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

To

FCC Part 15 Subpart C, Section 15.231

Date of Test: August 22 and 23, 2000

Report Number: J20004364

Contact: Mr. Jens-Ole Boldt

Table of Contents

I – Introduction and Summary

TO: Mr. Jens-Ole Boldt
FROM: Candy L. Campbell, ITE Engineering Team Leader
DATE: January 30, 2001
JOB #: J20004364

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

On August 22 and 23, 2000 we tested the Wireless Floor Heater Controller, Model: CFR to determine if it was in compliance with the 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 Wednesday, August 22, 2000 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	433.920 867.910	78.6 43.3	80.8 60.8	Pass Pass	15.231 15.231	IX IX
Rectricted Band & Spurious Emissions	1301.85	31.2	54.0 dBµV/m	Pass	15.205	IX
Transmitter Line-conducted	N/A	N/A	N/A	N/A	15.207	N/A
Bandwidth	433.92	75.0kHz	N/A	N/A	15.213	XI
Duty Cycle	N/A	24%	N/A	N/A	15.31	X
Receiver Radiated Emissions	The receiver CFM is not an integral part of the CFR and is not covered under this test report					
Receiver Conducted Emissions	The receiver CFM is not an integral part of the CFR and is not covered under this test report					

In summary, this report confirms that the Wireless Floor Heater Controller, Model: CFR 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 a lithium battery 3.6 VDC size AA which is 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. 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.

The unit for FCC verification and certification does not contain special software to facilitate testing. The EUT was operating in a normal mode.

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.

Please note that the transmitter was tested with the service cable present, this would represent a worst case configuration.

15.33 Frequency range of measurement

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

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 10^{th} harmonic	Average	1 MHz

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

15.36 Transition Provisions

Transition provisions were not applied to the device. The receiver is not being certified with the device. The receiver is not integral to the device and is separately authorized.

15.105 Information to the user.

(b) For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

-- Reorient or relocate the receiving antenna.
-- Increase the separation between the equipment and receiver.
-- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
-- Consult the dealer or an experienced radio/TV technician for help.

15.107 Conducted limits.

(a) Except for Class A digital devices, for equipment that 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 shall not exceed the following. 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.

Frequency of Emission Conducted Limit – Class B

Frequency (MHz)	Limit (μV)	Limit (dBμV)
0.45 to 30	250	48

(b) For a Class A digital device that 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 the limits in the following table. 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. The lower limit applies at the band edges.

Frequency of Emission Conducted Limit – Class A

Frequency (MHz)	Limit (μV)	Limit (dBμV)
0.45 to 1.705	1000	60
1.705 to 30	3000	69.5

The following option may be employed if the conducted emissions exceed the limits in paragraph (a) or (b) of this Section, as appropriate, when measured using instrumentation employing a quasi-peak detector function: if the level of the emission measured using the quasi-peak instrumentation is 6 dB, or more, higher than the level of the same emission measured with instrumentation having an average detector and a 9 kHz minimum bandwidth, that emission is considered broadband and the level obtained with the quasi-peak detector may be reduced by 13 dB for comparison to the limits. When employing this option, the following conditions shall be observed:

(1) The measuring instrumentation with the average detector shall employ a linear IF amplifier.

(2) Care must be taken not to exceed the dynamic range of the measuring instrument when measuring an emission with a low duty cycle.

(3) The test report required for verification or for an application for a grant of equipment authorization shall contain all details supporting the use of this option.

Summary of Test Results

The device is powered for a 3.6 VDC battery; Therefor this test is not required.

15.109 Radiated emission limits.

Except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency of Emission Radiated Limit – Class B

Frequency (MHz)	Limit (μV/m)	Limit (dBμV/m)
30 to 88	100	40.0
88 to 216	150	43.5
216 to 960	200	46.0
Above 960	500	54.0

The field strength of radiated emissions from a Class A digital device, as determined at a distance of 10 meters, shall not exceed the following:

Frequency of Emission Radiated Limit – Class A

Frequency (MHz)	Limit (μV/m)	Limit (dBμV/m)
30 to 88	90	39.1
88 to 216	150	43.5
216 to 960	210	46.4
Above 960	300	49.5

In the emission tables above, the tighter limit applies at the band edges. Sections 15.33 and 15.35 which specify the frequency range over which radiated emissions are to be measured and the detector functions and other measurement standards apply.

For a receiver which employs terminals for the connection of an external receiving antenna, the receiver shall be tested to demonstrate compliance with the provisions of this Section with an antenna connected to the antenna terminals unless the antenna conducted power is measured as specified in Section 15.111(a). If a permanently attached receiving antenna is used, the receiver shall be tested to demonstrate compliance with the provisions of this Section.

Summary of Test Results

The receiver CFM is not an integral part of the CFR and is not covered under this test report. Refer to the Declaration of Conformity for the CFM (Receiver).

15.111 Antenna power conduction limits for receivers.

In addition to the radiated emission limits, receivers that operate (tune) in the frequency range 30 to 960 MHz and CB receivers that provide terminals for the connection of an external receiving antenna may be tested to demonstrate compliance with the provisions of Section 15.109 with the antenna terminals shielded and terminated with a resistive termination equal to the impedance specified for the antenna, provided these receivers also comply with the following: with the receiver antenna terminal connected to a resistive termination equal to the impedance specified or employed for
the antenna, the power at the antenna terminal at any frequency within the range of measurements
specified in Section 15.33 shall not exceed 2.0 nanowatts.

Summary of Test Results

The receiver CFM is not an integral part of the CFR and is not covered under this test report. Refer to the Declaration of Conformity for the CFM (Receiver).

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. The device itself is a closed plastic container that the user would not be able to open to service.

15.204 External Radio Amplifier

The device is not an amplifier.

15.205 Restricted bands of operation

The attenuation required by 15.249 is greater 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

The device was not tested for line-conducted emissions. A 3.6 VDC battery powers the CFR, therefore this test is not required.

15.209 Radiated emission limits; general requirements

All un-wanted emissions from the transmitter were compared to the general requirements.

Test Method Justifications

For maximizing emissions, the system was rotated through 360°, the antenna height was varied from 1 meter to 4 meters above the ground plane, and the antenna polarization was changed.

The system was configured for testing in a typical fashion (as a customer would normally use it), and in the confines as outlined in C63.4 (1992).

The arrangement of the cables dangling from the rear of the table was varied to the extent possible to produce the maximum emissions.

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 906.0 and 916.4 MHz:

Field Strength of Fundamental

Frequency (MHz)	Emission Limit (mV/m)	Emission Limit (dBµV/m)	Test Distance (meters)
433.92	10964.8	80.8	3

Field strength of Spurious Emissions

Frequency (MHz)	Emission Limit (mV/m)	Emission Limit (dBµV/m)	Test Distance (meters)
433.92	1096.4	60.8	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 DK-6430 Nordborg
Model:	CFR
Date of Test(s):	August 22 and 23, 2000
Test Site Location:	INTERTEK TESTING SERVICES NA INC. 70 Codman Hill Road Boxborough, MA 01719
Site:	1

I attest to the accuracy of this report:

Signature

Candy Campbell
Reviewer

ITE Engineering Team Leader
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 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	HEWLETT PACKARD	8593A	2009A00659	12/30/2000
LISN	SOLAR ELECTRONICS	8012-50-R-24-BNC	934610	06/16/2001
PREAMPLIFIER	CDI	P1000+	3237	07/20/2001
HORN ANTENNA	EMCO	3115	9602-4675	11/04/2000
RECEIVER	HEWLETT PACKARD	85422E	3520A00125	11/12/2000
RF FILTER	HEWLETT PACKARD	85420E	3427A00126	11/12/2000
BICONOLOG	EMCO	3142	9701-1225	12/30/2000

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 is warmed up for 15 minutes prior to the test. AC power to the unit is varied from 85% to 115% nominal and variation in the fundamental emission field strength is recorded. If battery powered, a new battery is used.

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.

11. Transmitter measurements are normally conducted at a measurement distance of three meters. However, to assure low enough noise floor in the forbidden bands and above 1 GHz (where no preamplifier is used), signals are acquired at a distance of one meter or less. All measurements are extrapolated to three meters using inverse scaling, but those measurements taken at a closer distance are so marked.

12. For measurements made in the 9 kHz to 30 MHz range, a distance of 30 meters was used unless a good signal-to-noise ratio could not be obtained. In that case, a closer distance was used and that distance is so marked in the data table.

V – Summary of Equipment Under Test

1	**Manufacturer**:	Danfoss A/S Nordborgvej 81 DK-6430 Nordborg (+45) 74 88 22 69 TIN DK 20165715 Contact: Jens-Ole Boldt
2	**Grantee**:	Danfoss A/S Nordborgvej 81 DK-6430 Nordborg (+45) 74 88 22 69 TIN DK 20165715 Contact: Jens-Ole Boldt
3	**Model No.**:	CFR
4	**Trade Name**:	Room Thermostat
5	**Serial No.**:	Proto 001
6	**Date of Test**:	August 22 and 23, 2000
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**:	15.105, 15.109, 15.205, 15.207,15.209 and 15.231

VI - Configuration Information

Equipment Under Test:	Transmitter
Model:	CFR
Serial No.:	Proto 001
FCC Identifier:	PGBTYPE-CFR

Support Equipment:

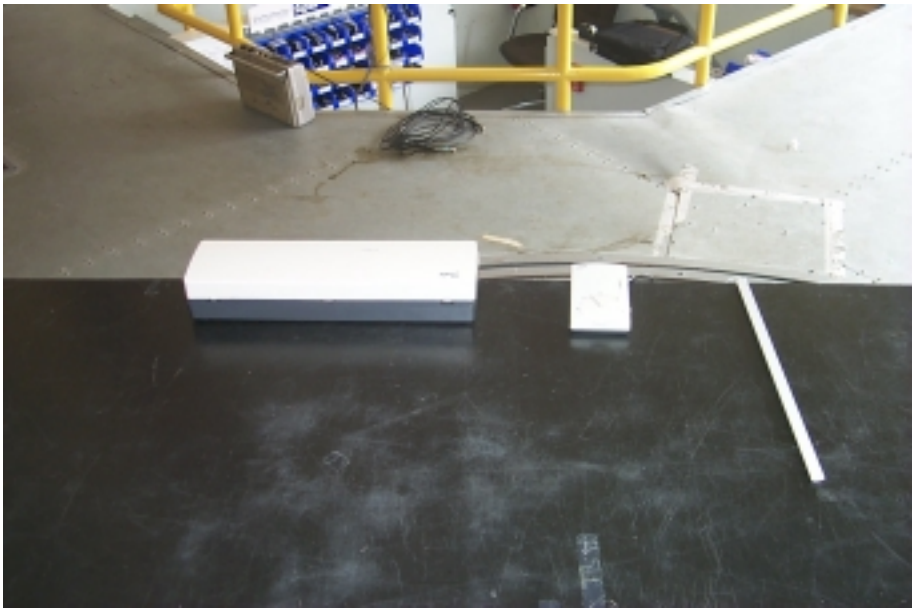
CFM	Manufacturer: Danfoss Model: CFM Part Number: 088H0041 Serial Number: Not Labeled
External Antenna	Manufacturer: Danfoss Model: Antenna Part Number: 088H0093 Serial Number: Not Labeled

Cables:

QTY	Description	Shield Description	Hood Description	Length (m)
6	Thermal I/O Cables	None	None	2 m
1	Service Cable	None	RJ45	1.5 m
1	Master I/O Cable	None	RJ45	5 m

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 906.0 (distance = 3 meters) see table [1].

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

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

IX - Data Tables

Intertek Testing Services

Radiated Emissions / Interference
Table: 2

Company: **Danfoss**
Model: **CFM**
Job No.: **J20004364**
Date: 08/22/00
Standard: FCC Part 15: 15.231, 15.205
Class: N/A
Notes: s/n: 10427

Tested by: Andy Bellezza
Location: Site 1C
Detector: HP8546A
Antenna: Log 1, HORN3
PreAmp: None
Cable(s): CBL101, 102, 103
Distance: **3** meters

	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
	V	433.920	60.1	16.8	1.8	0.0	0.0	78.6	80.8	-2.2
	V	867.910	16.3	23.9	3.2	0.0	0.0	43.3	60.8	-17.5
NF	V	1301.850	0.0	26.7	4.5	0.0	0.0	31.2	54.0	-22.8
NF	V	1735.760	-1.0	28.0	5.6	0.0	1.0	31.6	60.8	-29.2
NF	V	2169.600	-1.0	29.0	6.7	0.0	2.0	32.7	60.8	-28.1
NF	V	2603.520	1.0	30.8	8.1	0.0	0.0	39.9	60.8	-20.9
NF	V	2921.390	1.0	31.2	9.1	0.0	1.0	40.3	60.8	-20.5
NF	V	3355.310	1.0	31.7	10.4	0.0	2.0	41.1	60.8	-19.7
NF	V	3789.230	1.0	32.8	11.7	0.0	3.0	42.5	60.8	-18.3
NF	V	4223.150	1.0	34.4	13.1	0.0	0.0	48.5	60.8	-12.3

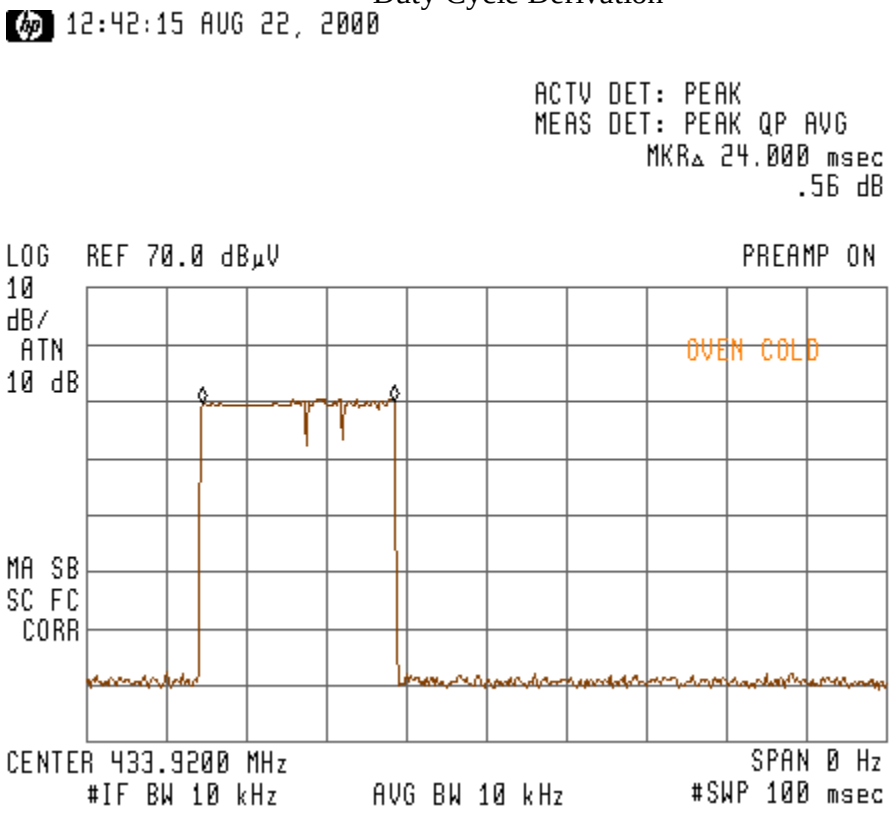
NF = Noise floor of the measuring equipment which is at least 6 dB below the applicable limit

-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.

The average factor is 20 Log (ON-TIME/PERIOD) of the emission. If the period is longer than 100 milliseconds then 100 milliseconds is used for the period. Average factor is determined using the worst-case duty cycle.

Duty Cycle Derivation



24.0 ms maximum RF on time per transmission

Maximum duty cycle over a 100ms period is 24% resulting in an averaging factor of 12.3 dB.

XI - Bandwidth

The following plot(s) show bandwidth measurements made. The Bandwidth is determined at the points 20 dB down from the modulation carrier.