Emissions Testing
Performed
on the
**Danfoss A/S**
**Wireless Floor Heater Controller**
**Model: CFR 1.5**

**To**

**FCC Part 15 Subpart C, Section 15.231**

Date of Test: March 11, 2002



Report Number: 3019045

Contact: Mr. Jens-Ole Boldt

# Table of Contents

**I – Introduction and Summary**

TO: Mr. Jens-Ole Boldt
FROM: Nicholas Abbondante
DATE: March 11, 2002
PROJECT #: 3019045

RE: Emissions Testing Performed on the Wireless Floor Heater Controller, Model: CFR

On March 11, 2002 we tested the Wireless Floor Heater Controller, Model: CFR 1.5 to determine if it was in compliance with FCC Part 15, Subpart C, Section 15.231. We found that the unit met the Part 15, Subpart C, Section 15.231 requirements when tested as received.

A Prototype version of the sample was received on March 8, 2002 in good condition.

The following Table summarizes the results of testing.

| Test | Frequency (MHz) | Measurement | Requirement | Pass/Fail | Section of FCC Rules | Section of Test Report |
|---|---|---|---|---|---|---|
| Fundamental Field Strength | 433.920 | 77.2 | 81.1 | Pass | 15.231 | IX |
| Transmitter Line-conducted | N/A | N/A | N/A, Battery Power | N/A | 15.207 | N/A |
| Bandwidth | 433.92 | 294 kHz | <1.085 MHz | N/A | 15.231 | XI |

In summary, this report confirms that the Wireless Floor Heater Controller, Model: CFR 1.5 is compliant with the FCC Part 15, Subpart C Section15.231 requirements when production units conform with the initial sample. Please address all questions and comments concerning this report to Sal Napoli, Operations Manager.

**II – Technical Requirements**

**15.1 Scope**

The CFR is a room thermostat, which measures the room temperature. The device is an intentional radiator intended to operate in accordance with 15.231 "Periodic operation in the band 40.66 - 40.70 MHz and above 70 MHz".

**15.15 General Technical Requirements**

The Danfoss wireless floor heating control system is used to control the room temperature in water based heating systems with central water distribution. The control system consist of the following parts:

1. CFM Master Controller, with radio receiver: The thermal actuators for controlling the heating circuits.
2. CFS Slave Controller: An extension module with 8 extra outputs. Up to 2 slave controllers can be connected to the Master Controller
3. CFR Room Thermostat: Transmitting wireless (radio waves). A CFR room thermostat is placed in each room/zone, which is to be temperature controlled.
4. CFZ Zone Controller: An Optional module, which gives extra programming facilities and the possibility to change parameters values (holiday function, zone programming with time control.

The respective CFR room thermostat is installed on the Master Controller by use of an installation cable, RS232. After the installation is complete this RS232 cable is removed. The Master Controller, Slave controller and the zone controller communicates by a bus connection, RS485.

The CFR Room Thermostat consists of a PCB with the RF circuitry and the Control circuitry contained on that board and 2 batteries 1.5 VDC size AA which are contained within a plastic housing. The RF board uses permanently attached wires for both the transmit and receive antennas. All circuitry is contained within the plastic housing and will not normally be accessible to the user.

The output duty cycle of the CFR is 24 ms varying between transmissions from a minimum of 2.5 minutes up to a maximum of 25 minutes between two messages, depending on if there are any changes in the room temperature. If the temperature changes enough to require the heat valve to be opened or closed, and it has been at least 2.5 minutes since the last transmission, a transmission is sent. Otherwise if there are no changes in temperature, the system will wait 25 minutes then send a keep alive message to notify the controller it still exists. Transmissions are not made at regular, pre-determined intervals. The specification regarding transmitting frequency is +/- 15 kHz.

All timing is derived from 5 MHz and 6.78 MHz oscillators.

**15.27 Special Accessories**

No special accessories are necessary for the CFR to meet the compliance requirements.

**15.31 Measurement Standards**

The measurement procedures as specified by ANSI C63.4:1992 were used to test this device. See Section IV of the test report for a detailed description of the test site and the measurement equipment.

**15.33 Frequency range of measurement**

The device was scanned for spurious and harmonic emissions from 30 MHz to the 10th harmonic of the fundamental emission, 4330 MHz.

**15.35 Measurement detector functions and bandwidth**

The following table illustrates the detector functions and bandwidth used to test the device.

| Frequency Range | Measurement Detector | Measurement Bandwidth |
|---|---|---|
| 450 kHz to 30 MHz | Quasi-Peak | 9 kHz |
| 30 MHz to 1000 MHz | Quasi-Peak | 120 kHz |
| 1000 MHz to 10th harmonic | Average | 1 MHz |

The quasi-peak detector meets the requirements of CISPR 16.

**15.201 Certification**

The device is required to be certified in accordance with Part 2 of the FCC rules, Subpart J.

**15.203 Antenna Requirements**

The antennas are a part of the PC board and cannot be readily removed from the device.

**15.205 Restricted bands of operation**

The limit of 15.231 is higher than the general requirements of 15.209. All un-wanted emissions from the transmitter were compared to the general limits which are the requirement for restricted band emissions.

Below 1000 MHz a quasi-peak detector was employed to measure emissions.
Above 1000 MHz an average detector was employed to measure emissions. Peak measurements were also performed above 1000 MHz to insure that they were not greater than 20 dB of the average.

**15.207 Conducted limits**

(a) For an intentional radiator designed to be connected to the AC mains network, the radio frequency voltage that is conducted back onto the AC power line between the frequencies 450 kHz and 30 MHz shall not exceed 250 uV, or 48 dBuV.
(b) If the proper measuring techniques are used, and the quasi-peak value of an emission exceeds its average value by 6 dB or more, that emission is broadband and the quasi-peak value may be reduced by 13 dB and compared to the limits.
(d) Devices powered from a battery are not subject to these limits unless there are provisions for connecting to a charger while the device is operating. Devices that obtain power through an AC adapter or through another device which is connected to the AC mains network are subject to these limits.

**15.209 Radiated emission limits; general requirements**

(a) Field Strength Requirements

| Frequency Range (MHz) | Field Strength (μV/m) | Measurement Distance (m) |
|---|---|---|
| 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 spurious emissions must be lower than that of the fundamental emission of the intentional radiator. The limits in the above table are based on the frequency of the spurious emission, not the frequency of the fundamental frequency.
(d) See 15.35 for a description of measurement detector functions and bandwidth.
(e) See 15.33 for a description of the frequency range of measurement.
(f) If the frequency range of measurement must extend beyond the $10^{th}$ harmonic because of a digital device in the intentional radiator, the emissions found above the $10^{th}$ harmonic are to be compared with the general limits for radiated emissions from unintentional radiators set forth in 15.109.

**15.231 Periodic operation in the band 40.66 – 40.70 MHz and above 70 MHz.**

The field strength limit for the device was based on the operating frequency of 433.92 MHz:

**Field Strength of Fundamental**

| Frequency (MHz) | Emission Limit (μV/m) | Emission Limit (dBμV/m) | Test Distance (meters) |
|---|---|---|---|
| 433.92 | 11319 | 81.1 | 3 |

**Field strength of Spurious Emissions**

| Frequency (MHz) | Emission Limit (μV/m) | Emission Limit (dBμV/m) | Test Distance (meters) |
|---|---|---|---|
| 433.92 | 1132 | 61.1 | 3 |

The fundamental emission was measured with a quasi-peak detector. For above 1000 MHz, measurements were made with both a peak and average detector to insure that peak measurements did not exceed the average by more than 20 dB.

**III - Attestation**

## LABORATORY MEASUREMENTS

## Pursuant To
## Part 15, Subpart C
## For
## Intentional Radiators

| | |
|---|---|
| **Company Name:** | Danfoss A/S |
| **Address:** | Nordborgvej 81<br>DK-6430 Nordborg |
| **Model**: | CFR 1.5 |
| **Serial**: | Proto 004 |
| **Date of Test(s)**: | March 11, 2002 |
| **Test Site Location**: | INTERTEK TESTING SERVICES NA INC.<br>70 Codman Hill Road<br>Boxborough, MA 01719 |
| **Site**: | 2 |

I attest to the accuracy of this report:

| | |
|---|---|
| Signature | Signature |
| Nicholas Abbondante | Michael F. Murphy |
| Engineer | Reviewer |
| Engineer | Staff Engineer/EMC |
| Title | Title |

**IV - Site Description and Measurement Equipment**

The following is a description of the test procedure used by Intertek Testing Services in the measurements of transmitters operating under Part 15, Subpart C, General Requirements.

A. **Test Set-Up**: The test set-up and procedures described below are designed to meet the requirements of ANSI C63.4 (1992).

1. The test site is a Plastic/Fiberglass structure with a groundplane. The site has attenuation characteristics which meet the requirements of ANSI C63.4 (1992). Information on the site has been filed with the FCC as required by Rule 2.948. The address of the site is 70 Codman Hill Road, Boxborough, MA 01719.

2. Power to the site is nominal line voltage of 117 $V_{AC}$ and 230 $V_{AC}$, 60 Hz.

3. The equipment under test (EUT) is placed on a wooden turntable which is four feet in diameter and approximately one meter in height above the groundplane. During the radiated emissions test, the turntable is rotated 360 degrees and any cables leaving the EUT are manipulated to find the configuration resulting in maximum emissions. The antenna height and polarization are also varied during the search for maximum signal levels. The height of the antenna is varied from one meter to four meters. Body-worn, hand-held and small portable devices, and transmitters are mounted on a non-conductive box and emissions are investigated on three orthogonal axis.

4. Detector function for radiated emissions is in peak or quasi-peak mode. Average readings, when required, are taken by measuring the duty cycle of the equipment under test and subtracting the corresponding amount in dB from the measured peak readings according to the following formula:

   Averaging Factor in dB = 20 LOG (duty cycle)

   The time period over which the duty cycle is measured is 100 msec. The worst-case (highest percentage on) duty cycle is used and described specifically in the data section. The duty cycle is measured by placing the spectrum analyzer in zero scan (receiver mode) and linear mode at maximum bandwidth (3 MHz at 3 dB down) and viewing the resulting time domain signal output from the analyzer on a Tektronix 465 Oscilloscope. The oscilloscope is used because of its superior time base and triggering facilities.

5. Antennas used below 1000 MHz were EMCO Model 3142 Biconolog Antennas and Compliance Design Inc. Model A100 tuned Dipole Antennas. For measurements between 1000 MHz and 18000 MHz above 1 GHz, an EMCO Model: 3115 Horn Antenna is used. The Antennas used are listed in the Test Equipment Summary in Section 6
6. The field strength measuring equipment used included:

**The following equipment was used to make measurements for emissions testing:**

| Description | Manufacturer | Model | Serial # | Cal Due |
|---|---|---|---|---|
| SPECTRUM ANALYZER | Agilent | E7405A | US40240205 | 11/02/2002 |
| HORN ANTENNA | EMCO | 3115 | 9602-4675 | 05/29/2002 |
| RECEIVER | HEWLETT PACKARD | 85422E | 3520A00125 | 12/07/2002 |
| RF FILTER | HEWLETT PACKARD | 85420E | 3427A00126 | 12/07/2002 |
| BICONOLOG | EMCO | 3142 | 9711-1123 | 10/08/2002 |

7. The frequency range to be scanned is from the lowest radio frequency signal generated in the device which is greater than 9 kHz to the tenth harmonic of the highest fundamental frequency, or 40 GHz, whichever is lower. For line-conducted emissions, the range scanned is 450 kHz to 30 MHz.

8. The EUT was powered from a fresh battery and was configured by the client to transmit continuously (normal command words repeated).

9. Conducted measurements were made as described in ANSI C63.4 (1992). An IF bandwidth of 9 kHz is used, and peak or quasi-peak detection is employed.

10. The IF bandwidth used for measurement of radiated signal strength was 100 kHz or greater below 1000 MHz. Where pulsed transmissions of short enough pulse duration warrant, a greater bandwidth is selected according to the recommendations of Hewlett Packard Application No. 150-2. A discussion of whether pulse desensitivity is applicable to this unit is included in this report. Above 1000 MHz, a bandwidth of 1 MHz is generally used.

**V – Summary of Equipment Under Test**

| | | |
|---|---|---|
| 1 | **Manufacturer**: | Danfoss A/S<br>Nordborgvej 81<br>DK-6430 Nordborg<br>(+45) 74 88 22 69<br>TIN DK 20165715<br>Contact: Jens-Ole Boldt |
| 2 | **Grantee**: | Danfoss A/S<br>Nordborgvej 81<br>DK-6430 Nordborg<br>(+45) 74 88 22 69<br>TIN DK 20165715<br>Contact: Jens-Ole Boldt |
| 3 | **Model No.**: | CFR 1.5 |
| 4 | **Trade Name**: | Wireless Floor Heater Controller |
| 5 | **Serial No.**: | Proto 004 |
| 6 | **Date of Test**: | March 11, 2002 |
| 7 | **Frequencies to which device can be tuned**: | 433.92 MHz |
| 8 | **Can customer tune device?** | No |
| 9 | **Detailed description of operation pursuant to 15.209**: | See 15.209 |
| 10 | **Applicable emissions limits**: | 15.205, 15.207,15.209 and 15.231 |

**VI - Configuration Information**

**Equipment Under Test**: Wireless Floor Heater Controller

**Model**: CFR 1.5

**Serial No.**: Proto 004

**FCC Identifier**: PGBTYPE-CFR15

## Support Equipment:

None

## Cables:

| QTY | Description | Shield Description | Hood Description | Length (m) |
|---|---|---|---|---|

None

**VII - Configuration Photographs**

## Worst-Case Radiated Emissions

## Worst-Case Line-Conducted Emissions

This test was not required

**VIII - Sample Calculation**

The following is how net field strength readings were determined:

NF = RF + AF + CF - PF - DF

Where,

NF = Net Reading in dBμV/m
RF = Reading from receiver in dBμV
AF = Antenna Correction Factor in dB(1/m)
CF = Cable Correction Factor in dB
PF = Preamplifier Correction Factor in dB
DF = Distance Factor in dB (using 20 dB/decade), from 3 to 1 meters 10.5 dB was added for measurements performed at 1 meter

To convert from dBμV/m to μV/m or mV/m the following was used:

$UF = 10^{(NF / 20)}$

Where,

UF = Net Reading in μV/m

**Example:**

For the fundamental field strength measurement at 433.92 (distance = 3 meters) see table [2].

NF = NF = RF + AF + CF - PF - DF = 61.6 + 27.7 + 3.9 + 0.0 - 0.0 = 89.8 dBμV/m

$UF = 10^{(89.8\ dB\mu V / 20)}$ = 30,902 μV/m

## IX - Data Tables

### Radiated Emissions / Interference

Table: 1

| | | | | | |
|---|---|---|---|---|---|
| Company: | DanFoss A/S | | | Tested by: | Nicholas Abbondante |
| Model #: | CFR 1.5 | Serial #: | Proto 004 | Location: | EMI Site 2 |
| Project #: | 3019045 | Pressure: | N/A | Detector: | HP 8542E |
| Date: | 03/11/02 | Temp: | 16.1C | Antenna: | LOG2 |
| Standard: | FCC Part 15.231 | Humidity: | 20% | PreAmp: | None |
| Class: | None | Group: | None | Cable(s): | 2C, 10MPRIME MAR02. None |
| Notes: | Sample 4 | | | Distance: | 10 meters |

Abbreviations: nb - narrow band, bb - broadband, pk - peak measurement

| Ant. Pol. (V/H) | Frequency MHz | Reading dB(uV) | Antenna Factor dB(1/m) | Cable Loss dB | Pre-amp Factor dB | Distance Factor dB | Net dB(uV/m) | Limit dB(uV/m) | Margin dB |
|---|---|---|---|---|---|---|---|---|---|
| H | 433.900 | 46.4 | 16.8 | 3.5 | 0.0 | -10.5 | 77.2 | 81.1 | -3.9 |
| V | 86.100 | 13.3 | 6.8 | 1.3 | 0.0 | -10.5 | 31.8 | 61.1 | -29.3 |
| V | 330.500 | -4.7 | 15.2 | 3.0 | 0.0 | -10.5 | 23.9 | 61.1 | -37.2 |
| V | 603.300 | 5.4 | 20.5 | 4.2 | 0.0 | -10.5 | 40.6 | 61.1 | -20.5 |
| V | 868.000 | 2.6 | 23.8 | 5.3 | 0.0 | -10.5 | 42.2 | 61.1 | -18.9 |
| V | 959.300 | 0.7 | 24.3 | 5.7 | 0.0 | -10.5 | 41.2 | 61.1 | -19.9 |

**X - Duty Cycle (Average Factor)**

Average factor is subtracted from peak readings to compare emissions readings to average limits. The average factor is calculated from duty cycle measurements from the following plots.

Please note that an averaging factor was not applied to the data for this device.

**XI - Bandwidth**

The following plot(s) show bandwidth measurements made. The Bandwidth is determined at the points 20 dB down from the modulation carrier. The Bandwidth was determined to be 294 kHz. The requirement is that the bandwidth not exceed 0.25% of the fundamental frequency. The fundamental frequency is 433.9 MHz, so therefore the bandwidth must not exceed 1.085 MHz.