b), for frequencies above 1000 MHz, the above field strength limits are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation.

Section 15.33 Frequency range of radiated measurements:

(a) Unless otherwise noted in the specific rule section under which the equipment operates for an intentional radiator the spectrum shall be investigated from the lowest radio frequency signal generated in the device, without going below 9 kHz, up to at least the frequency shown in this paragraph:

(1) If the intentional radiator operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

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

5.2.1 Test Equipment

Type	Manufacturer/ Model No.	Serial No.	Last Calibration	Next Calibration
Receiver (9 kHz - 30 MHz)	Rohde & Schwarz ESS	837010/001	May 2001	November 2002
Loop Antenna (9 kHz - 30 MHz)	R&S HFH2-Z2	892665/004	June 2000	June 2002

5.2.2 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 [*Remark: not applicable*]. The EUT is connected to its associated peripherals with any excess I/O cabling bundled to approximately 1 meter [*Remark: not applicable*].

Preview tests are performed to determine the "worst case" mode of operation.

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 [*Remark: not applicable*].

The test distance was reduced to 3 m, respectively, according to section 15.31 (f) (2).

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 and AV detector, respectively.

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	3 m*
Test instrumentation resolution bandwidth	200 Hz (9 kHz - 150 kHz), 10 kHz (150 kHz - 30 MHz)
Test instrumentation detector	QP / AV, Peak
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).

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5.2.3 Calculation of Field Strength Limits

Calculation: microvolts/meter to dB(μ V/m)

Frequency	Field Strength Limits according to §15.209		Measurement distance
[MHz]	[μ V/m]	[dB(μ V/m)]	[m]
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

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 and 110-490 kHz. Radiated emission limits in these two bands are based on measurements employing an average detector.

5.2.4 Field Strength Calculation

For obtaining the field strength in dB(μ V/m) a conversion factor of $20 \log(377\Omega/1\Omega) = 51.5 \text{ dB}(\Omega)$ is necessary, because the EMI receiver and the active loop antenna operate as a system, where the reading gives directly the H field strength result in dB(μ A/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:

$$FS = RA + CO + DF$$

where

FS = Field Strength in dB(μ V/m)

RA = Receiver Amplitude in dB(μ A/m)

CO = Conversion Factor in dB(Ω)

DF = Distance Extrapolation Factor in dB,

where $DF = 40 \log(D_{\text{test}}/D_{\text{spec}})$ where D_{test} = test distance and D_{spec} = specified distance

Assume the tests performed at a reduced test distance of 3 m instead of the specified distance of 300 m giving a Distance Extrapolation Factor of $DF = 40 \log(3m/300m) = -80.0 \text{ dB}$.

Assuming a receiver amplitude of 15.6 dB(μ A/m) is obtained. Adding the conversion factor of 51.5 dB(Ω) a corresponding level of 67.1 dB(μ V/m) is obtained. The distance factor of -80.0 dB is added, giving a field strength of -12.9 dB(μ V/m). The -12.9 dB(μ V/m) value can be mathematically converted to its corresponding level in μ V/m.

$$FS = 15.6 \text{ dB}(\mu\text{A}/\text{m}) + 51.5 \text{ dB}(\Omega) - 80 \text{ dB} = -12.9 \text{ dB}(\mu\text{V}/\text{m})$$

$$FS = 10^{(-12.9/20)} \mu\text{V}/\text{m} = 0.23 \mu\text{V}/\text{m}$$

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5.2.5 Test Results

PRODUCT EMISSIONS DATA 150 kHz - 30 MHz									
No	Emission Frequency [MHz]	Receiver Detector and Bandwidth [kHz]	Test Distance [m]	Receiver Reading RA [dB(µA/m)]	Conversion Factor CO [dB(Ω)]	Distance Extrapol. Factor DF [dB]	Result = Corrected Reading FS * [dB(µV/m)]	Spec Limit [dB(µV/m)]	Remarks
1	0.0186	Pk/200Hz	3	5.7	51.5	-80.0	-22.8	42.2 AV	
2	0.0922	Pk/200Hz	3	-12.2	51.5	-80.0	-40.7	28.3 QP	
3	0.690	PK/10kHz	3	-18.8	51.5	-40.0	-7.3	30.8 QP	ambient noise floor
4	2.960	PK/10kHz	3	-20.3	51.5	-40.0	-8.8	29.5 QP	ambient noise floor
5	10.710	PK/10kHz	3	-19.3	51.5	-40.0	-7.8	29.5 QP	ambient noise floor
6	27.670	PK/10kHz	3	-19.3	51.5	-40.0	-7.8	29.5 QP	ambient noise floor

* All given values are peak values. Average and quasi-peak are always less or equal to peak. Therefore, independent of the kind of limit specified, compliance is always demonstrated if the peak value is below the limit.

Device: Remote Control (RF) Transmitter

Transmitter Model: KILN Data Transmitter

The EUT meets the requirements of this section.

Test Personnel: Klaus Pfister

Test Date: 2002-06-24

TEST OF SMARTCO GMBH MODEL KILN DATA TRANSMITTER TO 47 CFR PART 15C - INTENTIONAL RADIATORS

5.3 Radiated Emissions Test, 30 MHz to 10 GHz

5.3.1 Test Equipment

Type	Manufacturer/ Model No.	Serial No.	Last Calibration	Next Calibration
Receiver (30 MHz - 1 GHz)	Rohde & Schwarz ESS	843513/012	May 2002	November 2003
Antenna (30 MHz - 1 GHz)	EMCO Model 3143	9604-1269	June 2002	December 2003
Receiver (1 GHz - 10 GHz)	Rohde & Schwarz ESAI-D ESMI-RF ESMI-B1	833771/008 833827/002 832504/005	May 2002	November 2003
Antenna (1 GHz – 10 GHz)	Schwarzbeck BBHA 9120 D	137	October 2001	October 2003

5.3.2 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 [*Remark: not applicable*]. The EUT is connected to its associated peripherals with any excess I/O cabling bundled to approximately 1 meter [*Remark: not applicable*].

Preview tests are performed. Emissions from the unit are maximized by adjusting the polarization and height of the receive antenna and rotating the EUT on the turntable. Manipulating the system cables also maximizes EUT emissions [*Remark: not applicable*]. All tests performed with the EUT placed in two polarizations on the nonconductive table: horizontal and vertical.

Radiated Emissions Test Characteristics	
Frequency range	30 MHz - 10,000 MHz
Test distance	3 m *
Test instrumentation resolution bandwidth	120 kHz (30 MHz - 1,000 MHz), 1 MHz (1000 MHz - 10,000 MHz)
Receive antenna scan height	1 m - 4 m
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).

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5.3.3 Calculation of Field Strength Limits

Fundamental field strength limit for the band 902 to 928 MHz:
 50 mV/m at 3 meters; 50 mV/m corresponds with 94.0 dB(µV/m).

Harmonics field strength limit for the band 902 to 928 MHz:
 500 µV/m at 3 meters; 500 µV/m corresponds with 54.0 dB(µV/m).

The above field strength limits are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation

Emissions radiated outside the frequency band 902 to 928 MHz, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

Calculation: microvolts/meter to dB(µV/m)

Frequency	Field Strength Limits according to §15.209		Measurement distance
[MHz]	[µV/m]	[dB(µV/m)]	[m]
30-88	100	40.0	3
88-216	150	43.5	3
216-960	200	46.0	3
Above 960	500	54.0	3

The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for frequencies above 1000 MHz. Radiated emission limits above 1000 MHz are based on measurements employing an average detector.

5.3.4 Calculation of Average Correction Factor

The average correction factor is computed by analyzing the "worst case" on time in any 100 ms time period and using the formula:

Correction Factor (dB) = $20 \times \log_{10}(\text{worst case on time}/100 \text{ ms})$

Analysis of the transmitter worst case on time in any 100 ms time period is an on time of $67\% \times 35 \text{ ms} = 23.45 \text{ ms}$ (see chapter 2 "product description"). Therefore the correction factor is $20 \log_{10}(23.45/100) = -12.6 \text{ dB}$.

5.3.5 Field Strength Calculation

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

$$FS = RA + AF + CF$$

where

FS = Field Strength in dB(µV/m)

RA = Receiver Amplitude in dB(µV)

AF = Antenna Factor in dB(1/m)

CF = Cable Attenuation Factor in dB

Assume a receiver reading of 23.5 dB(µV) 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 dB(µV/m). The 32 dB(µV/m) value can be mathematically converted to its corresponding level in µV/m.

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$$FS = 23.5 \text{ dB}(\mu\text{V}) + 7.4 \text{ dB}(1/\text{m}) + 1.1 \text{ dB} = 32 \text{ dB}(\mu\text{V}/\text{m})$$

$$FS = 10^{(32/20)} \mu\text{V}/\text{m} = 39.8 \mu\text{V}/\text{m}$$

For test distances 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:

$$FS = RA + AF + CF + DF$$

where

FS = Field Strength in dB($\mu\text{V}/\text{m}$)

RA = Receiver Amplitude in dB(μV)

AF = Antenna Factor in dB(1/m)

CF = Cable Attenuation Factor in dB

DF = Distance Extrapolation Factor in dB,

where $DF = 20 \log(D_{\text{test}}/D_{\text{spec}})$ where D_{test} = test distance and D_{spec} = specified distance

Assume the tests performed at a reduced test distance of 1.5 m instead of the specified distance of 3 m giving a Distance Extrapolation Factor of $DF = 20 \log(1.5\text{m}/3\text{m}) = -6 \text{ dB}$.

Assuming a receiver reading of 23.5 dB(μV) is obtained. The Antenna Factor of 7.4 dB(1/m), the Cable Factor of 1.1 dB and the Distance Factor of -6 dB are added, giving a field strength of 26 dB($\mu\text{V}/\text{m}$). The 26 dB($\mu\text{V}/\text{m}$) value can be mathematically converted to its corresponding level in $\mu\text{V}/\text{m}$.

$$FS = 23.5 \text{ dB}(\mu\text{V}) + 7.4 \text{ dB}(1/\text{m}) + 1.1 \text{ dB} - 6 \text{ dB} = 26 \text{ dB}(\mu\text{V}/\text{m})$$

$$FS = 10^{(26/20)} \mu\text{V}/\text{m} = 20.0 \mu\text{V}/\text{m}$$

TEST OF SMARTCO GMBH MODEL KILN DATA TRANSMITTER TO 47 CFR PART 15C - INTENTIONAL RADIATORS

5.3.6 Test Results

PRODUCT EMISSIONS DATA, FUNDAMENTAL AND HARMONICS											
No	Emission Frequency [MHz]	Receiver Bandwidth and Mode [kHz]	Test Distance [m]	Receiver Reading RA [dB(µV)]	Correction Factor AF+CF [dB(1/m)]	Distance Extrapol. Factor DF [dB]	Average Correction Factor [dB]	Result = Corrected Reading FS [dB(µV/m)]	Spec Limit [dB(µV/m)]	Polarization Ant.	Margin [dB]
1	916.567	120, PK	3	PK 75.0	27.6	0	-12.6	AV 90.0 PK 102.6	AV 94.0 PK 114.0	h	AV 4.0 PK 11.4
2	1833	1000, PK	3	PK 26.0	26.5	0	-12.6	AV 39.9 PK 52.5	AV 54.0 PK 74.0	h	AV 14.1 PK 21.5
3	2750	1000, PK	3	PK 27.4	29.4	0	-12.6	AV 44.2 PK 56.8	AV 54.0 PK 74.0	h	AV 9.8 PK 17.2
4	3666	1000, PK	3	PK 28.8	30.2	0	-12.6	AV 46.4 PK 59.0	AV 54.0 PK 74.0	h	AV 7.6 PK 15.0
5	4583	1000, PK	3	PK 21.7	32.0	0	-12.6	AV 41.1 PK 53.7	AV 54.0 PK 74.0	h	AV 12.9 PK 20.3

PRODUCT EMISSIONS DATA ABOVE 30 MHz (except fundamental and harmonics)											
No	Emission Frequency [MHz]	Receiver Bandwidth and Mode [kHz]	Test Distance [m]	Receiver Reading RA [dB(µV)]	Correction Factor AF+CF [dB(1/m)]	Distance Extrapol. Factor DF [dB]	Average Correction Factor [dB]	Result = Corrected Reading FS [dB(µV/m)]	Spec Limit [dB(µV/m)]	Polarization Ant.	Margin [dB]
1											
2											
3				ALL EMISSIONS FOUND MORE THAN 20 dB BELOW CORRESPONDING LIMIT							
4											
5											
6											

Device: Remote Control (RF) Transmitter

Transmitter Model: KILN Data Transmitter

The EUT meets the requirements of this section.

Test Personnel: Klaus Pfister

Test Date: 2002-06-24, 2002-06-25

TEST OF SMARTCO GMBH MODEL KILN DATA TRANSMITTER TO 47 CFR PART 15C - INTENTIONAL RADIATORS

6 CONDUCTED EMISSIONS TESTS

Test Requirement: FCC CFR47, Part 15C

Test Procedure: ANSI C63.4:1992

6.1 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.

6.2 Test Equipment

Not applicable.

6.3 Test Procedures

Not applicable.

6.4 Test Results

Device: Remote Control (RF) Transmitter

Transmitter Model: KILN Data Transmitter

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

TEST OF SMARTCO GMBH MODEL KILN DATA TRANSMITTER TO 47 CFR PART 15C - INTENTIONAL RADIATORS

7 MISCELLANEOUS COMMENTS AND NOTES

None.

8 LIST OF ANNEXES

Following annexes are separated parts to this test report.

Description	Pages
Annex 1: Photographs of test setups	3