ELECTROMAGNETIC EMISSIONS COMPLIANCE REPORT
CERTIFICATION TO FCC PART 15 REQUIREMENTS

for

INTENTIONAL RADIATOR

5.8 GHz TOILET VENTILATION ACCESSORY
(RANGE-GATED FIELD-DISTURBANCE SENSOR)

FCC ID: N82PNA1

REPORT NUMBER: 99U0050-1 AND 01U0855-1

ISSUE DATE: FEBRUARY 02, 1999 AND
JULY 02, 2001

Prepared for
KOHLER CO.
444 HIGH LAND DRIVE
KOHLER, WI 53044
USA

Prepared by
COMPLIANCE ENGINEERING SERVICES, INC.
d.b.a.
COMPLIANCE CERTIFICATION SERVICES
561 F MONTEREY ROAD
MORGAN HILL, CA 95037, USA
TEL: (408) 463-0885
FAX: (408) 463-0888

LAB CODE:200065-0

VERIFICATION OF COMPLIANCE

COMPANY NAME	:	KOHLER COMPANY 444 HIGHLAND DRIVE KOHLER, WI 53044 USA
CONTACT PERSON	:	D2M INC. DR. DAVE SHAFER 405 W. EVELYN MOUNTAIN VIEW, CA 94040 USA TEL: (650) 567-9995 x: 207
EUT DESCRIPTION	:	5.8GHz TOILET VENTILATION ACCESSORY
MODEL NAME/NUMBER	:	K-4657
SERIAL NO	:	002
FCC ID	:	N82PNA1
DATE TESTED	:	FEBRUARY 02, 1999 and JUNE 28, 2001
REPORT NUMBER	:	99U0050-1 and 01U0855-1

TYPE OF EQUIPMENT	INTENTIONAL RADIATOR
EQUIPMENT TYPE	5.8GHz RANGE-GATED FIELD-DISTURBANCE SENSOR
MEASUREMENT PROCEDURE	ANSI 63.4 / 1992
LIMIT TYPE	CERTIFICATION
FCC RULE	CFR 47, PART 15, SECTION 15.245

The above equipment was tested by Compliance Engineering Services, Inc. for compliance with the requirement set forth in CFR 47, PART 15. This said equipment in the configuration described in this report, shows the maximum emission levels emanating from equipment are within the compliance requirements.

Tested By:

JESSE SALDIVAR
ASSOCIATE EMC ENGINEER
COMPLIANCE CERTIFICATION SERVICES

Approved & Released For CCS By:

for Steve

STEVE CHENG
EMC ENGINEERING MANAGER
COMPLIANCE CERTIFICATION SERVICES

COMPLIANCE CERTIFICATION SERVICES
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Applicant:	Kohler Co. 444 Highland Drive Kohler, WI 53044
FCC ID:	N82PNA1
Center Frequency:	5.8 GHz
RF pulse length:	1 nsec
Pulse Rep Frequency:	1.0 MHz
FCC Rule Part:	15.245
Used For:	Activate toilet fan when toilet is in use.
Power Source:	12VDC plug in wall supply, regulated to 8.0 & 3.3 V on board.
Test Location:	Compliance Certification Services 561F Monterey Road Morgan Hill, CA 95037

Tests were performed in accordance to the test plan, which is an appendix to this report. Because the RF pulse durations are very short, **pulse desensitization** corrections are applied to spectrum analyzer readings to determine true peak levels of the fundamental frequency emission.

Pulse desensitization is applied only to **fundamental** and **harmonic emissions**; bandedge measurements are made in the standard way: 3 MHz RES BW and 3 MHz VID BW analyzer settings for peak reading measurements, and 1MHz/10 Hz settings for average reading measurements.

Data shows radiated emission levels well below the maximum levels allowed in 15.205 and 15.245.

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TEST RESULTS

A.1 Radiated Emissions
Test Requirement: 15.205, 15.245(b)(1)

A.1.1 Radiated Field Strength, 1 - 26 GHz

Measurement Equipment Used:
HP 8564E Spectrum Analyzer
HP 8449 B Preamplifier, 1-26 GHz
Double Ridge Waveguide Horn, 1 - 18 GHz
Waveguide Horn, 18 - 26 GHz, or equivalent

Test Set-Up

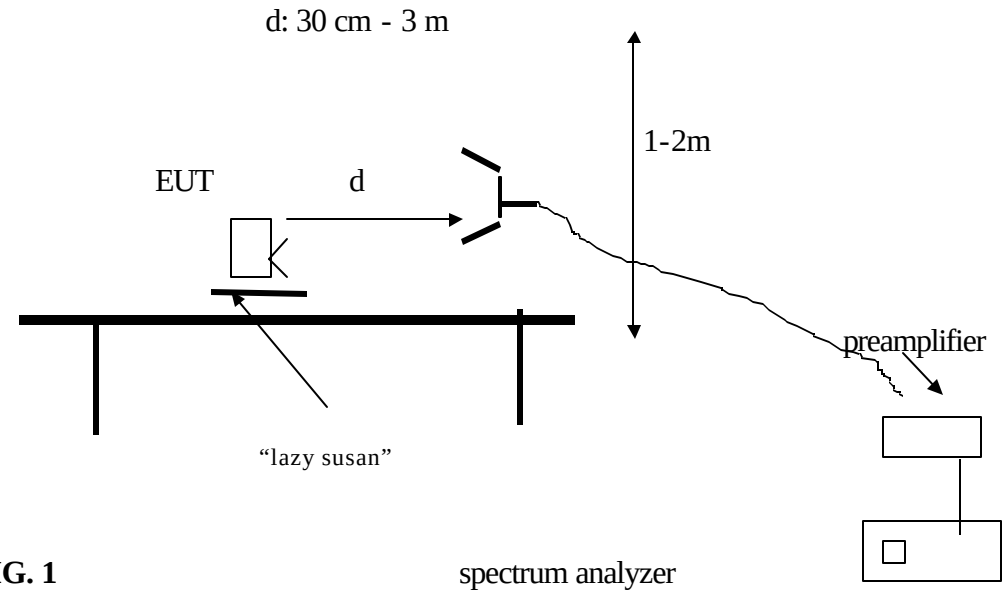

FIG. 1

Test Procedures

1. The EUT was placed on a wooden table. The search antenna was placed 3 ft. from the EUT.

2. The EUT was slowly rotated to locate the direction of maximum emission at each emission being measured. Maximum were found to be coming from the EUT antenna, as expected.

3. For each emission detected, the search antenna was raised and lowered in both vertical and horizontal polarizations. The maximum readings so obtained are recorded on the data sheets.

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NOTE:

The EUT has a duty cycle consisting of 1 nsec wide pulses with a PRF of 1 MHz

RES BW of the analyzer will either resolve a single spectral line (called "line spectrum") or will resolve several spectral lines (called "pulse spectrum").

I. The following conditions must be met for the occurrence of a **line spectrum display**:

(a) Resolution Bandwidth: B < 0.3 PRF

(b) Scan Time: Ts >(Fs/B^2) where Fs=scan width Hz/div

(c) Peak input power to analyzer Ppeak = - 10 dBm

line spectrum desensitization factor = aL = 20 log t eff*/T

The test configuration met the requirements for a line spectrum display. The 980 KHz PRF is equal to **1/T**. The quantity **t eff** is designed to be approximately 1 nsec. Actual measurements were made using Method 1.1 per the test plan [sin(x)/x = 2/π or –3.922dB (=20log2/π)]. The
3.992 dB bandwidth (see spectrum analyzer chart) is 895 MHz, representing a τeff of 1.12 nsec, in good agreement with the 1 nsec design parameter, and which will be used for calculation of line spectrum desensitization factor.

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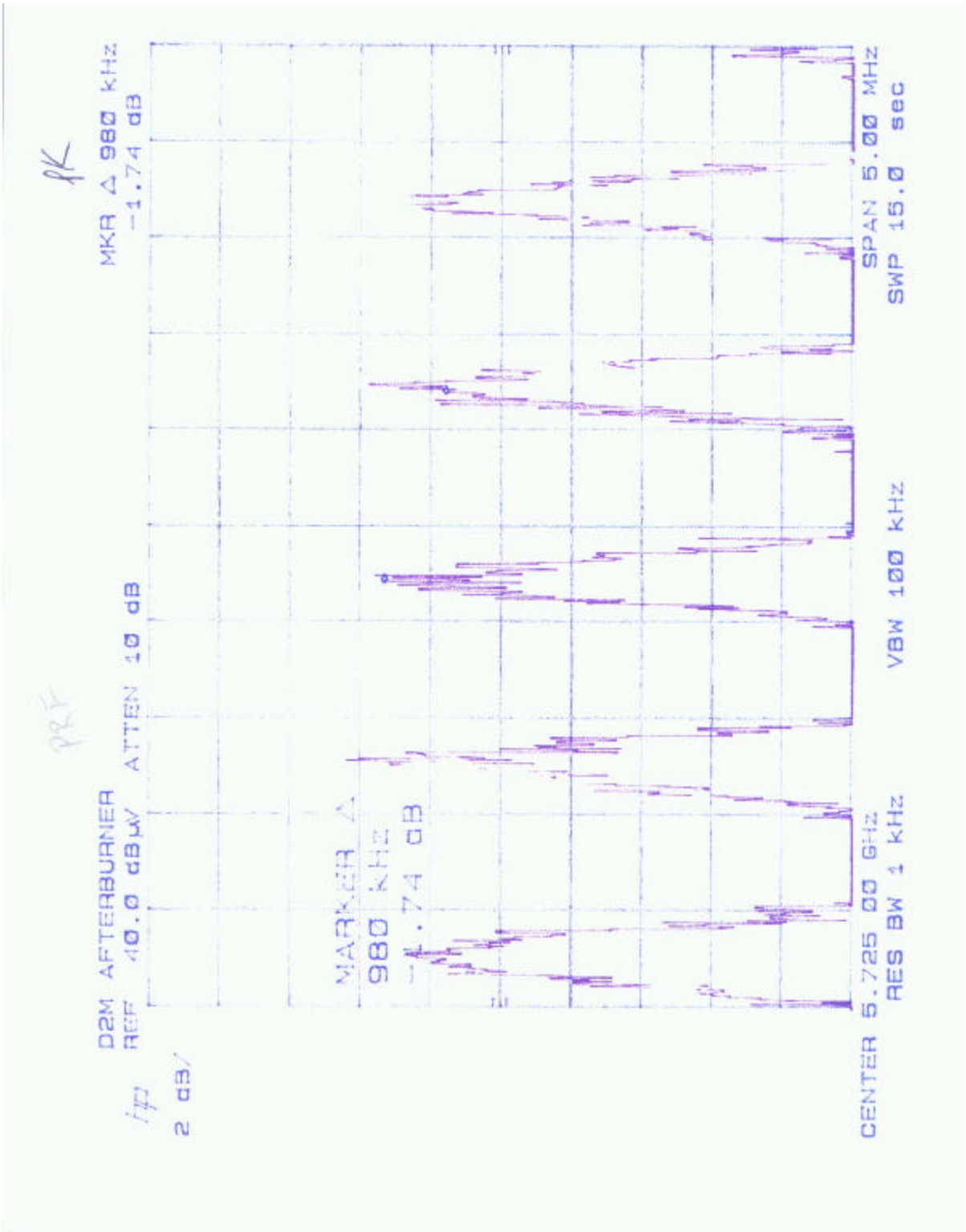

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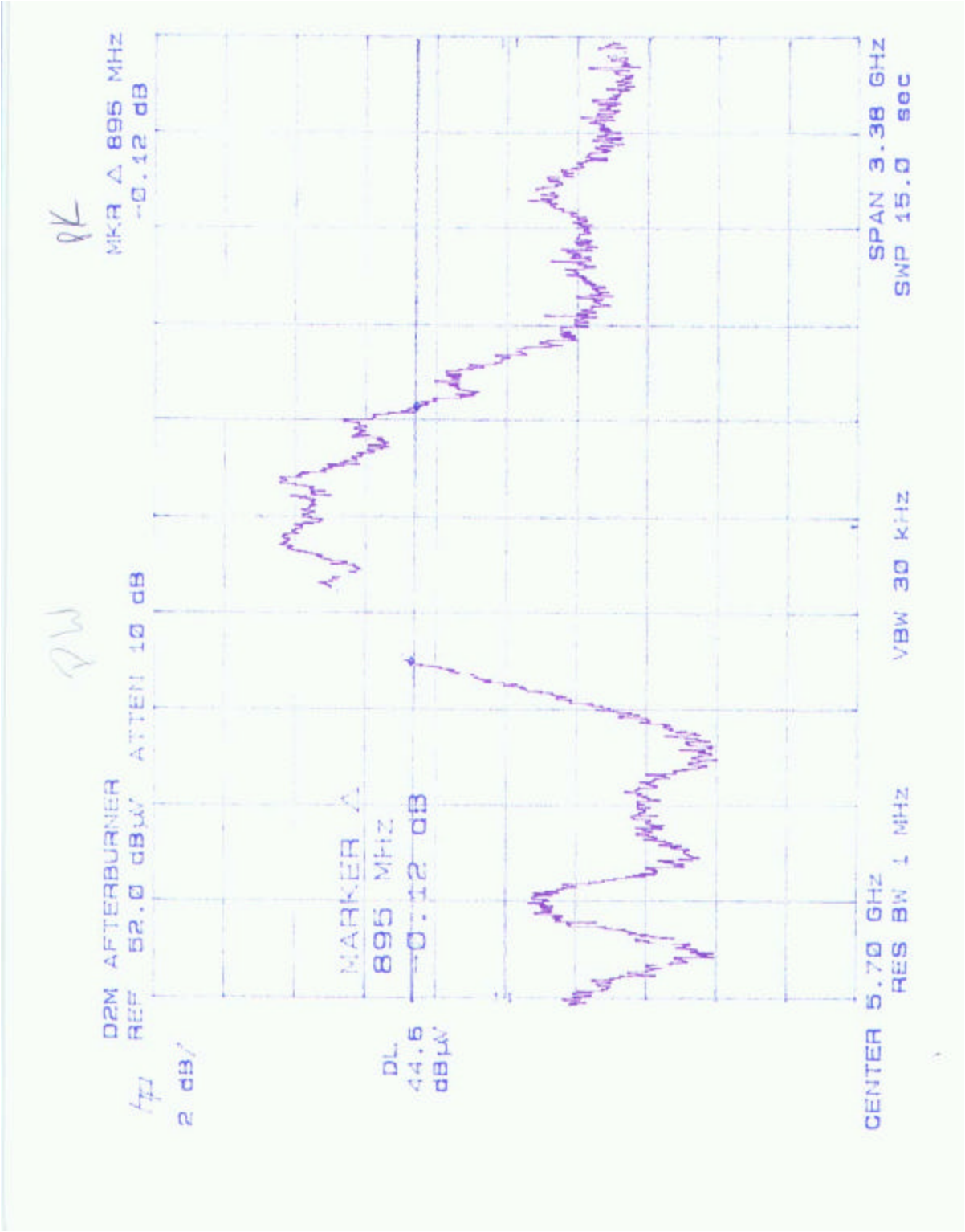

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A.1.2 Radiated Emissions, 26 - 40 GHz

Measurement Equipment Used:
HP 8566 Spectrum Analyzer
HP 11975A Preamplifier, 2 - 8 GHz (used with HP11970 external mixers)
Antenna Research Associates MWH 1826/B, 18 - 26.5 GHz
HP 11970K Harmonic mixer, 18 - 26.5 GHz
HP 11970A Harmonic mixer, 26.5 - 40 GHz with horn antenna
Low loss antenna cable (0.7 dB/ft @ 24 GHz) for leveling preamplifier connections

Test Set-Up

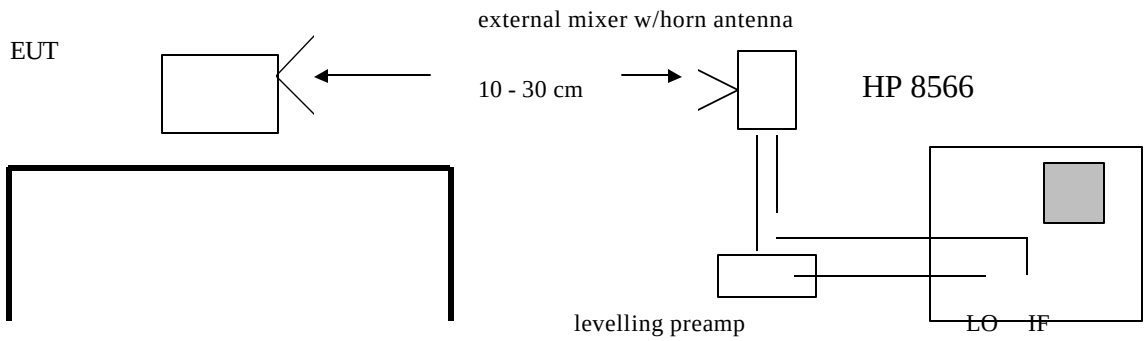

FIG.2

Test Procedures

1. The EUT was placed on a wooden table. The search antenna was placed 30 cm from the EUT. The spectrum analyzer was tuned to the first frequency for investigation, per instructions in the HP 11970 Harmonic Mixer Series user manual.

2. Signal identification routines were run per the HP 11970 Harmonic Mixer Series user manual, to determine whether a displayed signal is a mixer generated spurious or an actual emission from the EUT.

3. For each identified signal emission, the EUT was slowly rotated to locate the direction of maximum emission at each frequency being measured. Maximum emissions were found to come from the EUT antenna, as expected.

3. The search antenna was raised and lowered in both vertical and horizontal polarization. The maximum readings so obtained are recorded on the data sheets.

Pulse desensitization corrections were applied as in A.1 above.

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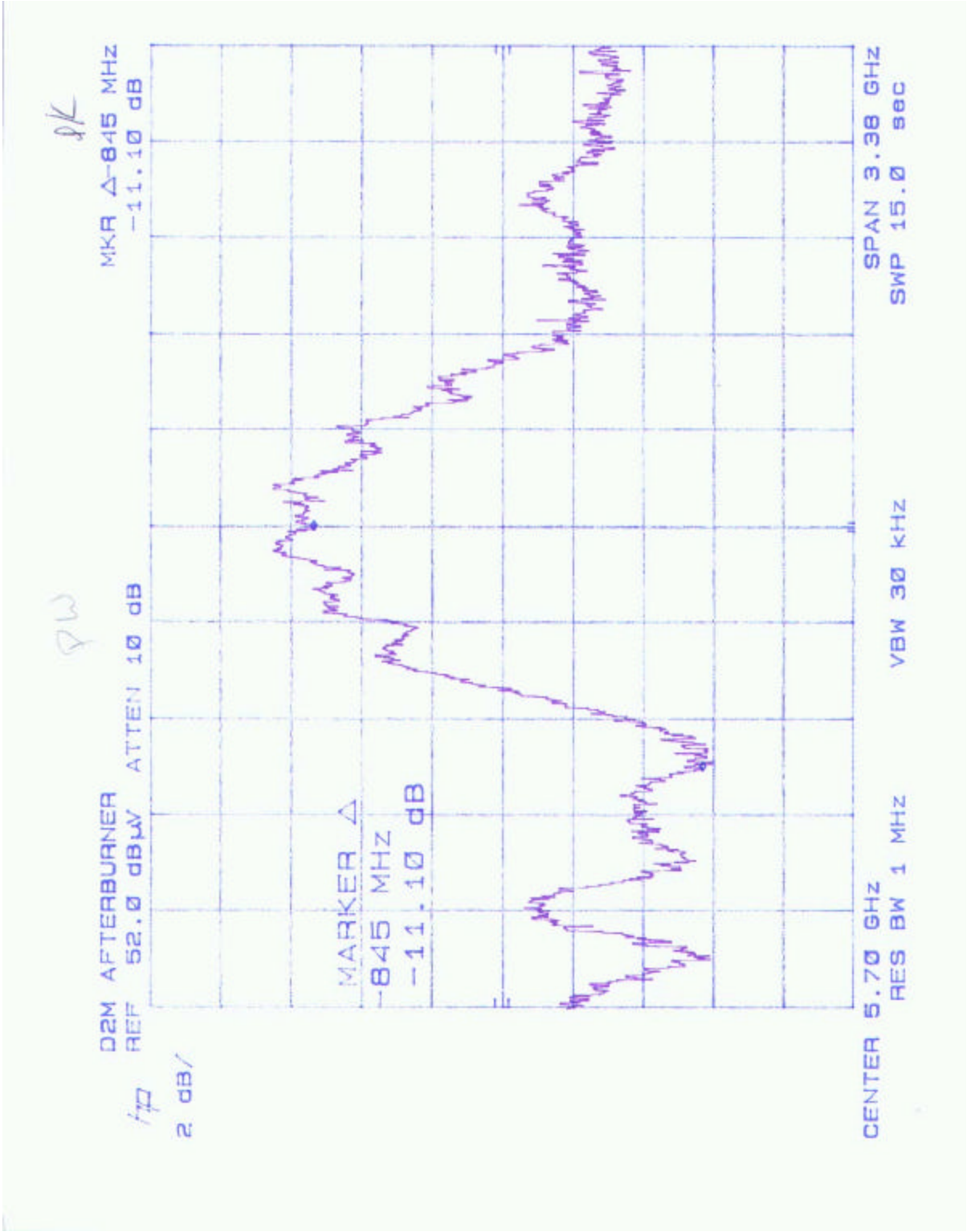

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A.2 Out of Band Emissions, 15.245(b)(3)

Radiated emissions outside the specified were below 15.209 limits. Worst-case out of band transmitter emission was at 5805 MHz. Refer to radiated emissions spreadsheet.

```
                                                Project No. : 99U0050
        Compliance Engineering Services Inc.    Report No. : 990203A1
                                                    Date : 02/03/1999
                                                       Time : 11:19
             >> 3 M RADIATED EMISSION DATA <<     Test Engr : PETE K


                     Company : D2M
          Equipment Under Test : KOHLER AFTERBURNER
            Test Configuration : EUT ONLY
                  Type of Test : FCC CLASS B
             Mode of Operation : NORMAL

Freq.   dBuV   PreAmp   Ant   Cable  dBuV/m  Limit  Margin  Pol  Hgt(m)  Az

  NO EMISSIONS FOUND.  BELOW ALL NOISE FLOOR.
    Bilog 2049 ; Pre-amp = 8447D-P1 2944A06833:
  31.00   38.50  -26.70  17.16   0.79   29.76  40.00  -10.24   V    1.0     0
  40.00   40.40  -26.60  11.55   0.96   26.31  40.00  -13.69   V    1.0     0
  50.00   38.60  -26.62   6.77   1.01   19.76  40.00  -20.24   V    1.0     0
  60.00   41.50  -26.65   5.35   1.13   21.33  40.00  -18.67   V    1.0     0
  70.00   39.60  -26.64   4.54   1.21   18.71  40.00  -21.29   V    1.0     0
  80.00   39.30  -26.66   7.35   1.34   21.33  40.00  -18.67   V    1.0     0

  Total # of data 6
  V. a2.
```


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AfterBurner (2/3/99)

S/N	002		
Lobe Wid	895	MHz	to -3.2 dB points
Pulse Len	1.1	nsec	by lobe measurment
Null Dist	845	MHz	center to first null
Pulse Len	1.2		by null measurement
PRF	0.98	MHz	by line spectrum spacing

F MHz	Distance feet	Reading dBuV	AF dB/m	CL dB	Amp dB	Dist Corr dB	Total dBuV/m	Desens dB	Peak dBuV/m	Average dBuV/m	Peak Lim dBuV/m	Avg Lim dBuV/m	Margin dB
5805P	3.0	53.6	35.2	4.8	-35.0	-10.5	48.1	59.2	107.4		114.0		-6.6
5805A	3.0	53.6	35.2	4.8	-35.0	-10.5	48.1	0.0		48.1		94.0	-45.9
5725P*	3.0	53.0	35.2	4.8	-35.0	-10.5	47.5	0.0	47.5		74.0		-26.5
5725A*	3.0	53.0	35.2	4.8	-35.0	-10.5	47.5	0.0		47.5		54.0	-6.5
5883P*	3.0	52.8	35.2	4.8	-35.0	-10.5	47.3	0.0	47.3		74.0		-26.7
5883A*	3.0	52.8	35.2	4.8	-35.0	-10.5	47.3	0.0		47.3		54.0	-6.7
5458P**	3.0	51.4	35.0	4.7	-35.0	-10.5	45.6	0.0	45.6		74.0		-28.4
5458A**	3.0	51.4	35.0	4.7	-35.0	-10.5	45.6	0.0		45.6		54.0	-8.4
5133P**	3.0	46.8	34.5	4.5	-35.0	-10.5	40.3	0.0	40.3		74.0		-33.7
5133A**	3.0	46.8	34.5	4.5	-35.0	-10.5	40.3	0.0		40.3		54.0	-13.7
4302P	3.0	47.7	33.0	4.1	-35.0	-10.5	39.3	0.0	39.3		74.0		-34.7
4302A	3.0	47.7	33.0	4.1	-35.0	-10.5	39.3	0.0		39.3		54.0	-14.7

*) Bandedge reading (no pulse desens)
**) Restricted band readings (no pulse desens)

Due to the width of the fundamental emission some energy is present in the restricted bands of 3.6-4.4GHz, 4.5-5.15GHz and 5.35-5.46GHz, this energy is not necessary for the performance of the device, but could not be practically filtered without affecting the necessary transmission , as explained below. Readings are given in the above table. These were taken at 3ft., since they were not detectable at 3 meters.

The sensor uses a short pulse of RF transmission centered at 5.8 GHz, with most of the power centered within about ±250 MHz of the carrier. In the ideal case this gives a round-trip distance resolution of about 2 feet, because the two main-lobe frequencies farthest from the carrier fall into and out of phase with each other every 2 nsec. Since light travels about 1 foot/nsec, and the round-trip distance difference is twice the amount of target motion, the sensor can reliably accept a target at a distance of, say, D, and reject a target at a distance of D + 1 foot.
For this application, that amount of range gate uncertainty is adequate, and we need to illuminate about 500 MHz of spectrum. It is not possible with practical filters to limit the spectrum to an absolute “brick wall” at this value, but if we could build such filters, the effect on the sensing performance of the device would be minimal, as long as a relatively flat spectrum could be maintained over the ±250 MHz interval. Sharp filtering of the transmitted pulse would cause ringing in the time domain, but this would contain only as much energy as was removed by the filter. For this sensor, such a filter would remove less than 10% of the transmitted energy, and so we would have a “tail” on the pulse of about 10% of the peak amplitude. This would not affect the sensing because it follows the main peak of the pulse, and any coupling to the receiver appears as a DC component in the sampler’s output, and is rejected by the baseband amplifier.

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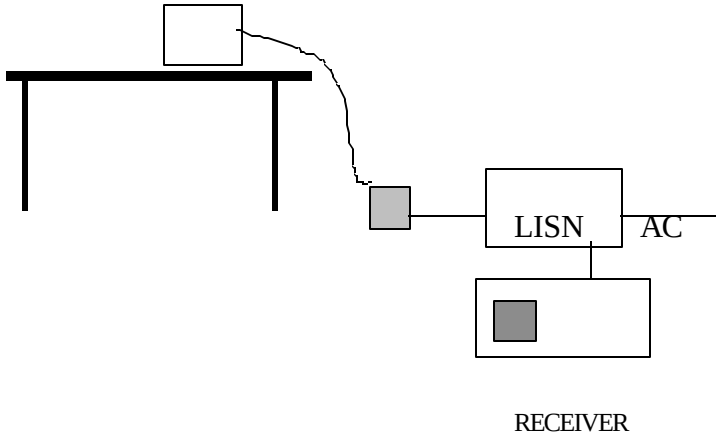
AC Line Conducted Emissions
Test Requirement: 15.207

Measurement Equipment Used:

Rhode & Schwarz EMI Receiver ESHS-20
Fischer Custom Communication LISN, FCC-LISN-50/250-25-2

Test Set-up



Test Procedure

1. The EUT was placed on a wooden table 40-cm from a vertical ground plane and approximately 80-cm above the horizontal ground plane on the floor. The EUT was set to transmit in a normal mode.

2. Line conducted data was recorded for both NEUTRAL and HOT lines.

Test Results

Refer to attached graph. (One page)

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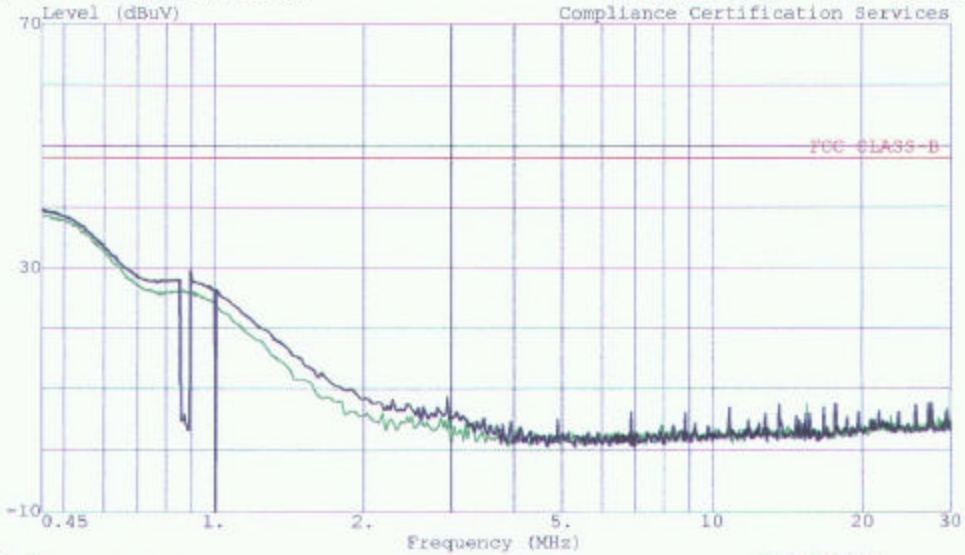
1366 Bordeaux Dr.
Sunnyvale, CA 94089-1005 USA
Tel: (408) 752-8166
Fax: (408) 752-8168

Data#: 7 File#: 99U0050.EMI Date: 02-03-1999 Time: 11:51:28



Trace: 3 Ref Trace:

Project No. : 99u0050
Report No. : 990203
Test Engr : PETE KREBILL
Company : D2M
EUT : AFTERBURNER
Test Config.: EUT ONLY
Type of Test: FCC
Mode of Op. : NORMAL
: 110VAC 60HZ
: L1=GREEN L2=BLACK

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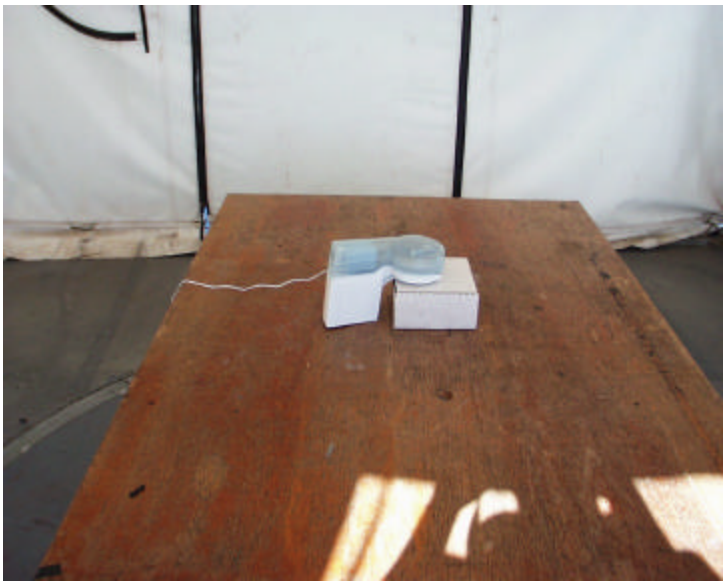
SETUP PHOTO 02/02/99



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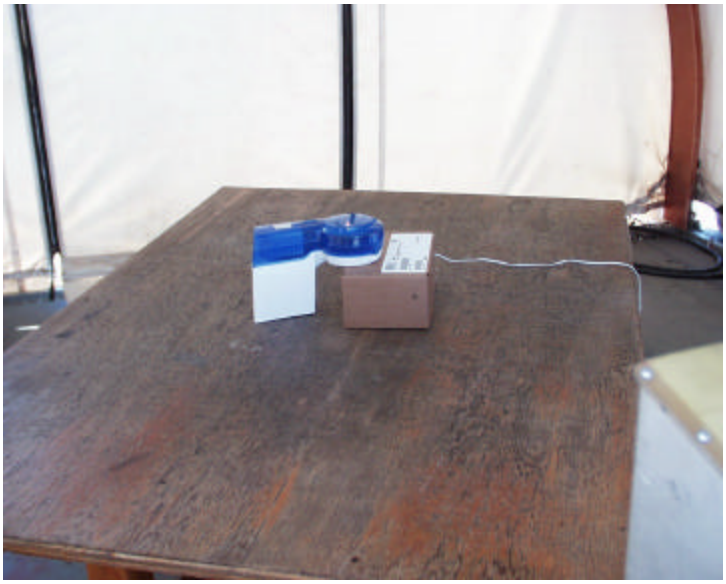
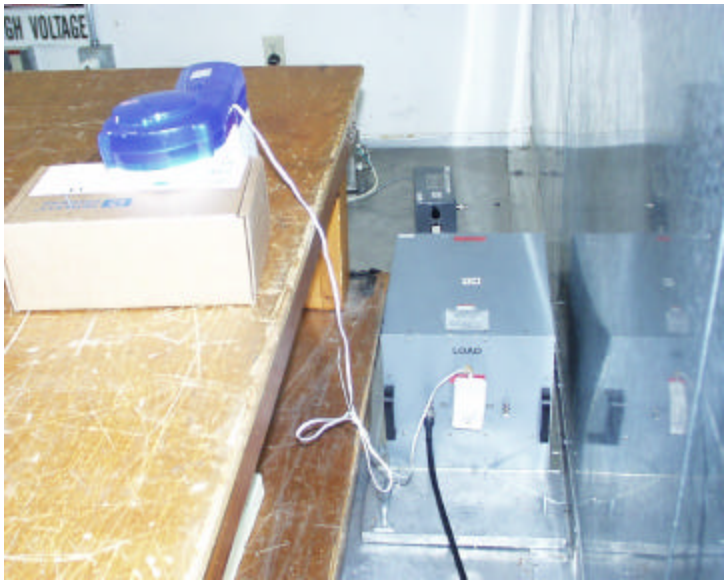
SETUP PHOTO 06/28/01





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28-Jun-01 AfterBurner Sensor FCC Measurement
Compliance Certification Services, Morgan Hill Open Field Site

Equipment for 1-22 GHz
HP8566B Analyzer
HP8449B Preamp
EMCO 3115 Antenna
Cable: 16.0 feet

Equipment for 22.58 GHz
HP8566B Analyzer
HP 11975A Amplifier (LO)
xxxx External mixer/antenna
Cable: IF Only (321 MHz)

Equipment for 28.22 GHz
HP8566B Analyzer
HP 11975A Amplifier (LO)
xxxx External mixer/antenna
Cable: IF Only (321 MHz)

Average Measurements:
1 MHz Resolution Bandwidth
Average Detector
10 Hz Video Filter

Peak Measurements:
Pulse Desens = -20*log(PRF*tau)
Peak = Average + Pulse Desens

EUT S/N: 08.02
Lobe Wid: 448 MHz to -3.92 dB points
Pulse Len: 2.2 nsec by lobe measurment
PRF: 1.01 MHz by line spectrum spacing
Peak Lim: 60.0 dB over average limit by waiver request

f GHz	Dist feet	Read dBuV	AF dB/m	CL dB	Amp dB	D Corr dB	Avg dBuV/m	Desen dB	Peak dBuV/m	Avg Lim dBuV/m	Pk Lim dBuV/m	Avg Mar dB	Pk Mar dB	Notes
5.64	3.0	41.9	34.3	6.8	-35.5	-10.3	37.1	52.9	90.0	54.0	114.0	-16.9	-24.0	Horizontal
5.64	3.0	48.3	34.3	6.8	-35.5	-10.3	43.6	52.9	96.5	54.0	114.0	-10.4	-17.5	Horizontal (Peak Detect)
5.23	3.0	35.4	33.5	6.4	-35.5	-10.3	29.5	52.9	82.4	54.0	114.0	-24.5	-31.6	Vertical
11.29	3.0	33.7	38.7	9.8	-35.5	-10.3	36.4	52.9	89.3	54.0	114.0	-17.6	-24.7	No Emissions Found
16.93	3.0	37.1	42.3	13.1	-35.5	-10.3	46.6	52.9	99.6	54.0	114.0	-7.4	-14.4	No Emissions Found
22.58	1.0	37.6	32.5	0.0	0.0	-19.9	50.2	52.9	103.2	54.0	114.0	-3.8	-10.8	No Emissions Found
28.22	1.0	39.3	24.2	0.0	0.0	-19.9	43.6	52.9	96.6	54.0	114.0	-10.4	-17.4	No Emissions Found

f	Measurement Frequency	Amp	Preamp Gain	Avg Lim	Average Field Strength Limit
Dist	Distance to Antenna	D Corr	Distance Correct to 3 meters	Pk Lim	Peak Field Strength Limit
Read	Analyzer Reading	Avg	Average Field Strength @ 3 m	Avg Mar	Margin vs. Average Limit
AF	Antenna Factor	Desen	Pulse Desens (Peak-to-Average)	Pk Mar	Margin vs. Peak Limit
CL	Cable Loss	Peak	Calculated Peak Field Strength		

This is the Average Field Strength over 5-7 GHz (Average Detector, 1 MHz RBW, ~1m measurement distance) and the Harmonic Emissions (Average Detector, 1 MHz RBW).

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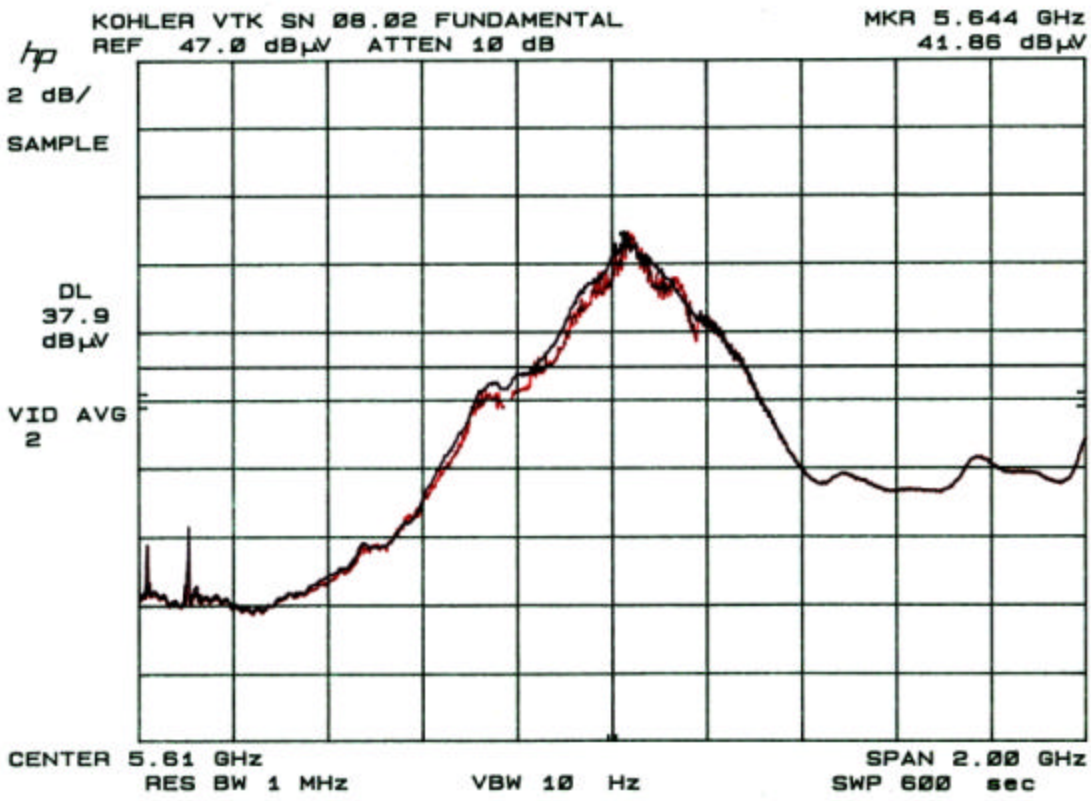

This is the Emission Bandwidth to –4dB points.

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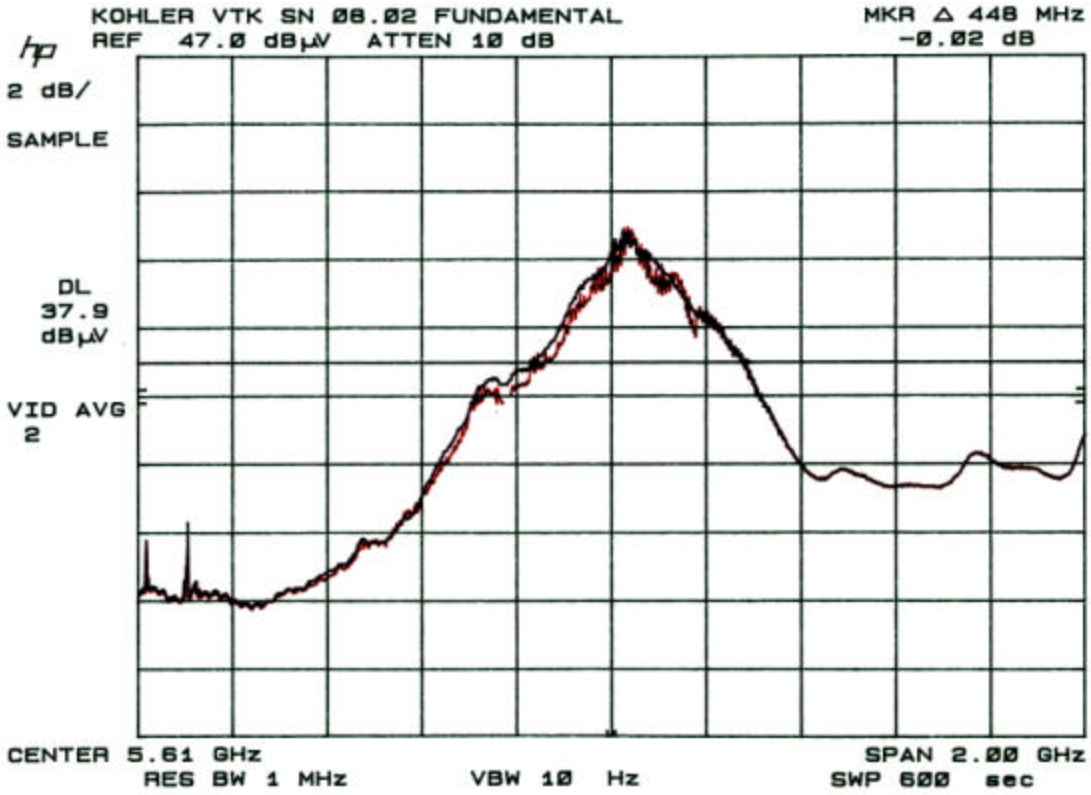

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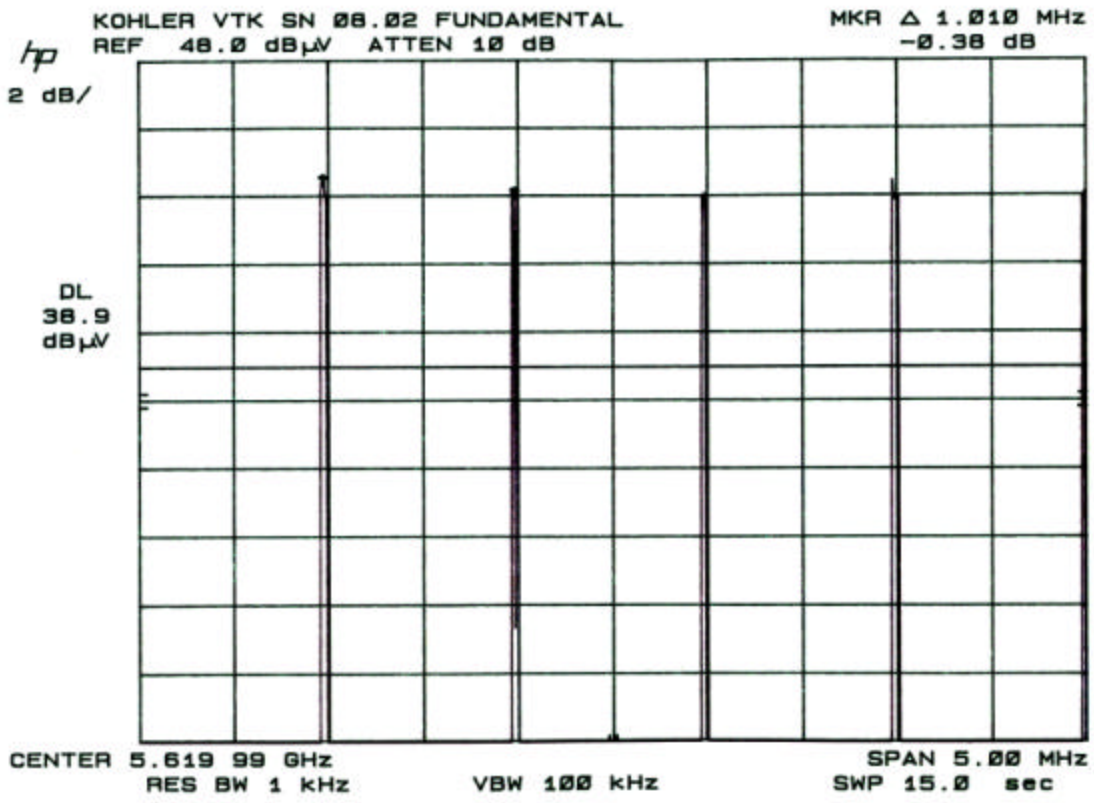

This is the Spacing of Spectral Line at 1MHz.

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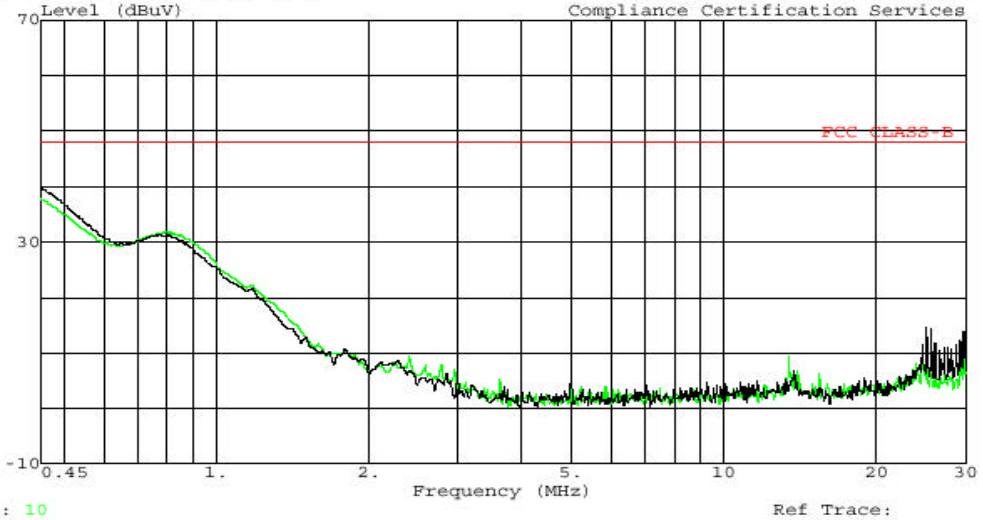
Data#: 14 File#: 01U0855.EMI Date: 06-28-2001 Time: 16:28:02



Trace: 10 Ref Trace:

Project No. : 014U0855-1
Report No. : 010628
Test Engr : Jesse Saldivar
Company : D2M
EUT Description : 5.8GHz Transmitter
Model : K4657
EUT Config. : EUT
Type of Test : FCC Class B
Mode of Operation: Continuous TX with Fan Motor Off
: PEAK: L1(Green), L2 (Black)
: 115Vac, 60Hz

This is the AC Line Conducted Emissions.

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