Measurement of RF Interference from a Model KC21 Bluetooth Module Transmitter

For : KC Wire Free

Date Received : January 3, 2005
Date Tested : January 3 through January 10, 2005
Test Personnel : Daniel E. Crowder
Specification : FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Section 15.247 for Frequency Hopping Spread Spectrum Intentional Radiators Operating within the 2400-2483.5MHz band.

Test Report By :

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ATL-0152-E

Approved By :

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Measurement of RF Interference from a

Model KC21 Bluetooth Module Transmitter

1.0 INTRODUCTION:

1.1 Description of Test Item - This document represents the results of the series of radio interference measurements performed on a Bluetooth Module, Model No. KC21, Serial No. FCC #2, (hereinafter referred to as the test item). The test item is a frequency hopping spread spectrum transceiver used in vehicle bluetooth applications. It transmits in the 2400.0MHz to 2483.5MHz band and uses an internal antenna. The test item was manufactured and submitted for testing by KC Wire Free located in Phoenix, AZ.

1.2 Purpose - The test series was performed to determine if the test item meets the conducted and radiated RF emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Section 15.247 for Intentional Radiators. Testing was performed in accordance with ANSI C63.4-2001.

1.3 Deviations, Additions and Exclusions - There were no deviations, additions to, or exclusions from the test specification during this test series.

1.4 Applicable Documents - The following documents of the exact issue designated form part of this document to the extent specified herein:

- Federal Communications Commission "Code of Federal Regulations", Title 47, Part 15, Subpart C, dated 1 October 2003
- FCC Public Notice, DA 00-705, "Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems", Released March 30, 2000
- ANSI C63.4-2003, "American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz"

1.5 Subcontractor Identification - This series of tests was performed by Elite Electronic Engineering Incorporated of Downers Grove, Illinois. The laboratory is accredited by the National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP). NVLAP Lab Code: 100278-0.

1.6 Laboratory Conditions - The temperature at the time of the test was 21^{o}C and the relative humidity was 15%.

2.0 TEST ITEM SETUP AND OPERATION:

The test item is a Bluetooth Module, model KC21. The test item was mounted on a model KC121 interface board. A block diagram of the test item setup is shown as Figure 1.

2.1 Power Input - The test item obtained 6 VDC power through two leads from a CUI, Inc. model DV-6250 Class 2 Transformer. The transformer received 120V 60Hz power through lowpass powerline filters on the wall of the shielded enclosure. The leads from the transformer to the test item were approximately 1 meter long.

2.2 Grounding - Since only two wires were used to provide the input power, the test item was ungrounded during the tests.

2.3 Support Equipment - There was no support equipment submitted with the test item.

2.4 Interconnect Cables - The following interconnect cables were submitted with the test item:

Item	Description
RS232 Cable	Used for programming only - Unterminated for radiated tests and connected to computer during conducted tests

2.5 Operational Mode - The test item and all support equipment was placed on an 80cm high non-conductive stand. The test item and all support equipment were energized. The test item was set to transmit at frequencies of 2402MHz, 2441MHz and 2480MHz.

3.0 TEST EQUIPMENT:

3.1 Test Equipment List - A list of the test equipment used can be found on Table I. All equipment was calibrated per the instruction manuals supplied by the manufacturer.

3.2 Calibration Traceability - Test equipment is maintained and calibrated on a regular basis. All calibrations are traceable to the National Institute of Standards and Technology (NIST).

4.0 REQUIREMENTS, PROCEDURES AND RESULTS:

4.1 Powerline Conducted Emissions

4.1.1 Requirements – All radio frequency voltages on the power lines of a intentional radiators shall be below the values shown below when using a quasi-peak detector:

CONDUCTED LIMITS FOR INTENTIONAL RADIATORS

Frequency MHz	RFI Voltage dBuV(QP)	RFI Voltage dBuV(Average)
0.15-0.5	66 decreasing with logarithm of frequency to 56	56 decreasing with logarithm of frequency to 46
0.5-5	56	46
5-30	60	50

Note 1: The lower limit shall apply at the transition frequencies.

Note 2: If the levels measured using the QP detector meet both the QP and the Average limits, the test item is considered to have met both requirements and measurements do not need to be performed using the Average detector.

4.1.2 Procedures - The interference on each power lead was measured by connecting the measuring equipment to the appropriate meter terminal of the LISN. The meter terminal of the LISN not under test was terminated with 50 ohm. Measurements were first made over the entire frequency range from 150kHz through 30MHz with a peak detector and the results were automatically plotted. The data thus obtained was then searched by the computer for the highest levels. Quasi-peak measurements were automatically performed at the frequencies selected from the highest peak measurements, and the results printed.

4.1.3 Results - The conducted emissions comply with the specification limit. The plots of the peak preliminary conducted voltage levels on each power line are presented on pages 15 and 16. The conducted limit is shown as a reference. The final quasi-peak results are presented on pages 17 and 18. Photographs of the test configuration which yielded the highest or worst case, conducted emission levels are shown on Figure 2.

4.2 Carrier Frequency Separation

4.2.1 Requirements - Per section 15.247 (a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25kHz or the 20dB bandwidth of the hopping channel, whichever is greater.

4.2.2 Procedures - The test item was setup inside the chamber. With the hopping function enabled, the test item was allowed to transmit continuously.

The resolution bandwidth (RBW) was set to $\geq$ to 1% of the span. The peak detector and 'Max-

Hold' function were engaged. The span was set wide enough to capture the peaks of at least two adjacent channels.

When the trace had stabilized after multiple scans, the marker-delta function was used to determine the separation between the peaks of the adjacent channels. The analyzer's display was plotted using a 'screen dump' utility.

4.2.3 Results - Page 19 shows the carrier frequency separation. As can be seen from this plot, the separation is 991.9 kHz which is greater than the 20dB bandwidth (951.9kHz).

4.3 Number of Hopping Frequencies

4.3.1 Requirements - Per section 15.247(a)(1)(iii), for frequency hopping systems operating in the 2400-2483.5MHz band, the frequency hopping systems shall use at least 15 non-overlapping channels.

4.3.2 Procedures - The test item was setup inside the chamber. The output of the test item was connected to the spectrum analyzer through a 30dB pad. With the hopping function enabled, the test item was allowed to transmit continuously.

The resolution bandwidth (RBW) was set to ≥ to 1% of the span. The peak detector and 'Max-Hold' function were engaged. The span was set wide enough to capture the entire frequency band of operation.

The test item's signal was allowed to stabilize after multiple scans. The number of hopping frequencies was counted. The analyzer's display was plotted using a 'screen dump' utility.

4.3.3 Results - Page 20 shows the number of hopping frequencies. As can be seen from this plot, the number of frequencies is 79 which is greater than the minimum required.

4.4 Time of Occupancy

4.4.1 Requirement - Per section 15.247(a)(1)(iii), for frequency hopping systems operating in the 2400-2483.5MHz band, the average time of occupancy shall not be greater than 0.4 seconds within a 0.4 second period multiplied by the number of hopping channels employed.

4.4.2 Procedures - The test item was setup inside the chamber. With the hopping function enabled, the test item was allowed to transmit continuously.

The resolution bandwidth (RBW) was set to 1 MHz. The peak detector and 'Max-Hold' function were engaged. With the span set to 0Hz, the sweep time was adjusted to capture a single event in order to measure the dwell time per hop. Then, the sweep time was expanded to capture the average time between hops. When the trace had stabilized after multiple scans, the time between hops was measured.

The analyzer's display was plotted using a 'screen dump' utility.

The dwell time in a 32 second period was then calculated from dwell time per hop multiplied by the number of hops.

4.4.3 Results - Pages 21 through 23 show the plots for the time of occupancy (dwell time). As can be seen from the plots, the time of occupancy can be determined by a 2.8mSec pulse multiplied by 98 hops. This calculated value is equal to 0.274 seconds which is less than the 0.4 seconds maximum allowed.

4.5 20dB Bandwidth

4.5.1 Requirement - Per section 15.247(a)(1)(iii), for frequency hopping systems operating in the 2400-2483.5MHz band, the 20dB bandwidth shall be measured for determination of the carrier frequency separation limits.

4.5.2 Procedures - The test item was setup inside the chamber. With the hopping function disabled, the test item was allowed to transmit continuously. The frequency hopping channel was set separately to low, middle, and high hopping channels. The resolution bandwidth (RBW) was set to $\geq$ to 1% of the 20 dB BW.

The 'Max-Hold' function was engaged. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined. The analyzer's display was plotted using a 'screen dump' utility.

4.5.3 Results - The plots on pages 24 through 26 show that the maximum 20 dB bandwidth was 951.9kHz.

4.6 Peak Output Power

4.6.1 Requirement - Per section 15.247(b)(1), For frequency hopping systems operating in the 2400-2483.5MHz band and employing at least 75 hopping channels. The peak output power shall not be greater than 1 watt.

Per section 15.247(4), the peak output power from an intentional radiator if the transmitting antenna(s) have a directional gain greater than 6dBi shall be reduced below by the amount in dB that the directional gain of the antenna exceeds 6dBi.

4.6.2 Procedures - The test item was placed on the non-conductive stand and set to transmit. A broadband measuring antenna was placed at a test distance of 3 meters from the test item. The test item was maximized for worst case emissions (or maximum output power) at the measuring antenna. The maximum meter reading was recorded. The peak power output was measured for the low, middle and high hopping frequencies.

The equivalent power was determined from the field intensity levels measured at 3 meters using the substitution method. To determine the emission power, another double ridged waveguide antenna was then set in place of test item and connected to a calibrated signal generator. The output of the signal generator was adjusted to match the received level at the spectrum analyzer. The signal level was recorded. The reading was then corrected to compensate for cable loss, as required. The peak power output was calculated for the low, middle and high hopping frequencies.

4.6.3 Results - The results are presented on page 27. The maximum EIRP measured from the transmitter was 1.4 dBm which meets the 36dBm defacto limit.

4.7 Bandedge Compliance

4.7.1 Requirement - Per section 15.247(c), the emissions at the band-edges must be at least 20dB below the highest level measured within the band. In addition, the radiated emissions which fall in the restricted band beginning at 2483.5 MHz, must meet the general limits of 15.209

4.7.2 Procedures - The test item was setup inside the chamber. With the hopping function disabled, the test item was allowed to transmit continuously. The frequency hopping channel was set separately to low and high hopping channels. The resolution bandwidth (RBW) was set to 100 kHz.

The 'Max-Hold' function was engaged. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined. The analyzer's display was plotted using a 'screen dump' utility. The measurement was repeated with the frequency hopping function enabled.

For the emissions which fall in the restricted band the "marker-delta" method described in Public Notice DA 00-705 was used. Initially radiated measurements were performed at the fundamentals of the highest hopping frequencies using 1 MHz bandwidth. For the measurements the "delta" required to meet the general limit was calculated.

Next, the band-edge emissions were plotted using peak detector and 100 kHz bandwidth. The "delta" limit was applied to this plot to determine compliance at the band-edge.

The test item was placed on the non-conductive stand and set to transmit. A broadband measuring antenna was placed at a test distance of 3 meters from the test item. The test item was maximized for worst case emissions (or maximum output power) at the measuring antenna. The maximum meter reading was recorded.

4.7.3 Results - Pages 28 through 31 show the radiated band-edge compliance results using the marker-delta method. As can be seen from these plots, the emissions at the band-edge and in

the restricted band are within the general limits.

4.8 Spurious Emissions

4.8.1 Radiated Spurious Emissions

4.8.1.1 Requirement – Per section 15.247(c), the radiated emissions which fall in the restricted bands must meet the general limits of 15.209.

4.8.1.2 Procedures – The radiated tests were performed in a 32ft. x 20ft. x 18ft. hybrid absorber lined semi-anechoic test chamber. With the exception of the floor, the reflective surfaces of the shielded chamber are lined with ferrite tiles on the walls and ceiling. The floor of the chamber is used as the ground plane. The chamber complies with ANSI 63.4 and CISPR 16 requirements for site attenuation.

Preliminary radiated measurements are performed to determine the frequencies where the significant emissions might be found. With the test item at one set position and the measurement antenna at a set height (i.e. without maximizing), the radiated emissions were measured using peak detection with 100 kHz BW. This data was then automatically plotted up through 18 GHz. The frequency range from 18 to 25 GHz was checked manually but not plotted.

Next, the harmonic or spurious emissions falling in the restricted bands were measured up through the 10th harmonic. For the measurements above 1GHz, the measurement bandwidth was set to 1 MHz RBW. The analyzer was set to **linear mode** with 10 Hz VBW in order to simulate an average detector. A pre-amplifier was used to increase the receiver sensitivity.

4.8.1.3 Results - The preliminary emissions levels were plotted. These plots are presented on pages 32 through 37. These plots indicate that the radiated spurious emissions were below the general limit.

The harmonics and any other emissions that fall in the restricted frequency bands were then re-measured manually. This data is shown in the tables on pages 38 through 40. The field intensities levels for the harmonics in the restricted band were within the limit.

4.9 Spectral Density

4.9.1 Requirement - Per section 15.247(d), the peak power spectral density from the intentional radiator shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

4.9.2 Procedures - The test item was put into inquiry mode. The test item was placed on

the non-conductive stand and set to transmit. A broadband measuring antenna was placed at a test distance of 3 meters from the test item. The test item was maximized for worst case emissions (or maximum output power) at the measuring antenna.

The resolution bandwidth (RBW) was set to 3kHz, the sweep time was set to the span divided by 3kHz (1MHz/3kHz = 333 seconds). The peak detector and 'Max-Hold' function was engaged. The analyzer's display was plotted using a 'screen dump' utility.

4.9.3 Results - Page 41 shows the power spectral density results. As can be seen from this plot, the peak power density is less than 8dBm in a 3kHz band during any time interval of continuous transmission.

5.0 CONCLUSIONS:

It was determined that the KC Wire Free Bluetooth Module, Model No. KC21, Serial No. FCC #2, did fully meet the conducted and radiated emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Section 15.247 for Bluetooth spread spectrum transmitters.

6.0 CERTIFICATION:

Elite Electronic Engineering Incorporated certifies that the information contained in this report was obtained under conditions which meet or exceed those specified in the test specifications.

The data presented in this test report pertains to the test item at the test date. Any electrical or mechanical modification made to the test item subsequent to the specified test date will serve to invalidate the data and void this certification.

7.0 ENDORSEMENT DISCLAIMER:

This report must not be used to claim product endorsement by NVLAP or any agency of the US Government.

TABLE I: TEST EQUIPMENT LIST

ELITE ELECTRONIC ENG. INC. Page: 1

Eq ID	Equipment Description	Manufacturer	Model No.	Serial No.	Frequency Range	Cal Date	Cal Inv	Due Date
Equipment Type: ACCESSORIES, MISCELLANEOUS								
XPR0	HIGH PASS FILTER	K&L MICROWAVE	11SH10-4800/	001	4.8-20GHZ	07/19/04	12	07/19/05
XZG0	ATTENUATOR/SWITCH DRIVER	HEWLETT PACKARD	11713A	3439A02724	---		N/A	
Equipment Type: AMPLIFIERS								
APK0	PRE-AMPLIFIER	HEWLETT PACKARD	8449B	3008A00662	1-26.5GHZ	02/04/04	12	02/04/05
Equipment Type: ANTENNAS								
NTA0	BILOG ANTENNA	CHASE EMC LTD.	BILOG CBL611	2057	0.03-2GHZ	07/12/04	12	07/12/05
NWI0	RIDGED WAVE GUIDE	AEL	H1498	153	2-18GHZ	09/05/04	12	09/05/05
NWI1	RIDGED WAVE GUIDE	AEL	H1498	154	2-18GHZ	09/05/04	12	09/05/05
Equipment Type: ATTENUATORS								
T1E7	10DB, 25W ATTENUATOR	WEINSCHEL	46-10-34	BG3489	DC-18GHZ	08/09/04	12	08/09/05
T2DH	20DB 25W ATTENUATOR	WEINSCHEL	46-20-34	BN1039	DC-18GHZ	03/29/04	12	03/29/05
Equipment Type: METERS								
MPC1	DUAL POWER METER	HEWLETT PACKARD	EPM-442A	US37480258	0.1MHZ-50GHZ	05/19/04	12	05/19/05
MPCI	POWER SENSOR	HEWLETT PACKARD	8482A	US3318A27650	0.1-4200MHZ	02/24/04	12	02/24/05
Equipment Type: RECEIVERS								
RAC1	SPECTRUM ANALYZER	HEWLETT PACKARD	85660B	3407A08369	100HZ-22GHZ	02/04/04	12	02/04/05
RACB	RF PRESELECTOR	HEWLETT PACKARD	85685A	3506A01491	20HZ-2GHZ	02/04/04	12	02/04/05
RAF3	QUASIPEAK ADAPTER	HEWLETT PACKARD	85650A	3303A01775	0.01-1000MHZ	02/04/04	12	02/04/05
RBA1	EMI TEST RECEIVER	RHODE & SCHWARZ	ESIB26	100146	20HZ-26.5GHZ	03/29/04	12	03/29/05
Equipment Type: SIGNAL GENERATORS								
GBX1	SYNTHESIZED SWEEPER	HEWLETT PACKARD	83630A	3420A00857	10MHZ-26.5GHZ		NOTE 1	

Cal. Interval: Listed in Months I/O: Initial Only N/A: Not Applicable
Note 1: For the purpose of this test, the equipment was calibrated over the specified frequency range, pulse rate, or modulation prior to the test or monitored by a calibrated instrument.

ELITE ELECTRONIC ENGINEERING INC.

Radiated Emissions Test Setup Anechoic Ferrite Chamber

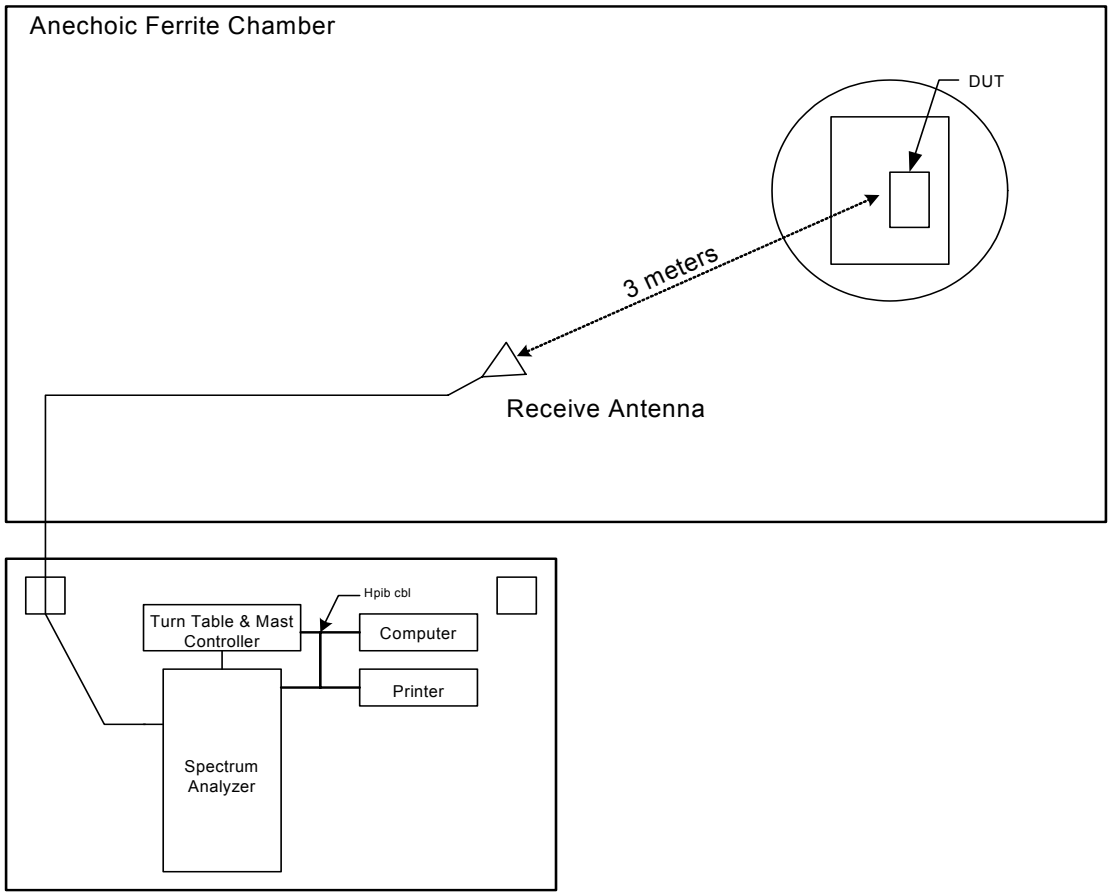
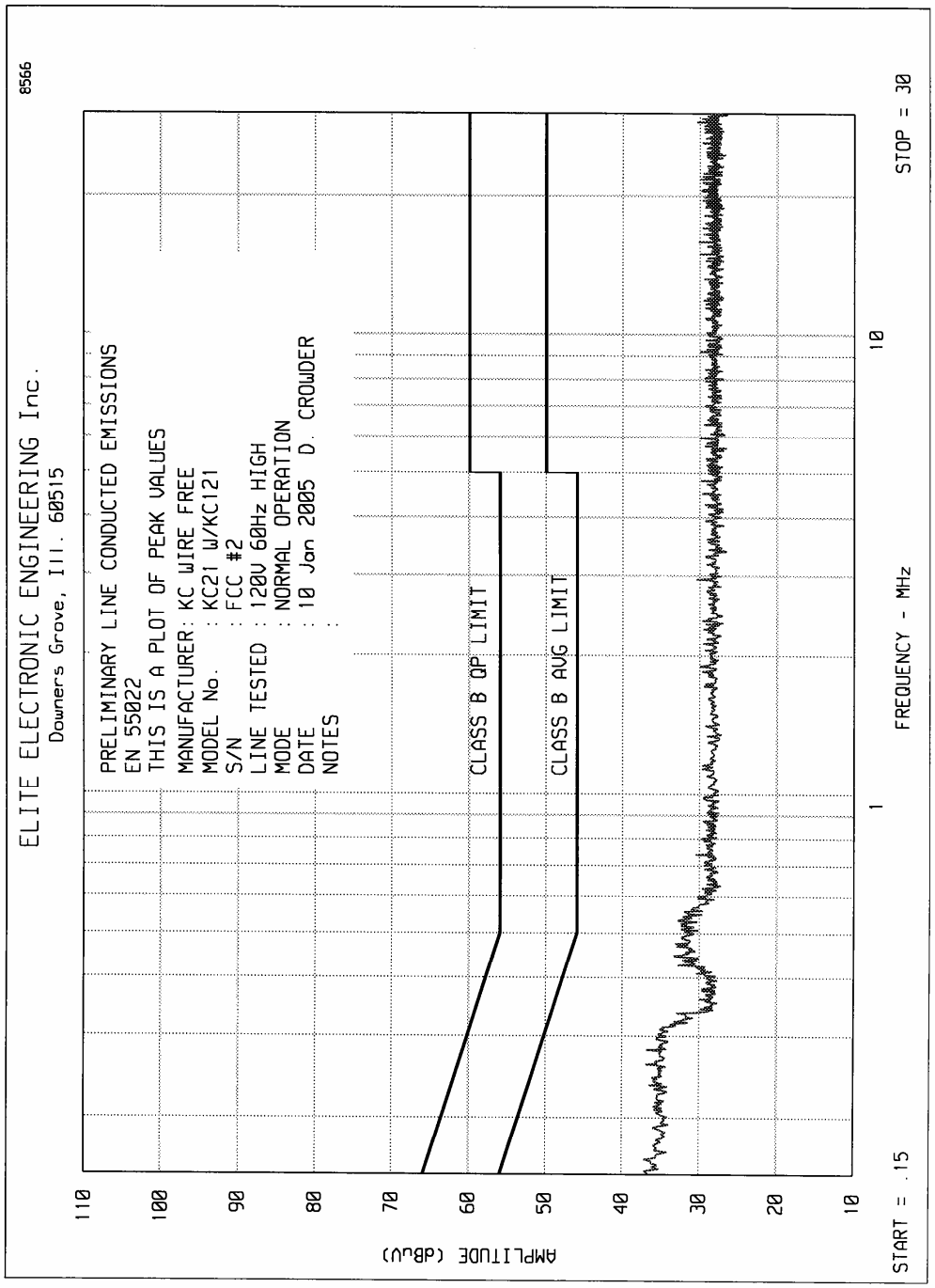


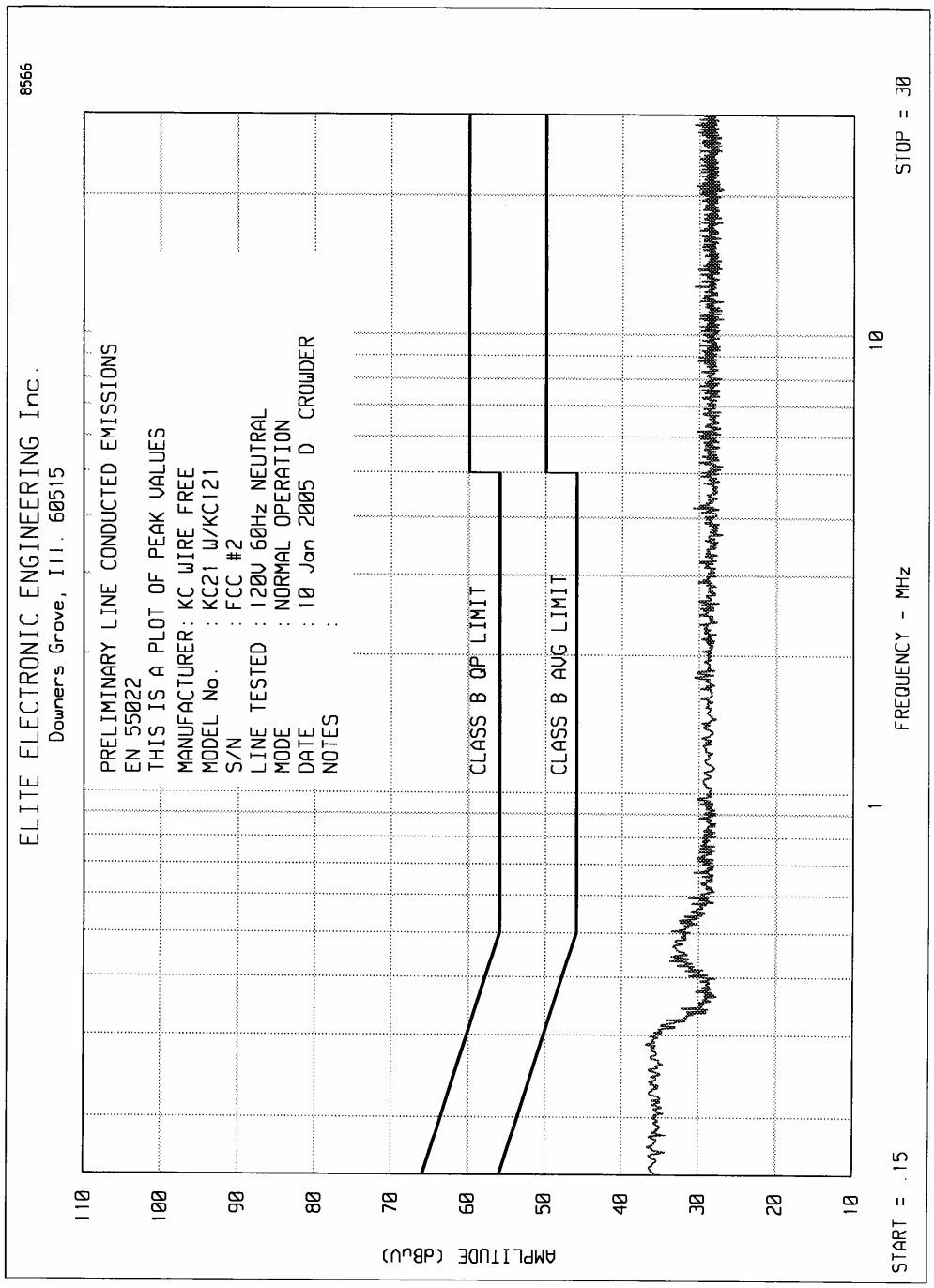
FIGURE 1 BLOCKDIAGRAM OF TEST SETUP

Figure 2 - Powerline Conducted Emissions 150kHz – 30MHz

Figure 3 - Radiated Emissions – Horizontal Polarization

Figure 3 - Radiated Emissions – Vertical Polarization


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
8566
PRELIMINARY LINE CONDUCTED EMISSIONS
EN 55022
THIS IS A PLOT OF PEAK VALUES
MANUFACTURER: KC WIRE FREE
MODEL No. : KC21 W/KC121
S/N : FCC #2
LINE TESTED : 120V 60Hz HIGH
MODE : NORMAL OPERATION
DATE : 10 Jan 2005 D. CROWDER
NOTES :
CLASS B QP LIMIT
CLASS B AVG LIMIT
AMPLITUDE (dBuV)
110
100
90
80
70
60
50
40
30
20
10
START = .15
1
10
STOP = 30
FREQUENCY - MHz


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
8566
PRELIMINARY LINE CONDUCTED EMISSIONS
EN 55022
THIS IS A PLOT OF PEAK VALUES
MANUFACTURER: KC WIRE FREE
MODEL No. : KC21 W/KC121
S/N : FCC #2
LINE TESTED : 120V 60Hz NEUTRAL
MODE : NORMAL OPERATION
DATE : 10 Jan 2005 D. CROWDER
NOTES :
CLASS B QP LIMIT
CLASS B AVG LIMIT
AMPLITUDE (dBuV)
110
100
90
80
70
60
50
40
30
20
10
START = .15
1
10
STOP = 30
FREQUENCY - MHz

ETR No.
ELITE ELECTRONIC ENGINEERING CO.

MANUFACTURER : KC WIRE FREE
MODEL : KC21 W/KC121
S/N : FCC #2
SPECIFICATION : EN 55022, CLASS B
TEST : LINE CONDUCTED EMISSIONS
LINE TESTED : 120V 60Hz HIGH
MODE : NORMAL OPERATION
DATE : 10 Jan 2005
NOTES :
RECEIVER : HP 8566 w/ HP85650A QP ADAPTOR
VALUES MEASURED WITH QP DETECTOR USING 9kHz BANDWIDTH

FREQUENCY MHz	METER RDG. dBuV	QP LIMIT dBuV	AVG RDG dBuV	AVG LIMIT dBuV	NOTES
.150	28.4	66.0		56.0	
.354	24.7	58.9		48.9	
.730	25.2	56.0		46.0	
1.126	25.1	56.0		46.0	
2.272	24.9	56.0		46.0	
4.066	24.8	56.0		46.0	
6.247	24.1	60.0		50.0	
8.922	24.1	60.0		50.0	
10.793	24.1	60.0		50.0	
14.930	24.1	60.0		50.0	
17.538	24.1	60.0		50.0	
20.523	24.0	60.0		50.0	
24.977	24.1	60.0		50.0	
27.410	24.1	60.0		50.0	

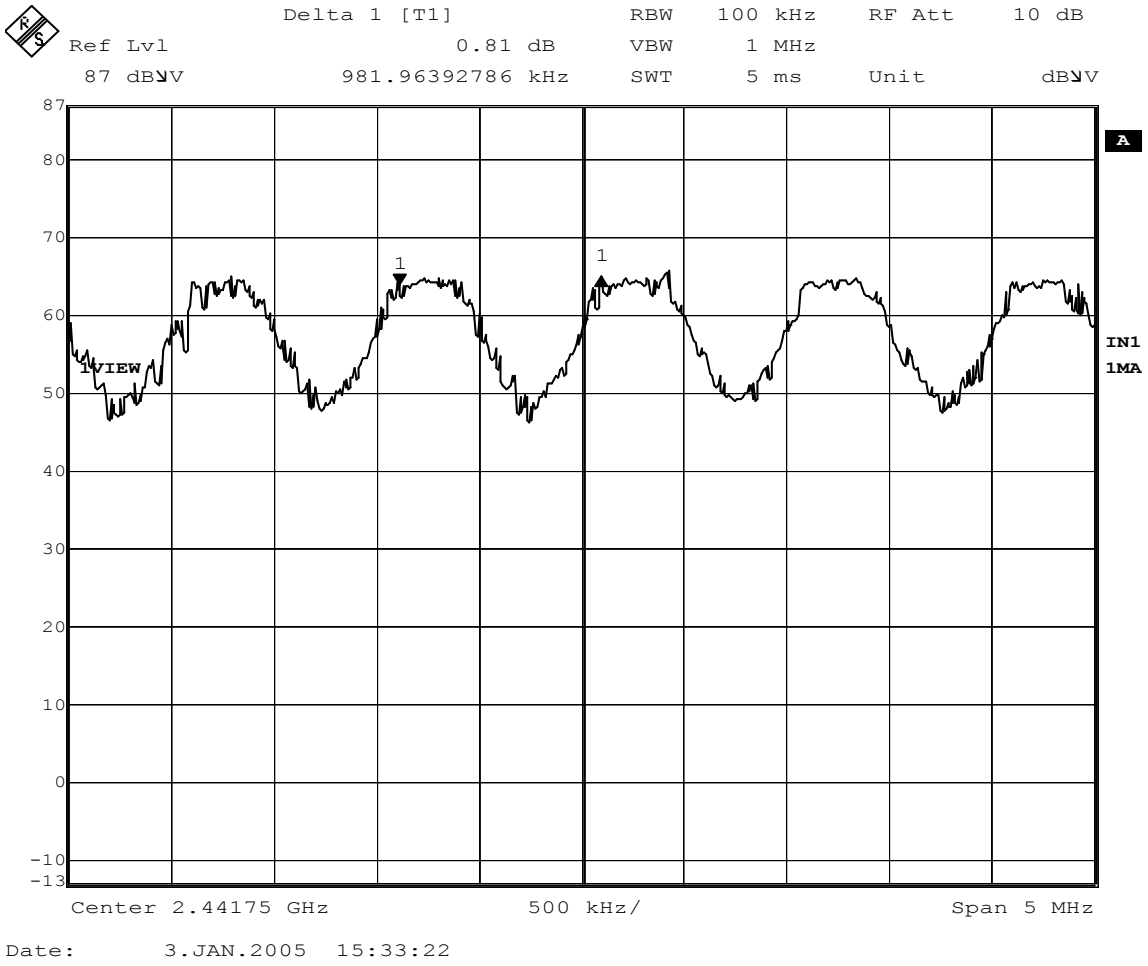
CHECKED BY: D. CROWDER

ETR No.
ELITE ELECTRONIC ENGINEERING CO.

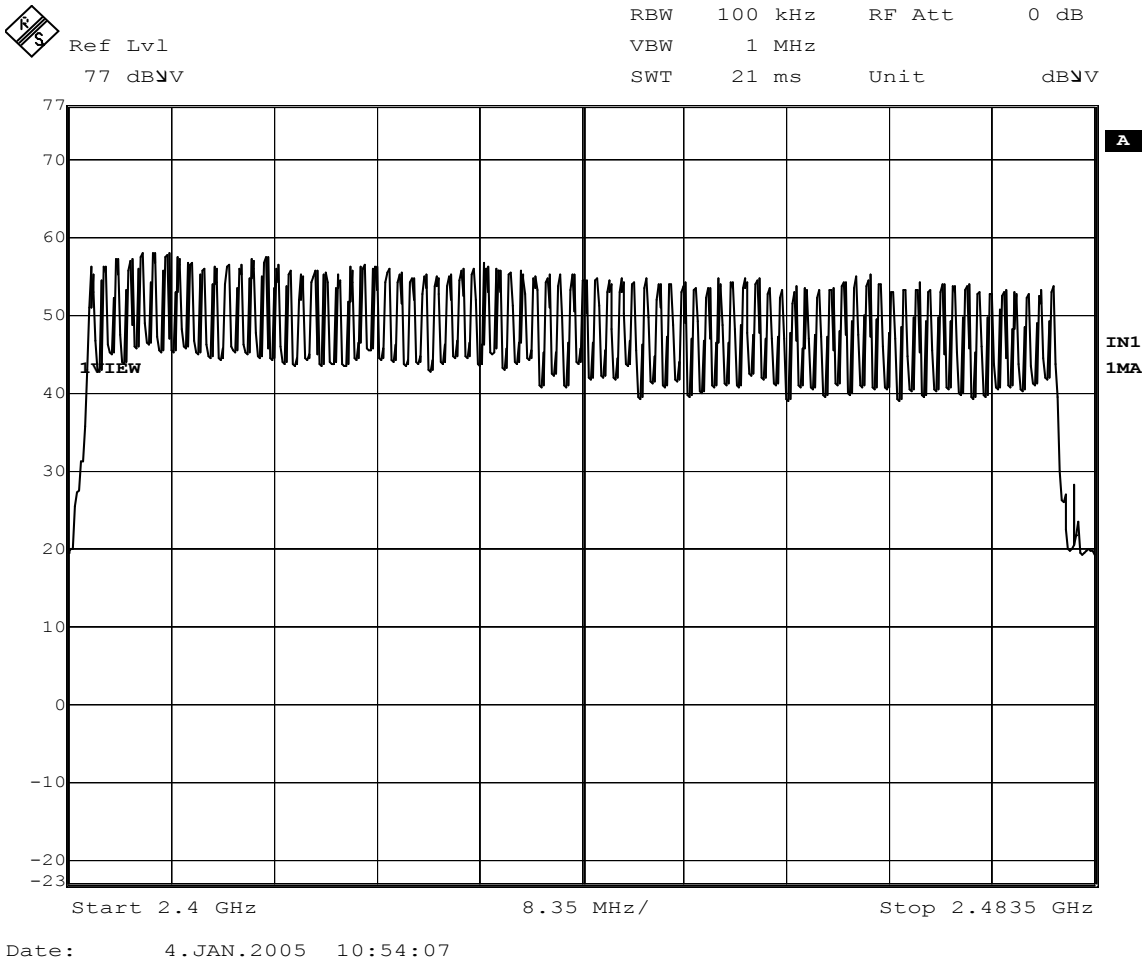
MANUFACTURER : KC WIRE FREE
MODEL : KC21 W/KC121
S/N : FCC #2
SPECIFICATION : EN 55022, CLASS B
TEST : LINE CONDUCTED EMISSIONS
LINE TESTED : 120V 60Hz NEUTRAL
MODE : NORMAL OPERATION
DATE : 10 Jan 2005
NOTES :
RECEIVER : HP 8566 w/ HP85650A QP ADAPTOR
VALUES MEASURED WITH QP DETECTOR USING 9kHz BANDWIDTH

FREQUENCY MHz	METER RDG. dBuV	QP LIMIT dBuV	AVG RDG dBuV	AVG LIMIT dBuV	NOTES
.276	27.0	60.9		50.9	
.502	25.3	56.0		46.0	
.962	25.3	56.0		46.0	
1.786	25.0	56.0		46.0	
3.170	25.0	56.0		46.0	
5.239	24.3	60.0		50.0	
7.126	24.5	60.0		50.0	
8.729	24.3	60.0		50.0	
12.685	24.3	60.0		50.0	
15.579	24.5	60.0		50.0	
19.256	24.5	60.0		50.0	
21.099	24.3	60.0		50.0	
24.670	24.3	60.0		50.0	
27.452	24.5	60.0		50.0	

CHECKED BY: _____
D. CROWDER

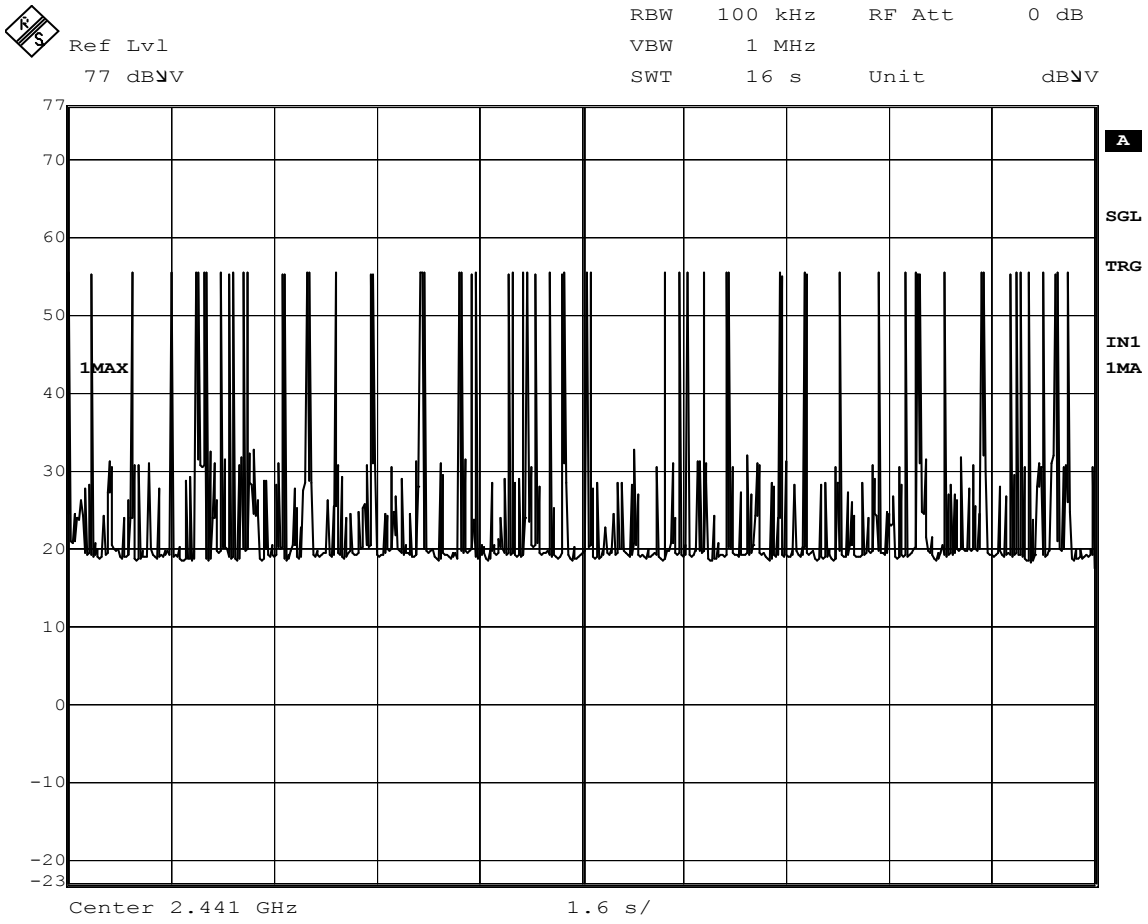


MANUFACTURER : KC WIRE FREE
MODEL NO. : KC21 W/KC121
SERIAL NO. : FCC #2
TEST PERFORMED : FCC 15.247 CARRIER FREQUENCY SEPERATION
MODE : FREQUENCY HOPPING ENABLED



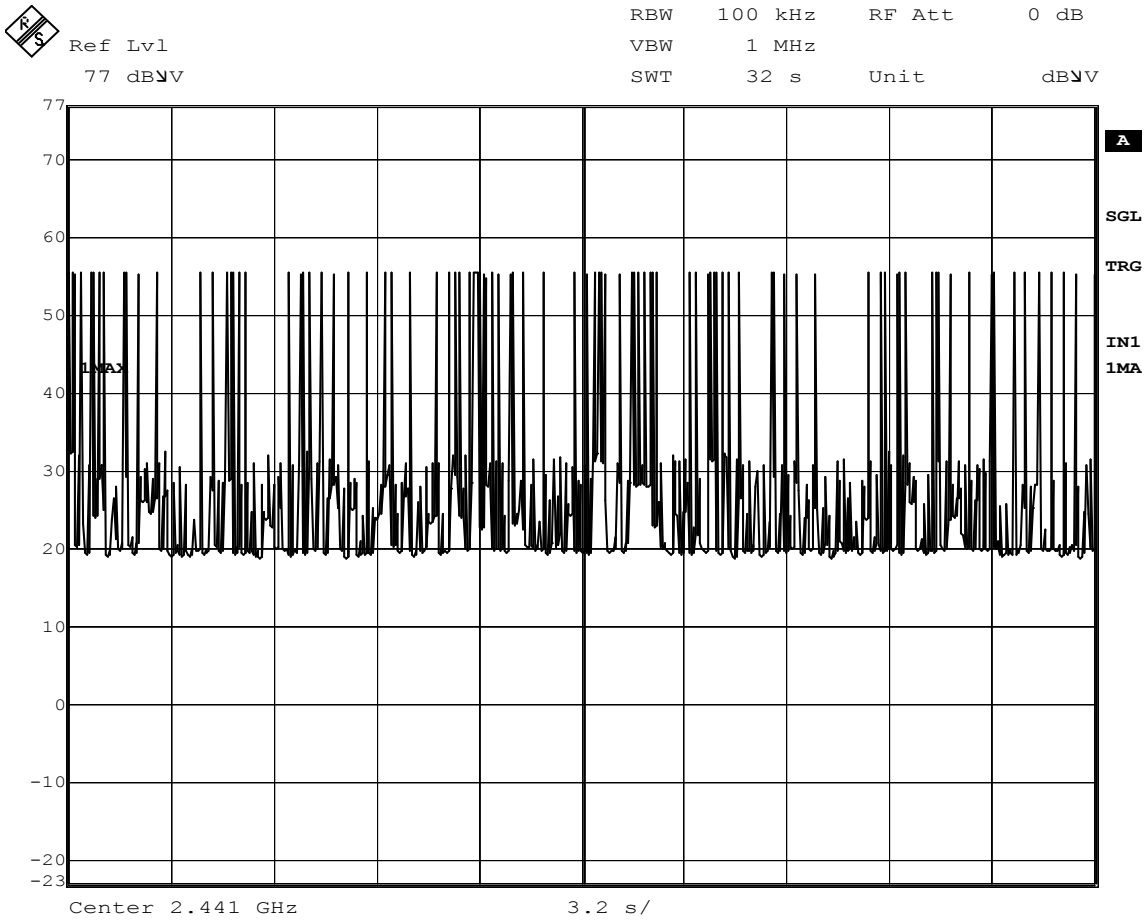
Number of Hopping Frequencies = 79

MANUFACTURER : KC WIRE FREE
MODEL NO. : KC21 W/KC121
SERIAL NO. : FCC #2
TEST PERFORMED : FCC 15.247 NUMBER OF HOPPING FREQUENCIES
MODE : FREQUENCY HOPPING ENABLED



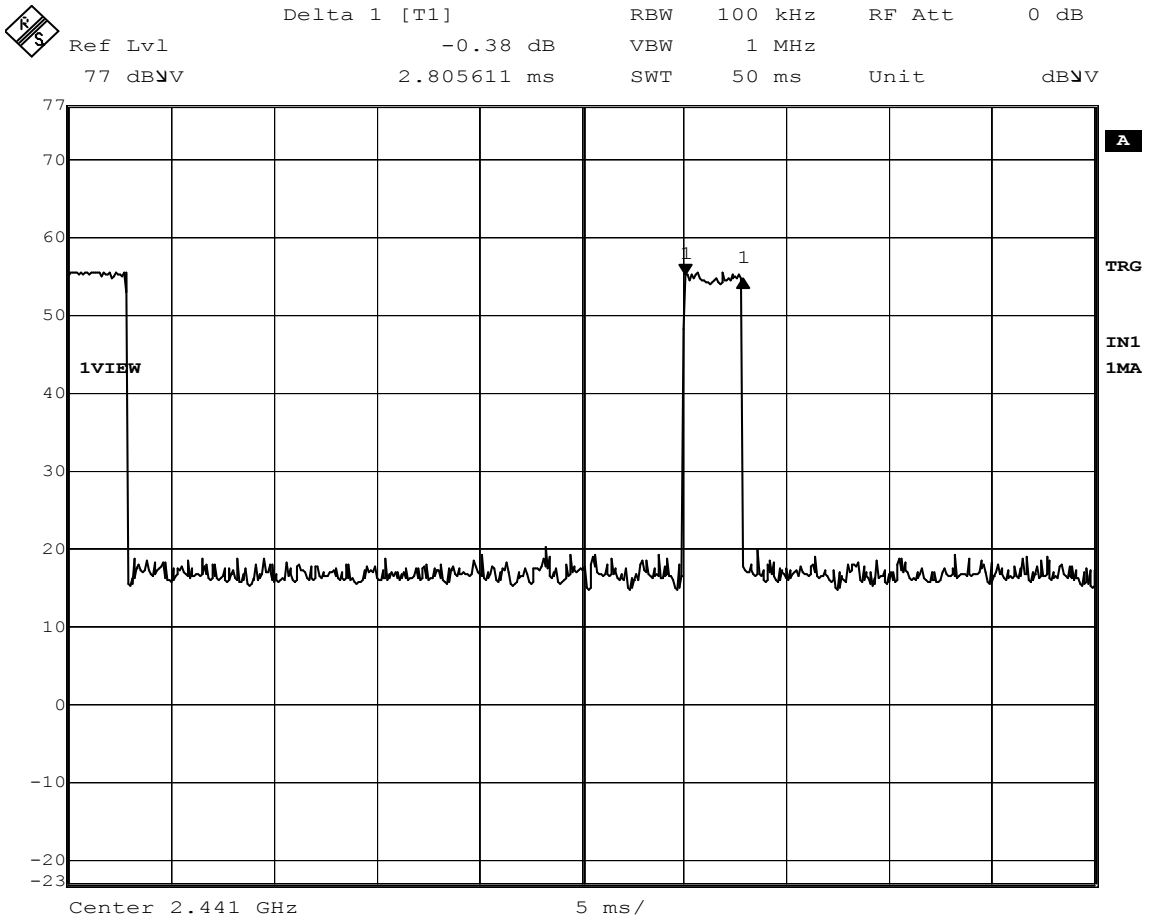
Number of pulses in a 16 second window = 52

MANUFACTURER : KC WIRE FREE
MODEL NO. : KC21 W/KC121
SERIAL NO. : FCC #2
TEST PERFORMED : FCC 15.247 DWELL TIME
MODE : FREQUENCY HOPPING ENABLED



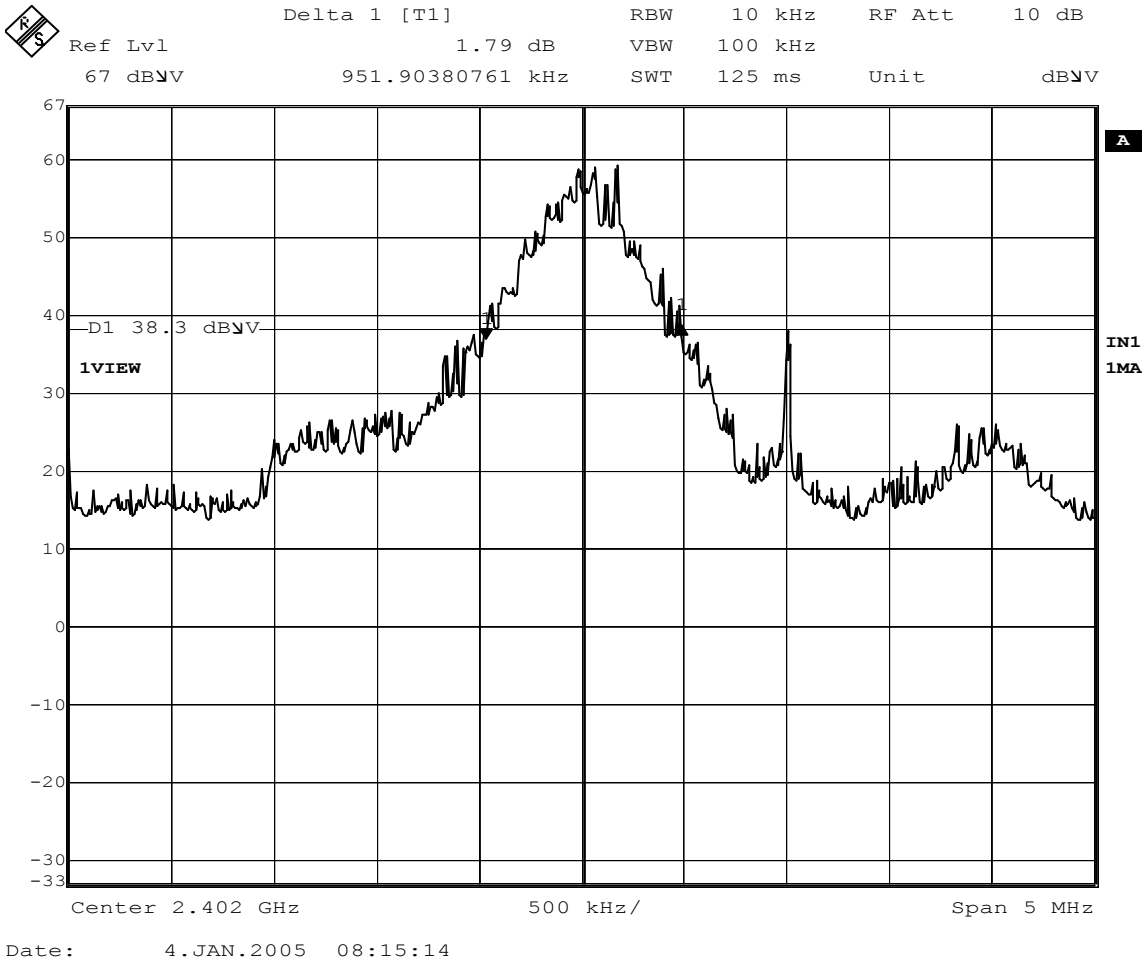
Number of pulses in a 32 second window = 98

MANUFACTURER : KC WIRE FREE
MODEL NO. : KC21 W/KC121
SERIAL NO. : FCC #2
TEST PERFORMED : FCC 15.247 DWELL TIME
MODE : FREQUENCY HOPPING ENABLED

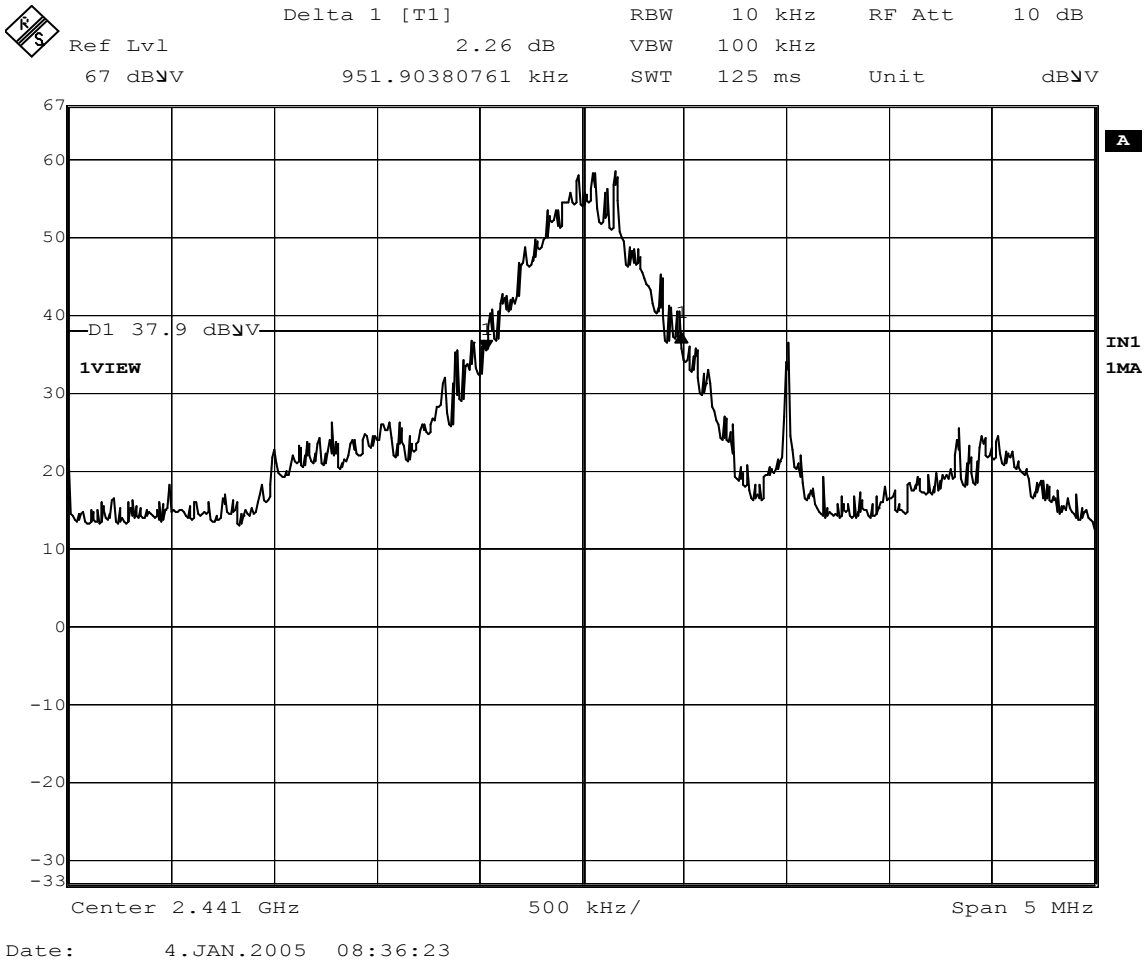


Dwell Time = (# of pulses) * (pulse width)
= 98 * 2.8mSec = 0.274 Seconds

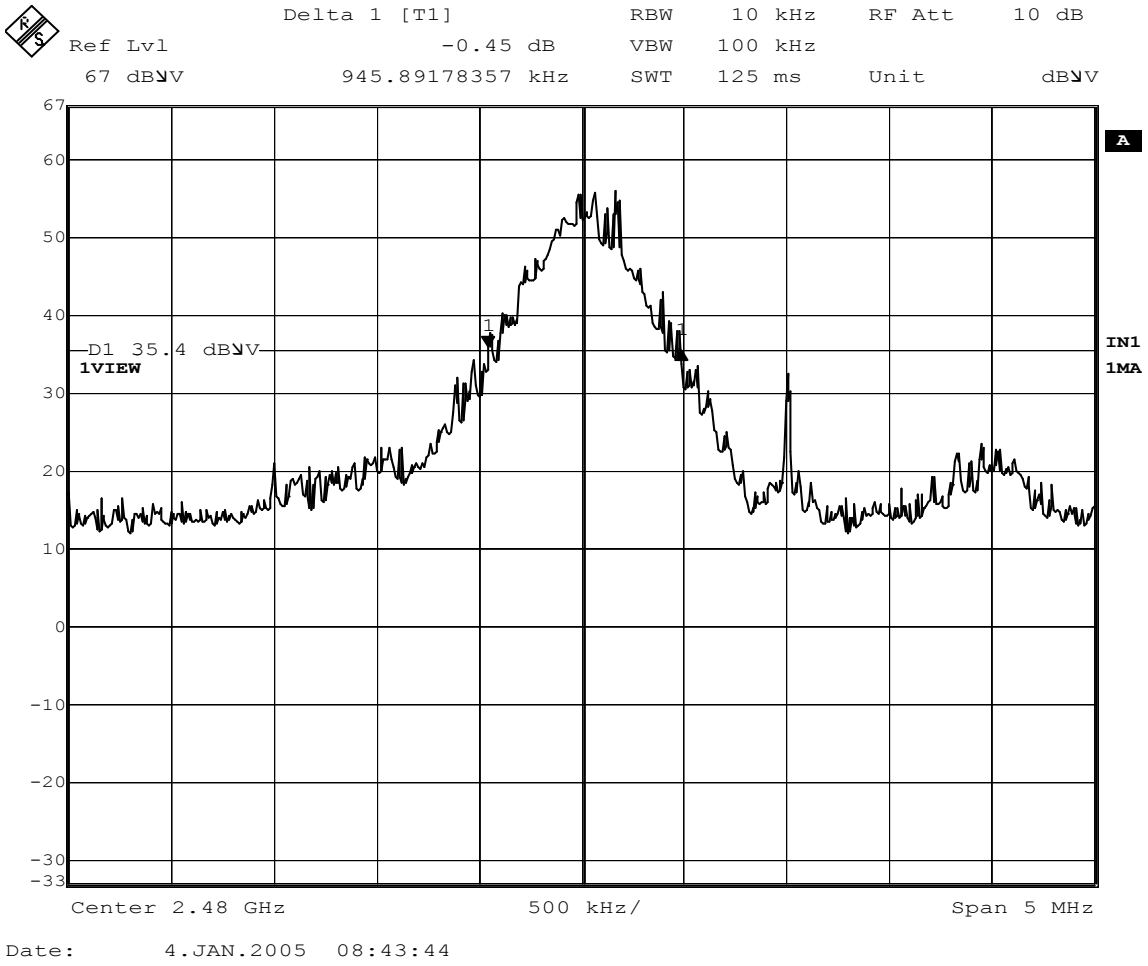
MANUFACTURER : KC WIRE FREE
MODEL NO. : KC21 W/KC121
SERIAL NO. : FCC #2
TEST PERFORMED : FCC 15.247 DWELL TIME
MODE : FREQUENCY HOPPING ENABLED



MANUFACTURER : KC WIRE FREE
MODEL NO. : KC21 W/KC121
SERIAL NO. : FCC #2
TEST PERFORMED : FCC 15.247 20dB BANDWIDTH
MODE : TRANSMIT @ 2.402GHz, MAXIMUM DATA RATE



MANUFACTURER : KC WIRE FREE
MODEL NO. : KC21 W/KC121
SERIAL NO. : FCC #2
TEST PERFORMED : FCC 15.247 20dB BANDWIDTH
MODE : TRANSMIT @ 2.441GHz, MAXIMUM DATA RATE



MANUFACTURER : KC WIRE FREE
MODEL NO. : KC21 W/KC121
SERIAL NO. : FCC #2
TEST PERFORMED : FCC 15.247 20dB BANDWIDTH
MODE : TRANSMIT @ 2.480GHz, MAXIMUM DATA RATE

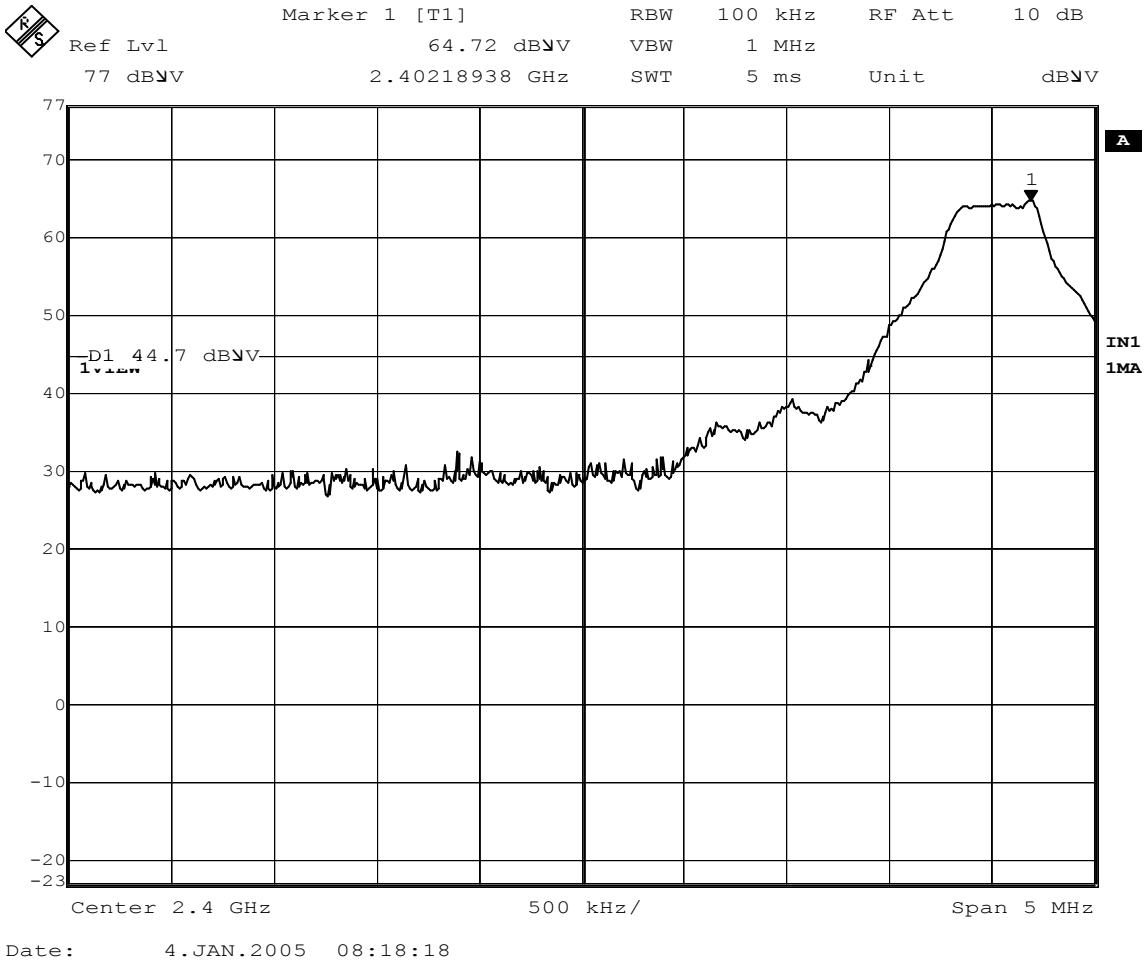
Data Sheet

MANUFACTURER : KC Wire Free
MODEL : KC21
S/N : 2
SPECIFICATION : FCC Part 15, Subpart C, Section 15.247
Peak Output Power – Radiated Measurement
DATE : January 3, 2005
NOTES :
: TEST DISTANCE IS 3 METERS

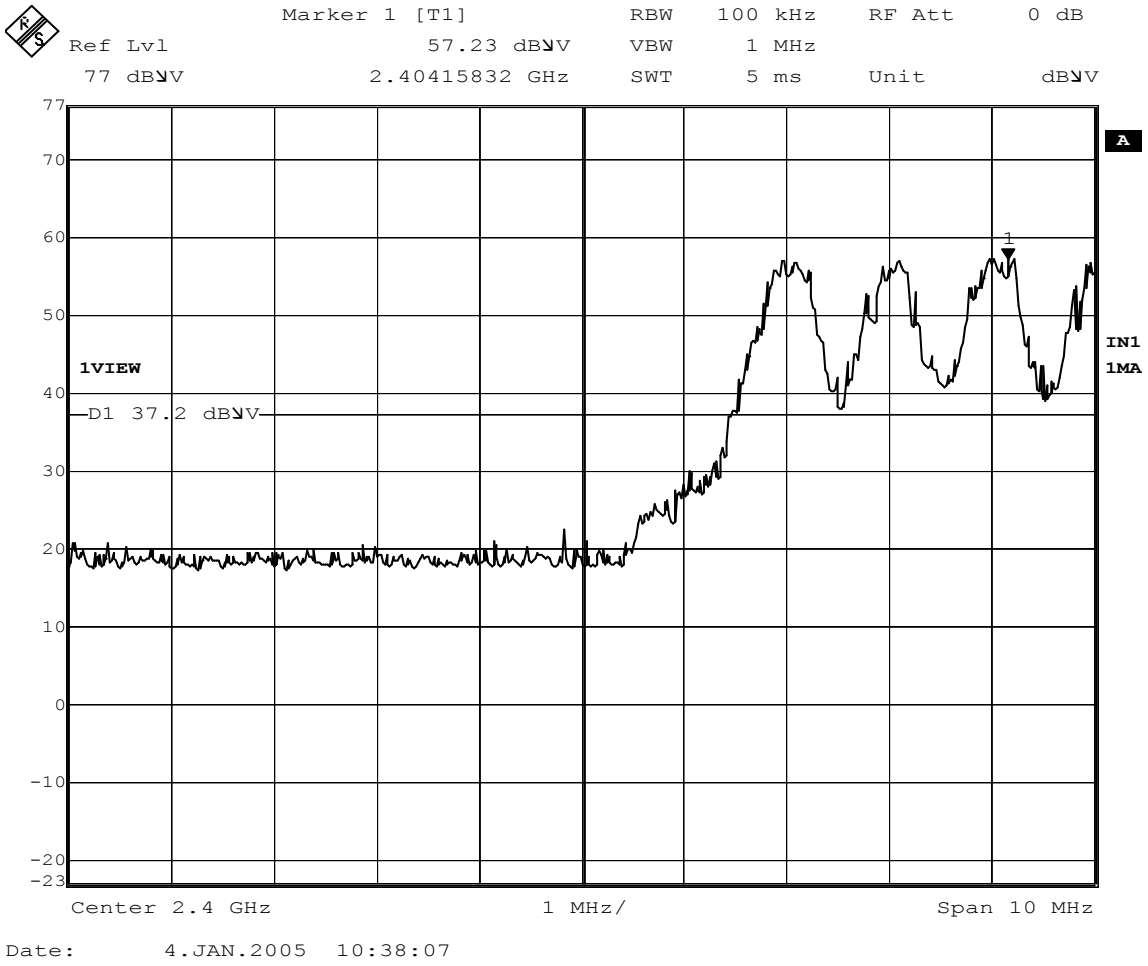
FREQ. (MHz)	ANT POL	SPECTRUM ANALYZER RDG(dBuV)	MATCHED SIGNAL GENERATOR RDG (dBm)	CABLE LOSS (dB)	ANTENNA GAIN (dB)	EIRP TOTAL (dBm)
2402	V	64.0	5.4	2.8	6.8	1.4
	H	61.5	4.8	2.8	6.8	0.8
2441	V	61.3	4.8	2.8	6.8	0.8
	H	57.3	4.3	2.8	6.8	0.3
2480	V	59.1	4.5	2.8	6.9	0.5
	H	59.4	4.5	2.8	6.9	0.5

EIRP = S.G. RDG + Cable Loss – Antenna Gain

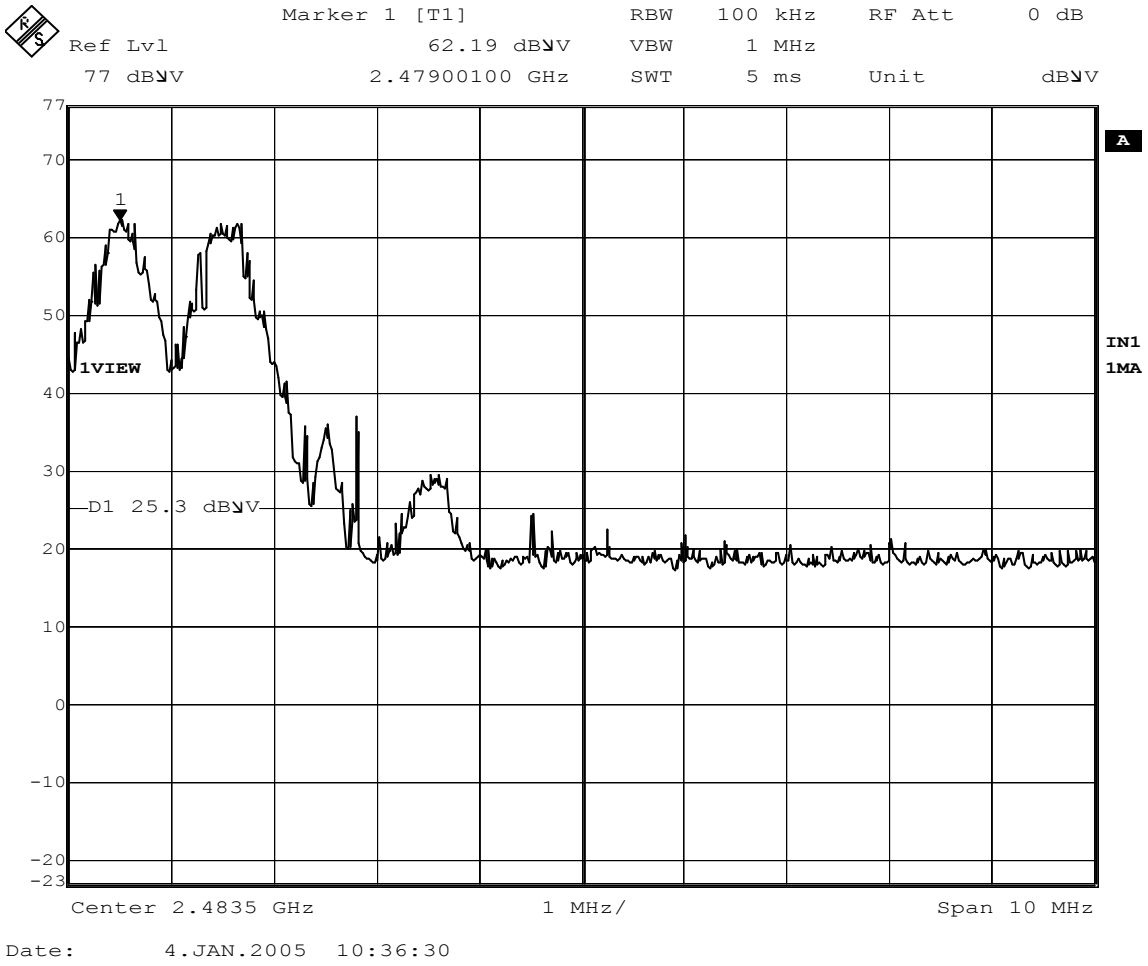
CHECKED BY: _____



MANUFACTURER : KC WIRE FREE
MODEL NO. : KC21 W/KC121
SERIAL NO. : FCC #2
TEST PERFORMED : FCC 15.247 BANDEDGE COMPLIANCE
MODE : TRANSMIT @ 2.402GHz, MAXIMUM DATA RATE

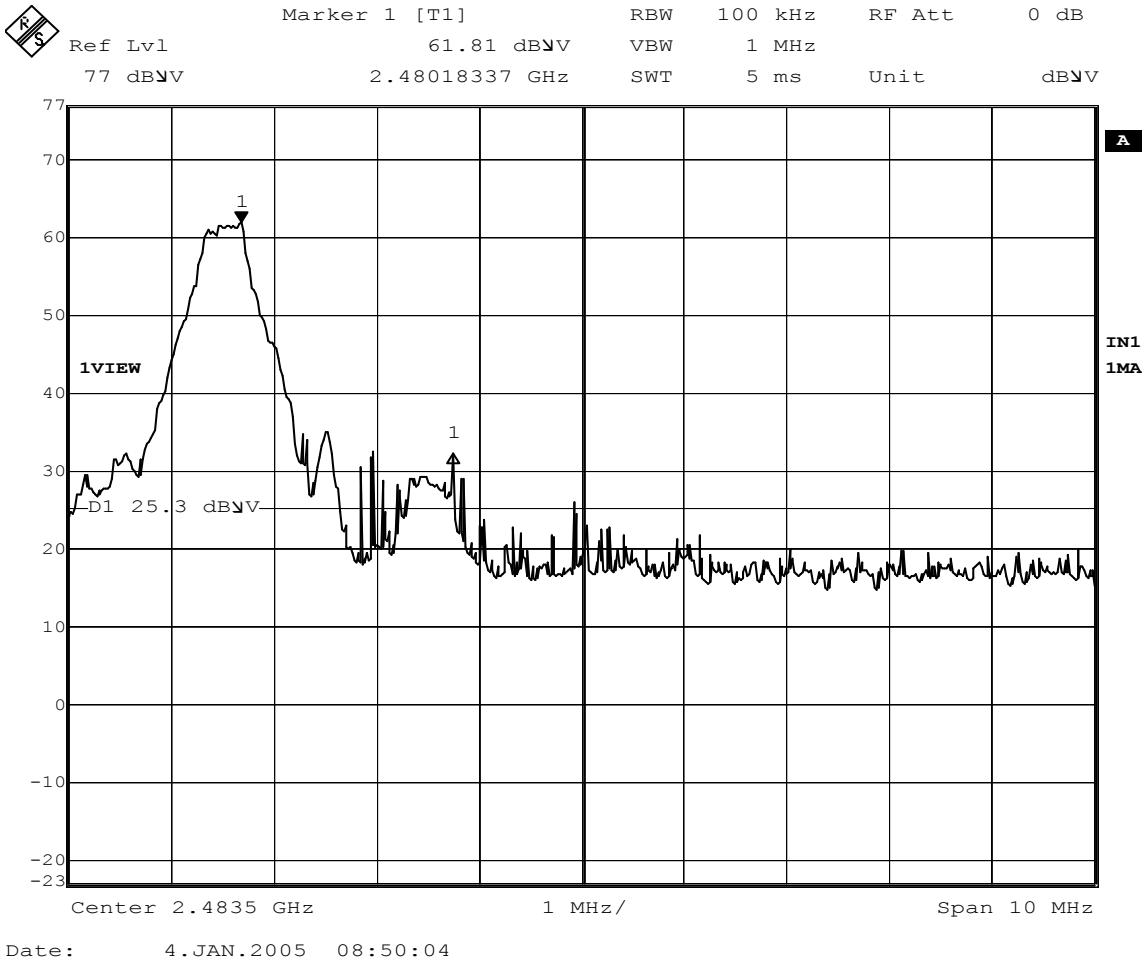


MANUFACTURER : KC WIRE FREE
MODEL NO. : KC21 W/KC121
SERIAL NO. : FCC #2
TEST PERFORMED : FCC 15.247 BANDEDGE COMPLIANCE
MODE : FREQUENCY HOPPING ENABLED



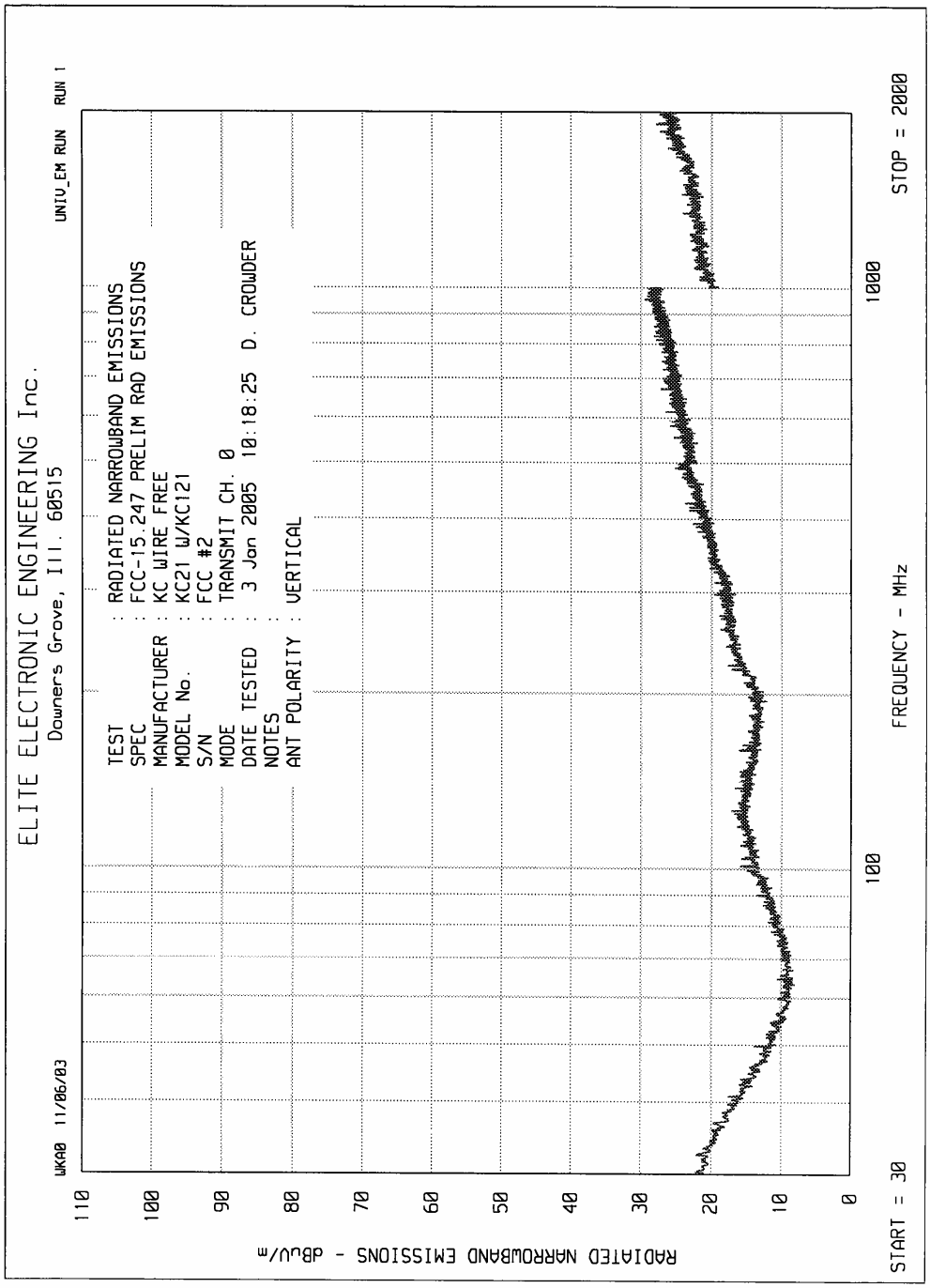
Marker Delta Method: 90.5dBuV/m – 54.0dBuV/m = 36.5 dB down

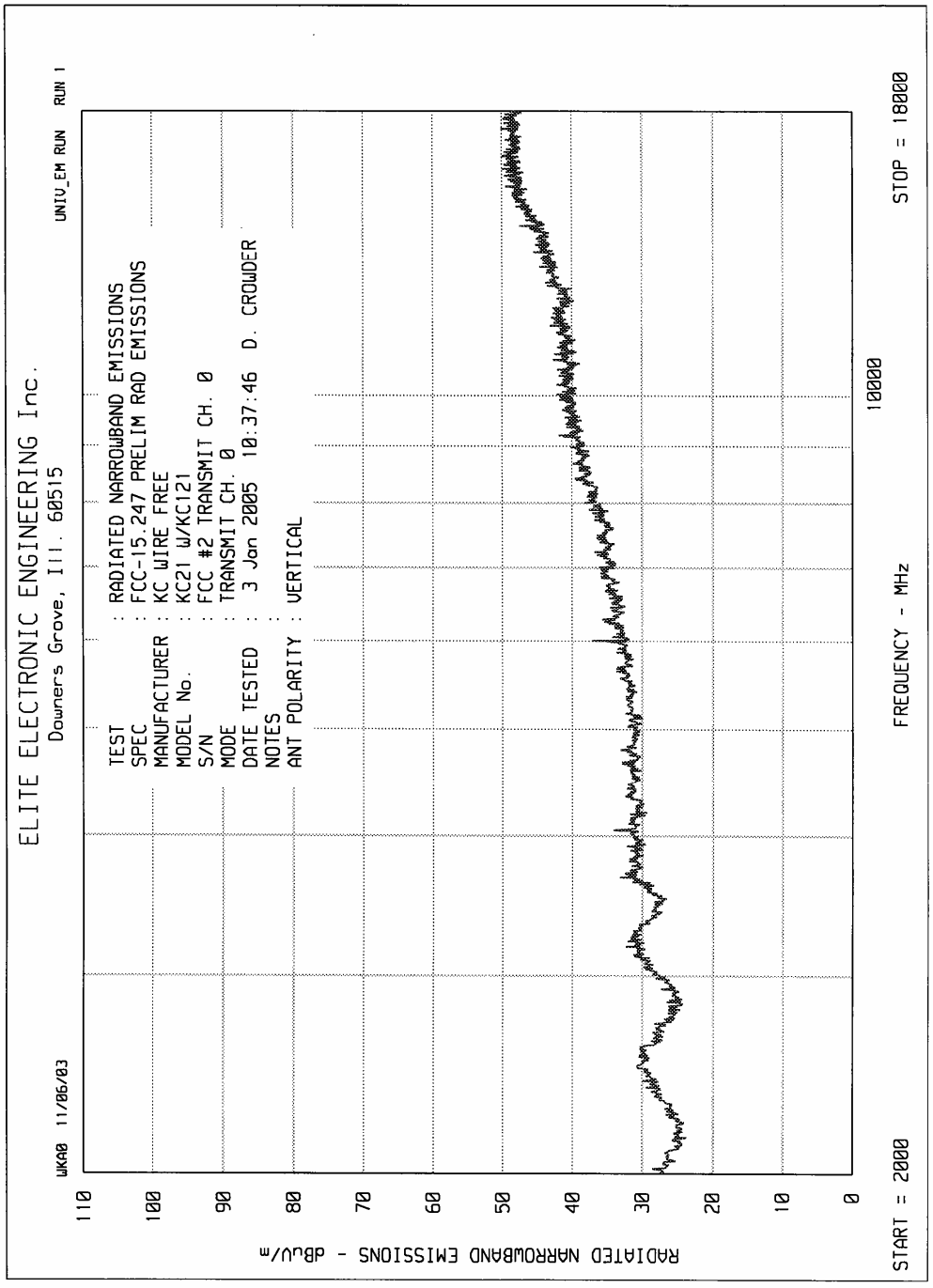
MANUFACTURER : KC WIRE FREE
MODEL NO. : KC21 W/KC121
SERIAL NO. : FCC #2
TEST PERFORMED : FCC 15.247 BANDEDGE COMPLIANCE
MODE : FREQUENCY HOPPING ENABLED

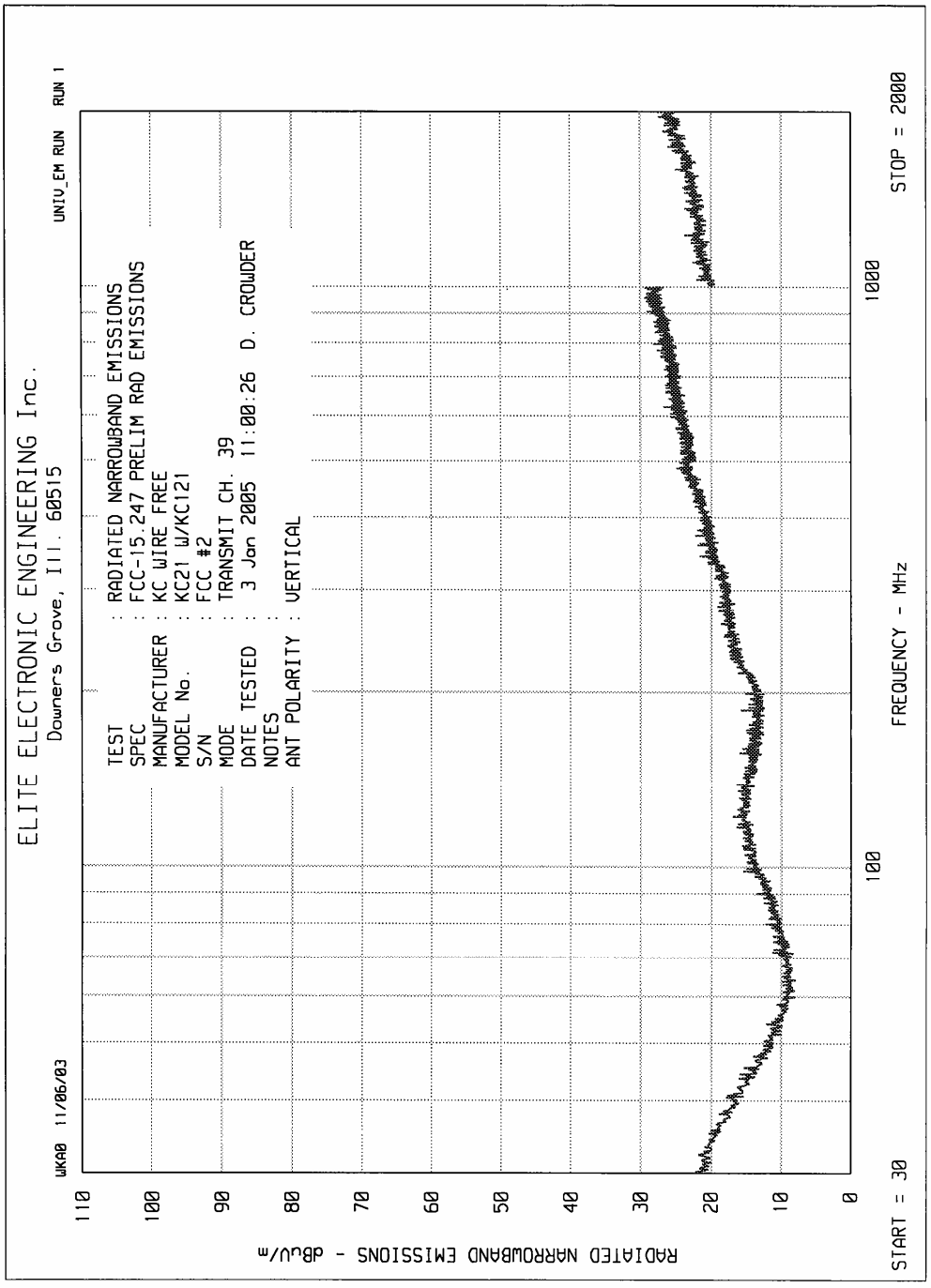


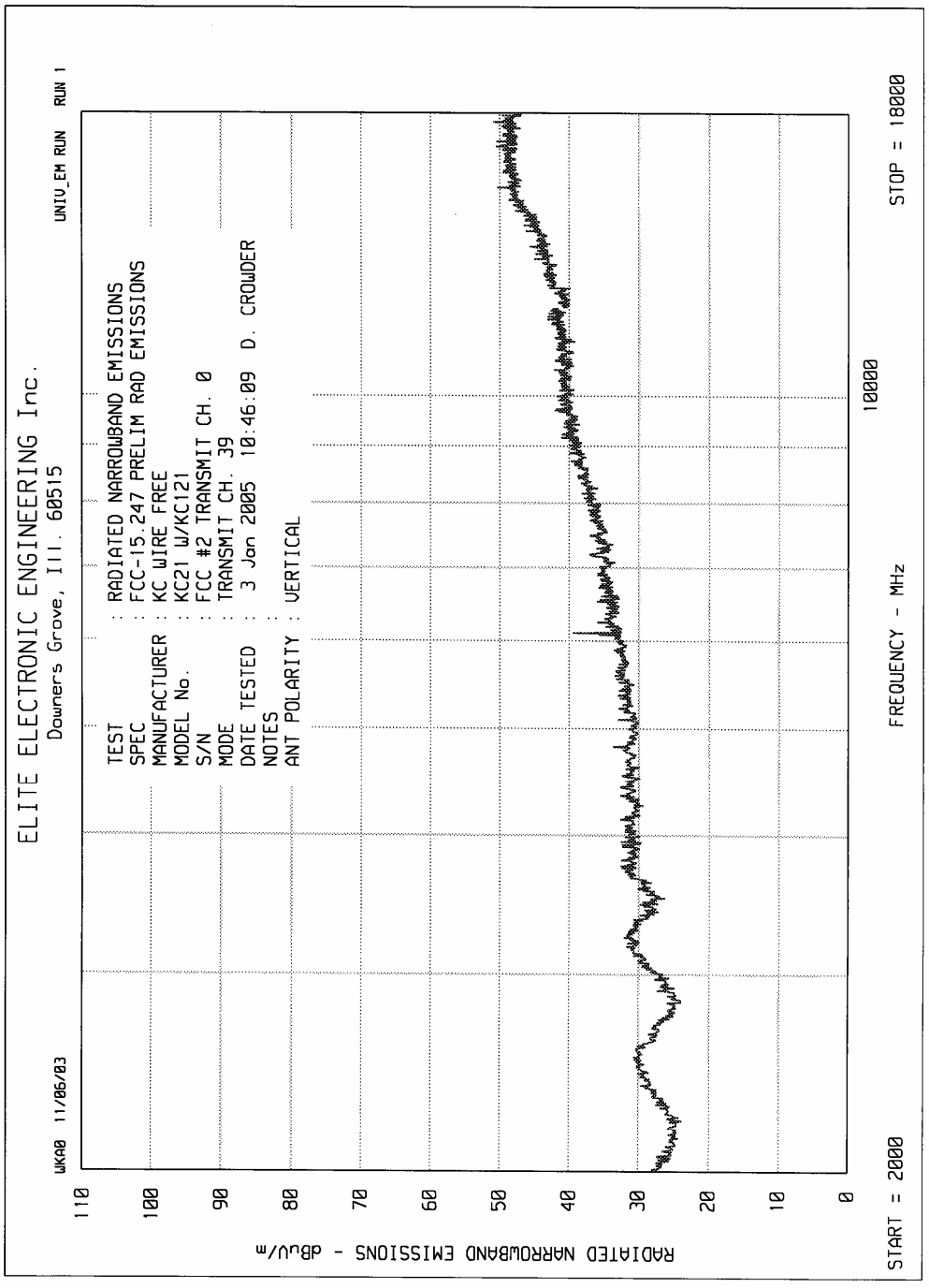
Marker Delta Method: 90.5dBuV/m – 54.0dBuV/m = 36.5 dB down

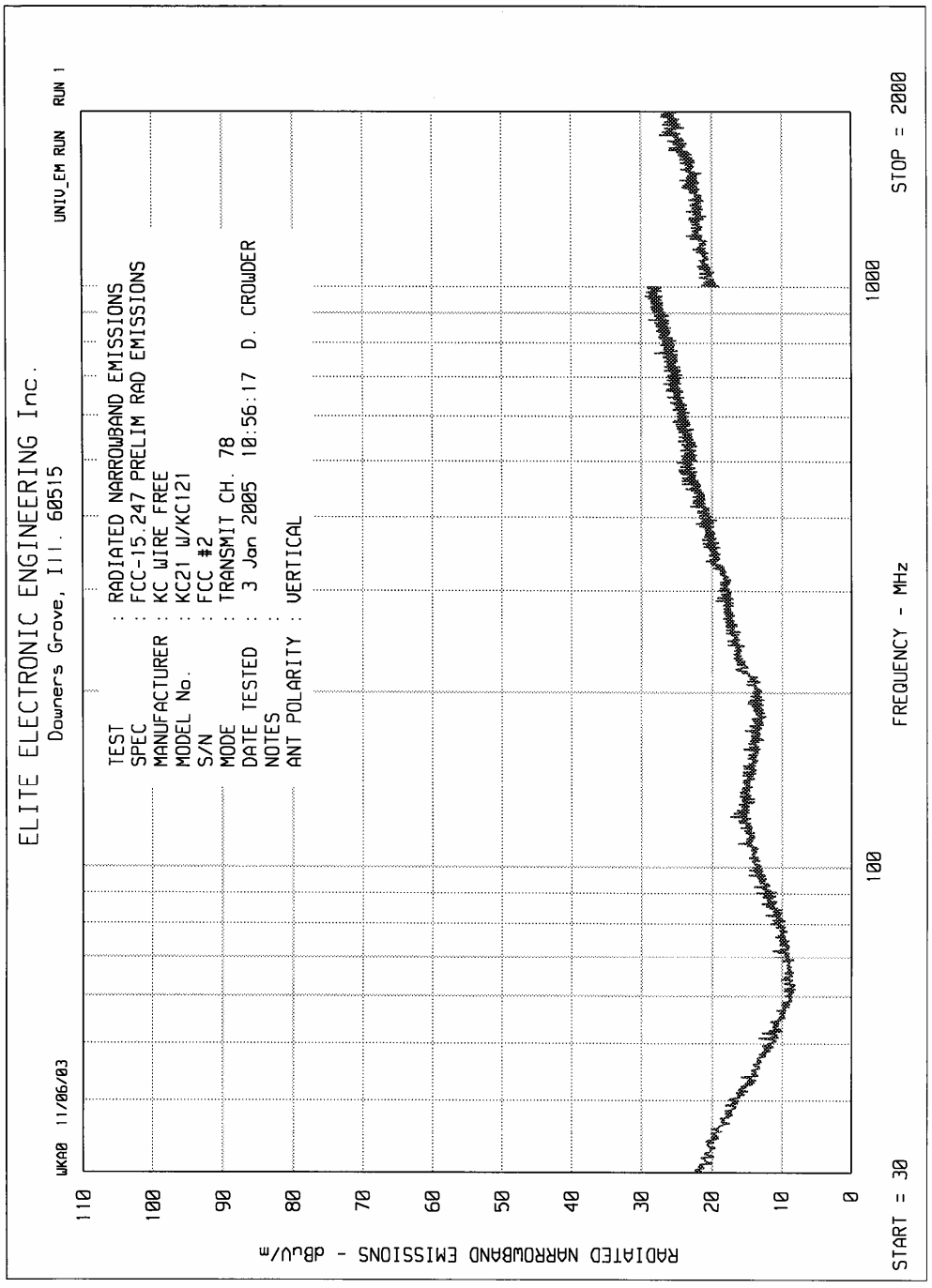
MANUFACTURER : KC WIRE FREE
MODEL NO. : KC21 W/KC121
SERIAL NO. : FCC #2
TEST PERFORMED : FCC 15.247 BANDEDGE COMPLIANCE
MODE : TRANSMIT @ 2.480GHz, MAXIMUM DATA RATE

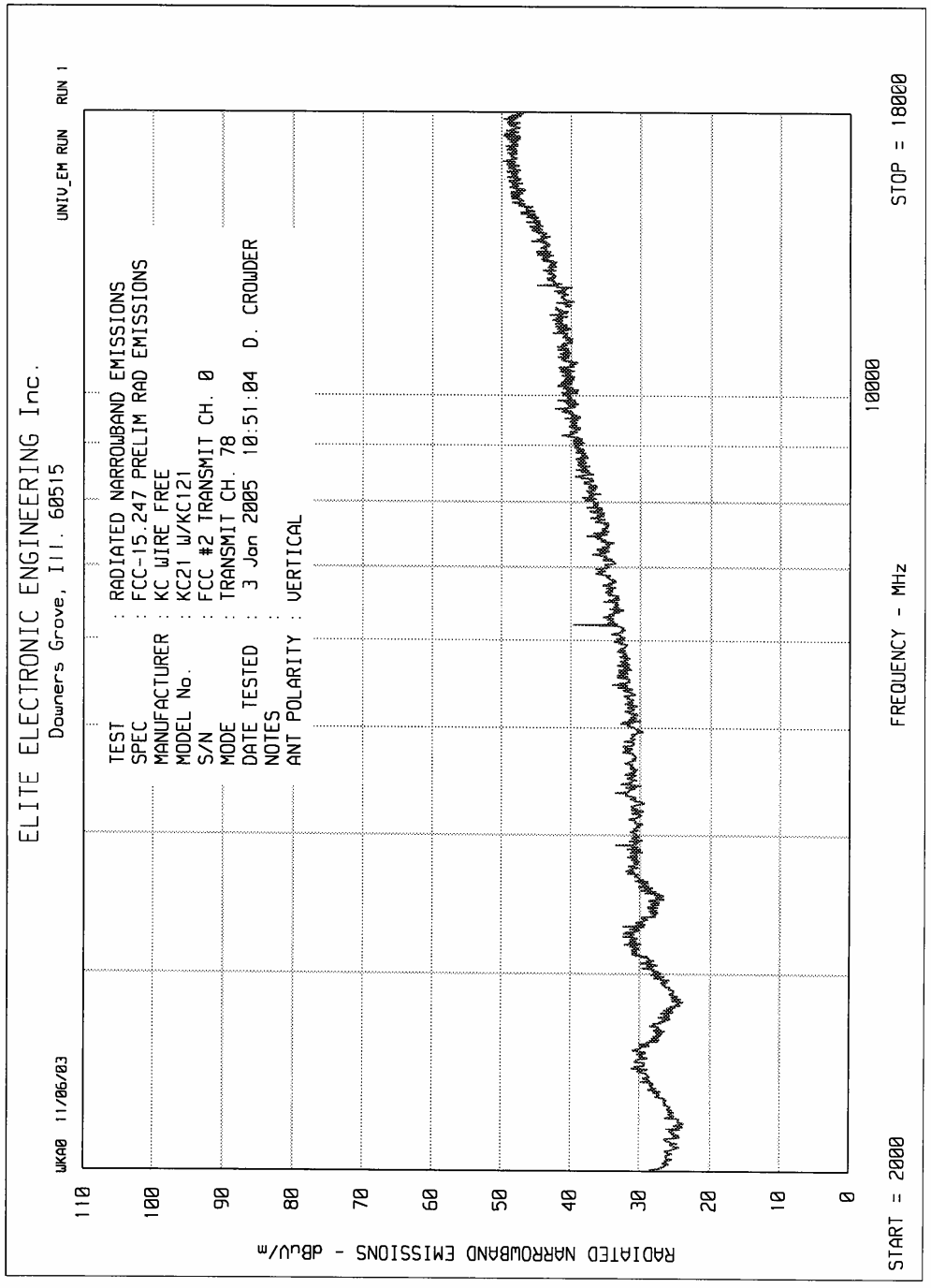

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
UNIV_EM RUN RUN 1
WK#0 11/06/03
TEST : RADIATED NARROWBAND EMISSIONS
SPEC : FCC-15.247 PRELIM RAD EMISSIONS
MANUFACTURER : KC WIRE FREE
MODEL No. : KC21 W/KC121
S/N : FCC #2
MODE : TRANSMIT CH. 0
DATE TESTED : 3 Jan 2005 10:18:25 D. CROWDER
NOTES :
ANT POLARITY : VERTICAL
RADIATED NARROWBAND EMISSIONS - dBuV/m
110
100
90
80
70
60
50
40
30
20
10
0
START = 30
100
1000
STOP = 2000
FREQUENCY - MHz


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
UNIV_EM RUN RUN 1
WKA0 11/06/03
TEST : RADIATED NARROWBAND EMISSIONS
SPEC : FCC-15.247 PRELIM RAD EMISSIONS
MANUFACTURER : KC WIRE FREE
MODEL No. : KC21 W/KC121
S/N : FCC #2 TRANSMIT CH. 0
MODE : TRANSMIT CH. 0
DATE TESTED : 3 Jan 2005 10:37:46 D. CROWDER
NOTES :
ANT POLARITY : VERTICAL
RADIATED NARROWBAND EMISSIONS - dBuV/m
110
100
90
80
70
60
50
40
30
20
10
0
START = 2000
10000
STOP = 18000
FREQUENCY - MHz


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
UNIV_EM RUN RUN 1
WKA0 11/06/03
TEST : RADIATED NARROWBAND EMISSIONS
SPEC : FCC-15.247 PRELIM RAD EMISSIONS
MANUFACTURER : KC WIRE FREE
MODEL No. : KC21 W/KC121
S/N : FCC #2
MODE : TRANSMIT CH. 39
DATE TESTED : 3 Jan 2005 11:00:26 D. CROWDER
NOTES :
ANT POLARITY : VERTICAL
RADIATED NARROWBAND EMISSIONS - dBuV/m
110
100
90
80
70
60
50
40
30
20
10
0
START = 30
100
1000
STOP = 2000
FREQUENCY - MHz


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
UNIV_EM RUN RUN 1
WKA0 11/06/03
TEST : RADIATED NARROWBAND EMISSIONS
SPEC : FCC-15.247 PRELIM RAD EMISSIONS
MANUFACTURER : KC WIRE FREE
MODEL No. : KC21 W/KC121
S/N : FCC #2 TRANSMIT CH. 0
MODE : TRANSMIT CH. 39
DATE TESTED : 3 Jan 2005 10:46:09 D. CROWDER
NOTES :
ANT POLARITY : VERTICAL
RADIATED NARROWBAND EMISSIONS - dBuV/m
110
100
90
80
70
60
50
40
30
20
10
0
START = 2000
10000
STOP = 18000
FREQUENCY - MHz


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
UNIV_EM RUN RUN 1
WKA0 11/06/03
TEST : RADIATED NARROWBAND EMISSIONS
SPEC : FCC-15.247 PRELIM RAD EMISSIONS
MANUFACTURER : KC WIRE FREE
MODEL No. : KC21 W/KC121
S/N : FCC #2
MODE : TRANSMIT CH. 78
DATE TESTED : 3 Jan 2005 10:56:17 D. CROWDER
NOTES :
ANT POLARITY : VERTICAL
RADIATED NARROWBAND EMISSIONS - dBuV/m
110
100
90
80
70
60
50
40
30
20
10
0
START = 30
100
1000
STOP = 2000
FREQUENCY - MHz


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
UNIV_EM RUN RUN 1
WKA0 11/06/03
TEST : RADIATED NARROWBAND EMISSIONS
SPEC : FCC-15.247 PRELIM RAD EMISSIONS
MANUFACTURER : KC WIRE FREE
MODEL No. : KC21 W/KC121
S/N : FCC #2 TRANSMIT CH. 0
MODE : TRANSMIT CH. 78
DATE TESTED : 3 Jan 2005 10:51:04 D. CROWDER
NOTES :
ANT POLARITY : VERTICAL
RADIATED NARROWBAND EMISSIONS - dBuV/m
110
100
90
80
70
60
50
40
30
20
10
0
START = 2000
10000
STOP = 18000
FREQUENCY - MHz

Data Sheet

MANUFACTURER : KC Wire Free
MODEL : KC21
S/N : 2
SPECIFICATION : FCC Part 15, Subpart C, Section 15.247
Radiated Spurious Emissions Measurement
DATE : January 3, 2005
NOTES : Transmitting at 2402MHz
: TEST DISTANCE IS 3 METERS

FREQ. MHz	ANT. POL.	MTR. RDG. dBuV	AMBIENT	B.W. RBW/VBW Hz	DIST. CORR. FACT. dB	ANT. FACT. dB	CABLE LOSS dB	PRE. AMP. dB	TOTAL dBuV/m	15.209 Limit dBuV/m
2402.0	H	64.0		3M/3M	31.8	0.8	0.0	96.6	67608.3	
	V	61.5		3M/3M	31.8	0.8	0.0	94.1	50699.1	
4804.0	H	28.8		1M/10	35.2	1.3	35.2	30.1	32.0	500.0
	V	28.8		1M/10	35.2	1.3	35.2	30.1	32.0	500.0
12010.0	H	28.3	AMB	1M/10	41.4	2.0	34.8	36.9	70.0	500.0
	V	28.2	AMB	1M/10	41.4	2.0	34.8	36.8	69.2	500.0
19216.0	H	10.2	AMB	1M/10	40.3			50.5	335.0	500.0
	V	10.5	AMB	1M/10	40.3			50.8	346.7	500.0

CHECKED BY: _____

Data Sheet

MANUFACTURER : KC Wire Free
MODEL : KC21
S/N : 2
SPECIFICATION : FCC Part 15, Subpart C, Section 15.247
Radiated Spurious Emissions Measurement
DATE : January 3, 2005
NOTES : Transmitting at 2441MHz
: TEST DISTANCE IS 3 METERS

FREQ. MHz	ANT. POL.	MTR. RDG. dBuV	AMBIENT	B.W. RBW/VBW Hz	DIST. CORR. FACT. dB	ANT. FACT. dB	CABLE LOSS dB	PRE. AMP. dB	TOTAL dBuV/m	15.209 Limit dBuV/m
2441.0	H	61.3		3M/3M	31.8	0.8	0.0	93.9	49545.0	
	V	57.3		3M/3M	31.8	0.8	0.0	89.9	31260.8	
4882.0	H	28.1		1M/10	35.2	1.3	35.2	29.4	29.5	500.0
	V	27.9	AMB	1M/10	35.2	1.3	35.2	29.2	28.8	500.0
7323.0	H	28.7	AMB	1M/10	38.0	1.6	35.5	32.8	43.7	500.0
	V	28.6	AMB	1M/10	38.0	1.6	35.5	32.7	43.2	500.0
12205.0	H	27.9	AMB	1M/10	41.4	2.0	34.8	36.5	66.8	500.0
	V	27.6	AMB	1M/10	41.4	2.0	34.8	36.2	64.6	500.0
19528.0	H	10.1	AMB	1M/10	40.3			50.4	331.1	500.0
	V	10.1	AMB	1M/10	40.3			50.4	331.1	500.0

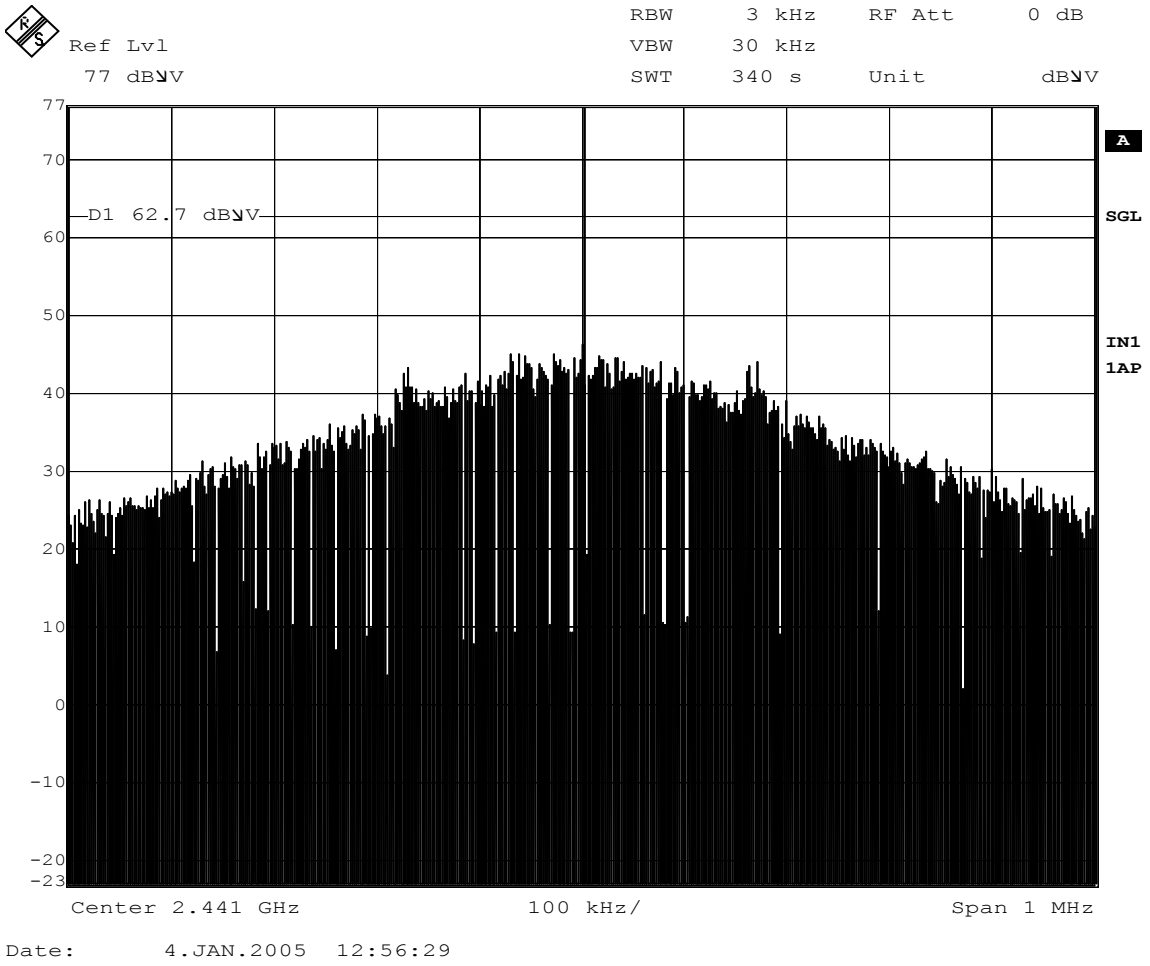
CHECKED BY: _____

Data Sheet

MANUFACTURER : KC Wire Free
MODEL : KC21
S/N : 2
SPECIFICATION : FCC Part 15, Subpart C, Section 15.247
Radiated Spurious Emissions Measurement
DATE : January 3, 2005
NOTES : Transmitting at 2480MHz
: TEST DISTANCE IS 3 METERS

FREQ. MHz	ANT. POL.	MTR. RDG. dBuV	AMBIENT	B.W. RBW/VBW Hz	DIST. CORR. FACT. dB	ANT. FACT. dB	CABLE LOSS dB	PRE. AMP. dB	TOTAL dBuV/m	15.209 Limit dBuV/m
2480.0	H	59.1		3M/3M	31.8	0.8	0.0	91.7	38459.2	
	V	59.4		3M/3M	31.8	0.8	0.0	92.0	39810.7	
4960.0	H	25.8		1M/10	35.2	1.3	35.2	27.1	22.6	500.0
	V	24.1		1M/10	35.2	1.3	35.2	25.4	18.6	500.0
7440.0	H	28.2	AMB	1M/10	38.0	1.6	35.5	32.3	41.2	500.0
	V	28.0		1M/10	38.0	1.6	35.5	32.1	40.3	500.0
12400.0	H	25.5	AMB	1M/10	41.4	2.0	34.8	34.1	50.7	500.0
	V	25.6	AMB	1M/10	41.4	2.0	34.8	34.2	51.3	500.0
19840.0	H	10.1	AMB	1M/10	40.3			50.4	331.1	500.0
	V	10.2	AMB	1M/10	40.3			50.5	335.0	500.0
22320.0	H	10.5	AMB	1M/10	40.4			50.9	350.8	500.0
	V	10.5	AMB	1M/10	40.4			50.9	350.8	500.0

CHECKED BY: _____



MANUFACTURER : KC WIRE FREE
MODEL NO. : KC21 W/KC121
SERIAL NO. : FCC #2
TEST PERFORMED : FCC 15.247 POWER SPECTRAL DENSITY
MODE : INQUIRIY MODE
NOTES : DISPLAY LINE REPRESENTS 8dBm LIMIT