ITS Intertek Testing Services
ETL SEMKO

Test Report
for
Motorola, Inc.
on the
Cordless Phone and Base
Model: CLS 1450C
to
FCC Part 90 Output Power and Spurious Emissions for Mobile Radios,
FCC Part 15 Emissions Requirements for Frequency Hopping Radios,
and
FCC Part 15 Emissions Requirements for Unintentional Radiators

Test Report #: 3046379
Date of Report: October 7, 2003

Project #s: 3046378 & 3046379
Dates of Test: August 5-6 and September 25-26, 29-30, 2003

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1.0 Summary of Tests

Motorola Cordless Phone and Base
Serial No.: 134ABC0005
Model No.: CLS 1450C

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2.0 General Description

2.1 Product Description

The EUTs are a telephone handset and associated base, with a charger for the handset. The base includes a frequency hopping spread spectrum radio operating in the 2.4 GHz – 2.4835 GHz band, while the handset is a composite device that includes the same frequency hopping spread spectrum radio module as the base, as well as an additional Push-To-Talk mobile radio feature which operates between 461.0375 and 469.5625 MHz and is designed to talk with any other mobile radio operating at this frequency. During testing the base was used to exercise the handset and vice versa, when appropriate.

The EUT has been tested at the request of

Company:	Motorola, Inc. 8000 West Sunrise Blvd. Mail 1C-15 Plantation, FL, 33322
Name of contact:	Wayne Phang
Telephone:	(954) 723-4678
Fax:	(954) 723-8170

2.2 Related Submittal(s) Grants

None.

2.3 Test Facility

Site 2C (Middle Site) is a 3m and 10m sheltered EMI measurement range located in a light commercial environment in Boxborough, Massachusetts. It meets the technical requirements of ANSI C63.4-1992 and CISPR 22:1993/EN 55022:1994 for radiated and conducted emission measurements. The shelter structure is entirely fiberglass and plastic, with outside dimensions of 33 ft x 57 ft. The structure resembles a quonset hut with a center ceiling height of 16.5 ft.

The testing floor is covered by a galvanized sheet metal groundplane that is earth-grounded via copper rods around the perimeter of the site. The joints between individual metal sheets are bridged with 2 inch wide metal strips to provide low RF impedance contact throughout. The sheets of metal are screwed in place with stainless steel, round-head screws every three inches. Site illumination and HVAC are provided from beneath the ground reference plane through flush entry ports, the port covers are electrically bonded to the ground plane.

A flush metal turntable with 12 ft. diameter and 5000 lb. load capacity is provided for floor-standing equipment. A wooden table 80 cm high is used for table-top equipment. The turntable is electrically connected to the ground plane with three copper straps. The straps are connected to the turntable at the center of it with ground braid. A copper strap is directly connected to the groundplane at the edges of the turntable. The turntable is located on the south end of the structure and the antennas are mounted 3 and 10 meters away to the north. The antenna mast is a non-conductive with remote control of antenna height and polarization. The antenna height is adjustable from 1 to 4 meters.

All final radiated emission measurements are performed with the testing personnel and measurement equipment located below the ground reference plane. The site has a full basement underneath the turntable where support

equipment may be remotely located. Operation of the antenna, turntable and equipment under test is controlled by remote controls that manipulate the antenna height and polarization with a turntable control. Test personnel are located below the ellipse when measurements are performed, however the site maintains the ability of having personnel manipulate cables while monitoring test equipment. Ambient radiated emissions are 6 dB or more below the relevant FCC emission limits.

AC mains power is brought to the equipment under test through a power line filter, to remove ambient conducted noise. 50 Hz (240 VAC single phase), 60 Hz power (120 VAC single phase, 208 VAC three phase), and 60 Hz (480 VAC three phase) are available. Conducted emission measurements are performed with a Line Impedance Stabilization Network (LISN) or Artificial Mains Network (AMN) bonded to the ground reference plane. A removable vertical groundplane (2 meter X 2 meter area) is used for line-conducted measurements for table top equipment. The vertical groundplane is electrically connected to the reference groundplane.

2.4 Test Equipment and Support Equipment

Test Equipment

Description	Manufacturer	Model Number	ITS ID	Serial Number	Cal Due Date
Antenna[1,2,3]	EMCO	3142	LOG2	9711-1223	11/05/2003
Antenna[2,3]	EMCO	3142	LOG4	9711-1225	02/18/2004
EMI Receiver Set[1,2,3]	Hewlett Packard	8542E	REC2	3520A00125	12/05/2003
RF Filter[1,2,3]	Hewlett Packard	85420E	RECFL2	3427A00126	12/05/2003
Spectrum Analyzer[2,3]	Rohde & Schwarz	FSEK-30	ROS001	100225	05/26/2004
High Frequency Cable[2,3]	Megaphase	TM40 K1K1 197	CBL027	CBL027	11/13/2003
High Frequency Cable[2,3]	Megaphase	TM40 K1K1 197	CBL028	CBL028	11/13/2003
High Frequency Cable[2,3]	Megaphase	TM40 K1K1 80	CBL029	CBL029	11/13/2003
High Frequency Cable[2,3]	Megaphase	TM40 K1K1 80	CBL030	CBL030	11/13/2003
Attenuator[2,3]	Weinschel Corp	47-10-34	WEI8	BD8309	02/15/2004
Synthesized Sweep Generator[2,3]	Hewlett Packard	83620A	HEW62	3213A01244	10/08/2003
Horn Antenna[2,3]	EMCO	3115	HORN2	9602-4675	09/03/2004
Horn Antenna[2,3]	EMCO	3115	HORN1	9512-4632	10/31/2003
Attenuator, 20 dB[1]	Mini Circuits	20 dB, 50 Ohm	DS24	DS24	01/07/2004
Cable, BNC – BNC[1]	Alpha	RG58B/U	CBL310E	CBL310E	01/08/2004
LISN, 50uH, 0.01-50 MHz, 24 A[1]	Solar Electronics	8012-50-R-24-BNC	LISN1	871083	03/11/2004
Preamplifier[2,3]	Miteq	NSP4000-NF	PRE8	507145	09/27/2003+
Antenna[3]	Compliance Design	B300	ANT1	00668	08/25/2004

+ - Not used after 9/25-26/2003 testing

Support Equipment*			
Description	**Manufacturer**	**Model Number**	**Serial Number**
Telephone Line Simulator[1,2]	Teltone	TLS-4	017400194

* - Note that in addition to equipment listed, the EUT Base and Handset were used as support equipment to exercise each other during all the Part 15 testing.

Cables					
Quantity	**Type**	**Length (m)**	**Shielding**	**Ferrite**	**Connector Type**
1	Telephone Cable[1, 2]	3	None	None	Plastic
1	Charger AC Mains[1]	2	None	None	Metal/360
1	Base AC Mains[1]	2	None	None	Metal/360

1 – Present during Part 15 Unintentional Radiator Testing

2 – Present during Part 15 Frequency Hopping Spread Spectrum Testing

3 – Present during Part 90 Mobile Radio Testing

3.0 RF Power Output
FCC § 15.247(b)(1), § 90.205(g)

3.1 Test Procedure

The transmitter was placed on a wooden turntable. The measurement antenna was placed at a distance of 10 meters from the EUT below 1 GHz, and 3 meters from the EUT above 1 GHz. During the tests, the antenna height and polarization were varied in order to identify the maximum level of emissions from the EUT.

The Radiated Power was measured by the substitution method using a horn antenna or a biconical antenna connected to a signal generator. Power P (in dBm) was calculated as follows:

$$P = P_{sg} - L + G_H - G_d$$

Where G_H is the gain of the transmit horn/biconical antenna attached to the signal generator
L is the loss in the cable between the signal generator and the transmit antenna
P_{sg} is the generator output power (on the end of the cable connected to an antenna)
G_d is 2.14 dBi – the gain of the half-wave dipole.

Requirement: The RF Power Output must be below 2 Watts (3 dBW) for the worst case service area and HAAT for the Part 90 Push-To-Talk radio. The RF output power must be below 1 Watt (0 dBW) for the Frequency Hopping Spread Spectrum (FHSS) radio.

3.2 Test Results

Results: Passed

Frequency (MHz)	Description	Value (dBm)	Value (dBW)	Limit (dBW)
464.5	Push-To-Talk Radio	28.61	-1.39	3
2400.0	FHSS Low Channel	14.61	-15.39	0
2441.5	FHSS Middle Channel	14.67	-15.33	0
2482.2	FHSS High Channel	16.76	-13.24	0

4.0 Frequency Hopping Characteristics

FCC § 15.247

4.1 Bandwidth

FCC § 15.247

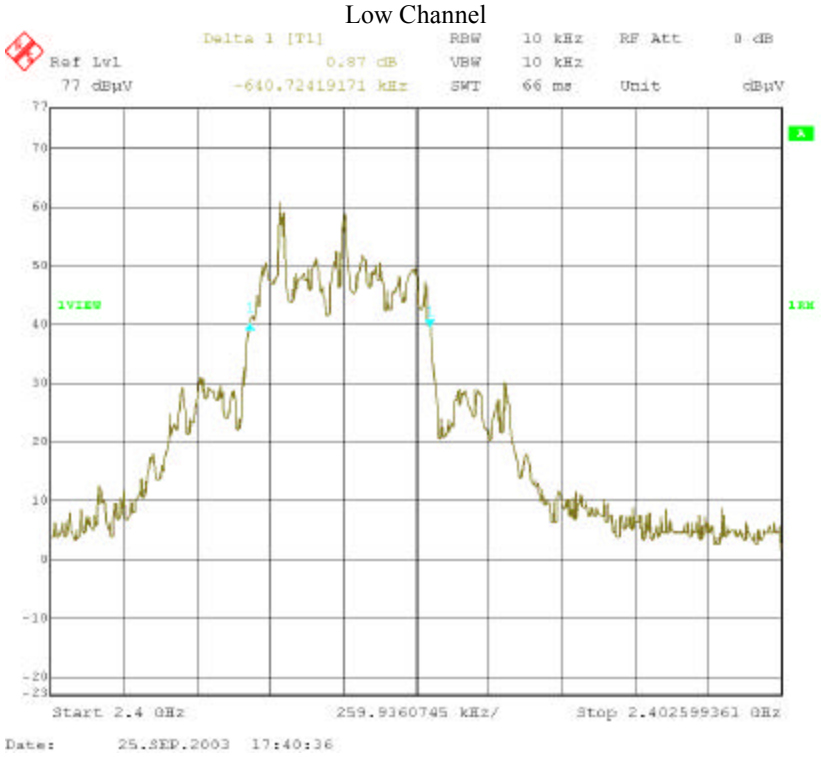
The EUT was set to transmit continuously at the low end, middle, and high end of its passband, and the bandwidth was measured 20 dB down from the peak using the marker delta function. Resolution and Video bandwidth were set to 10 kHz.

Requirement: There is no limit on the bandwidth in the frequency band 2.4 – 2.4835 GHz; however the bandwidth determines limits for other tests and therefore must be measured.

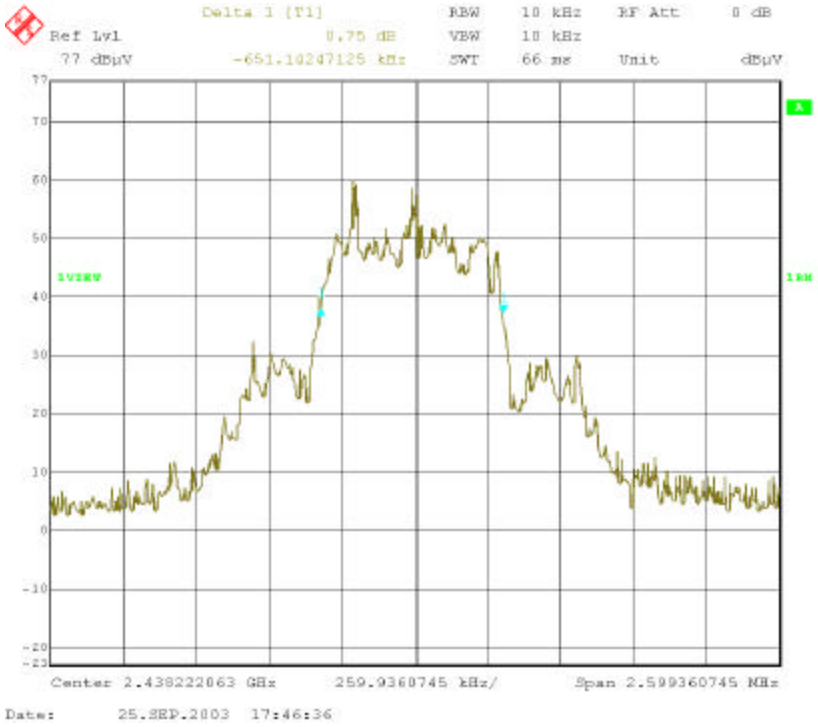
Results: No requirement

Channel	Frequency (MHz)	Bandwidth (kHz)	Limit (kHz)
Low	2400.0	641	None
Middle	2441.5	651	None
High	2482.2	653	None

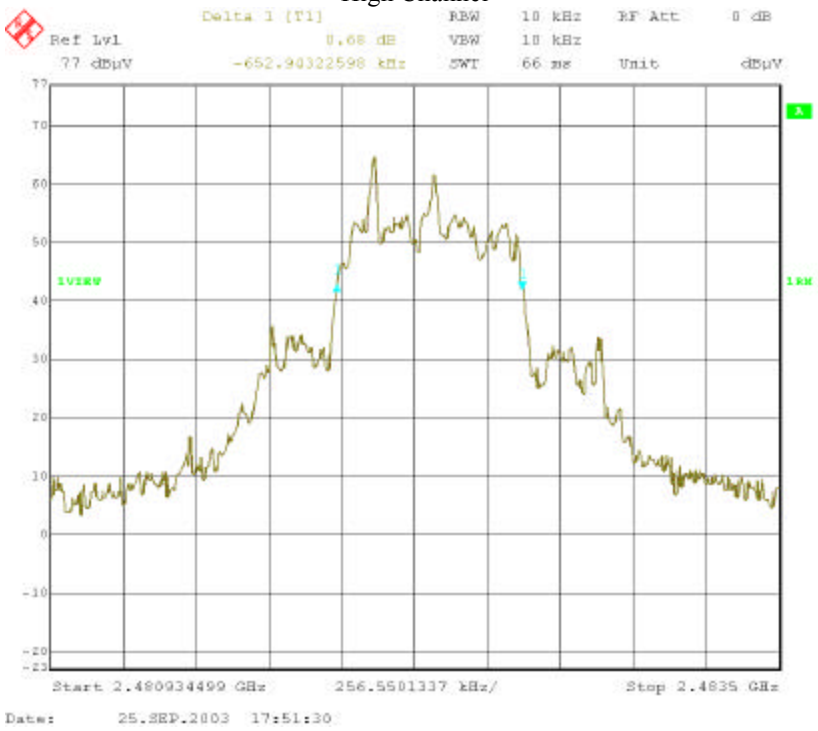
Low Channel



Middle Channel



High Channel

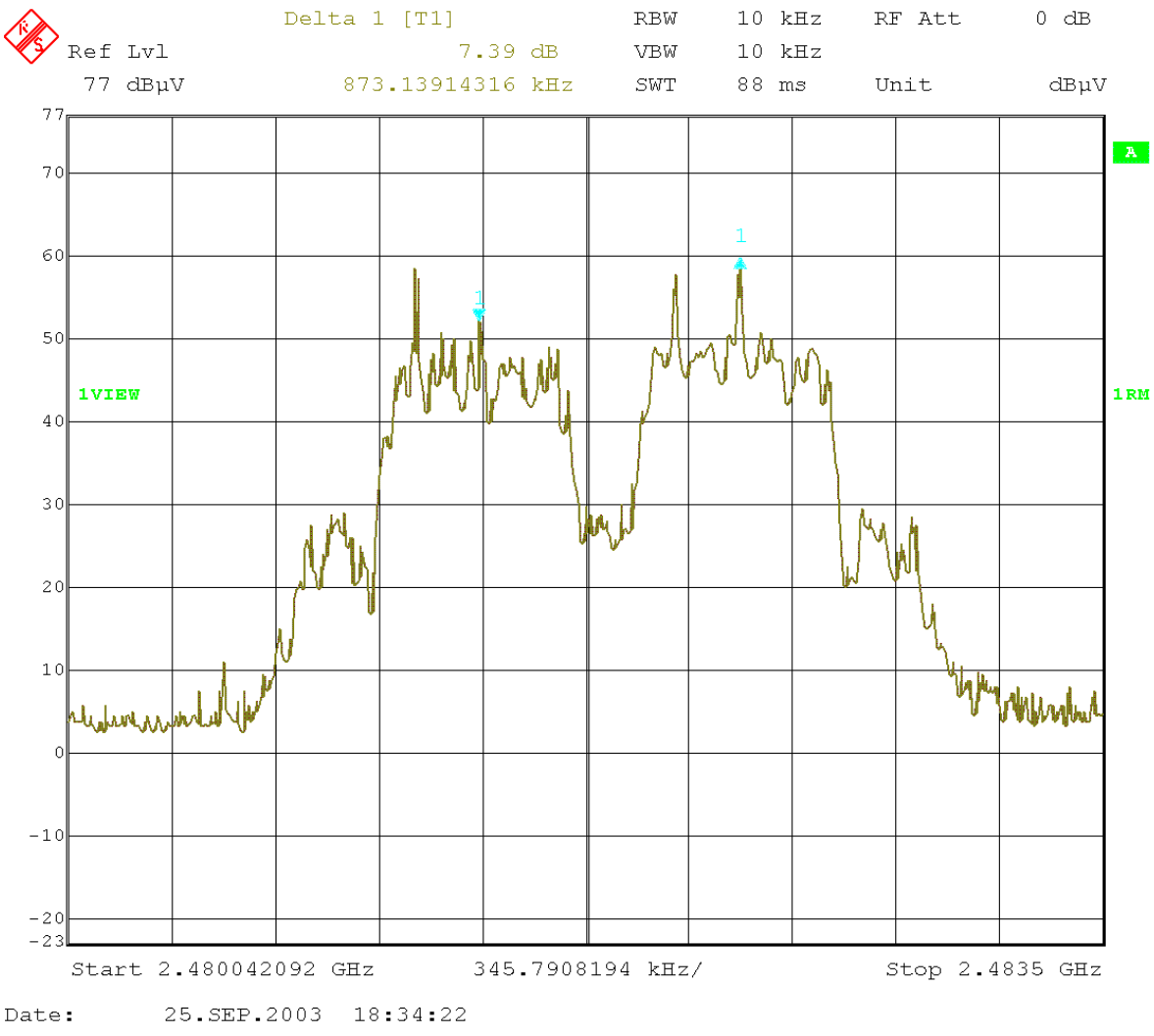


4.2 Channel Separation
FCC § 15.247(a)(1)

A measurement was made using a max hold function on the analyzer while the EUT was set to transmit first at one channel, then next at the channel adjacent.

Requirement: The channels of a frequency hopping system must be separated by at least 25 kHz, or the 20 dB bandwidth, whichever is greater. The largest 20 dB bandwidth is 653 kHz, therefore the channels must be separated by at least 653 kHz.

Results: Passed

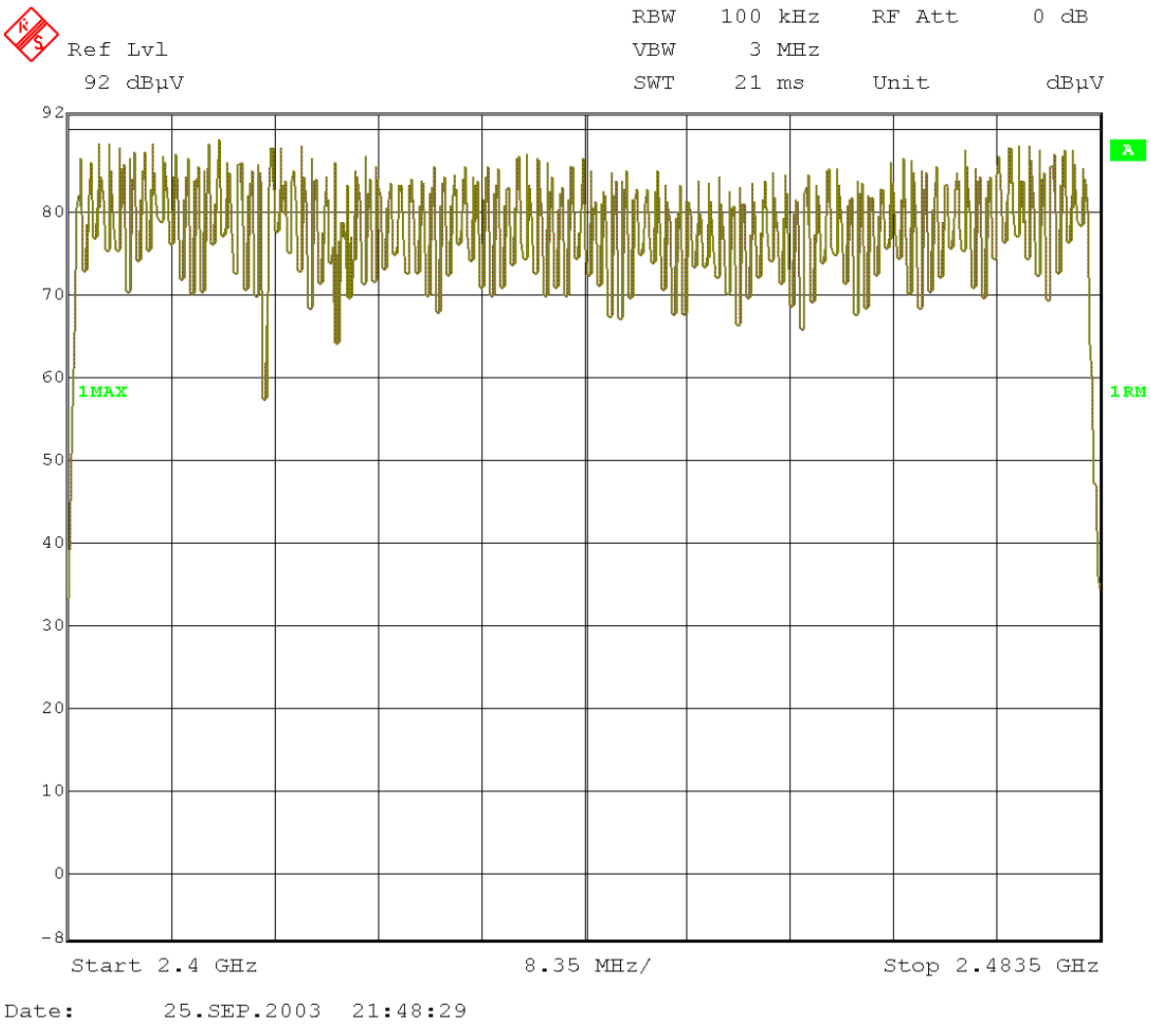


4.3 Number of Hopping Channels
FCC § 15.247(a)(1)(iii)

The EUT was activated and radiated measurements were made of the number of hopping channels by using a max hold function with 100 kHz resolution bandwidth and counting the channels as the radio was keyed sequentially through the channel set. 95 channels were found.

Requirement: Any frequency hopping system operating in the 2.4 to 2.4835 GHz band must employ at least 15 hopping channels.

Results: Passed



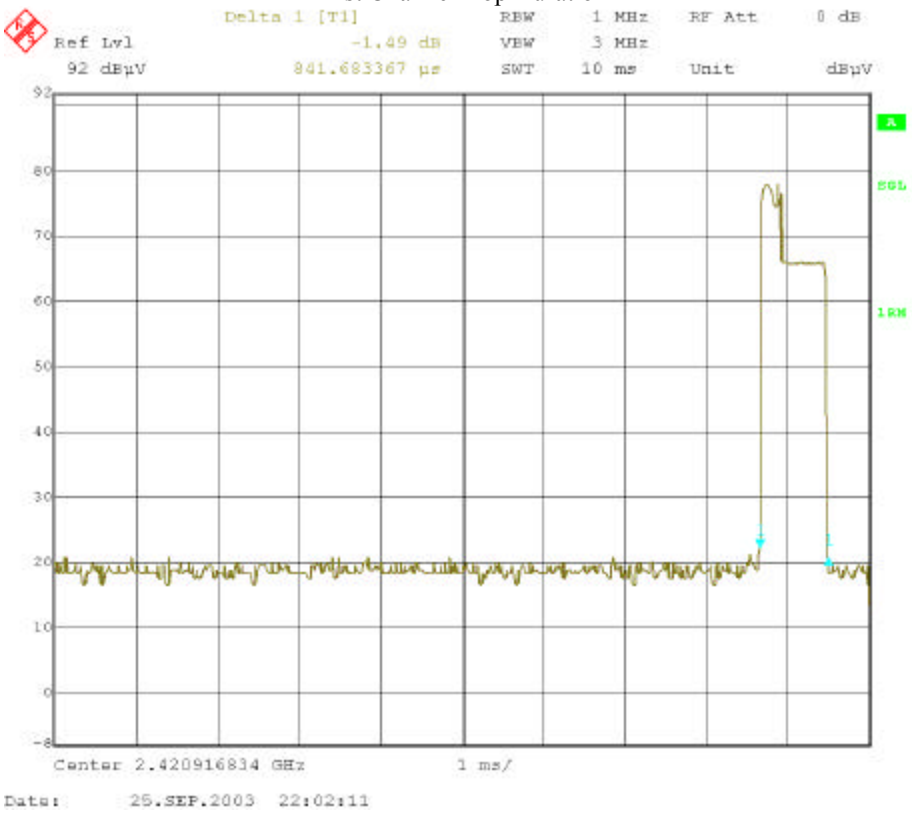
4.4 Channel Dwell Time
FCC § 15.247(a)(1)(iii)

Two hopping channels were selected at random and the EUT was set into normal hopping mode. A zero span time domain plot was made of the activity in the channels. A 10 kHz resolution bandwidth was used to assist in resolution of hops and to reduce adjacent hop contributions. Plots of hop duration use 1 MHz resolution bandwidth in order to capture the full duration of the hop. Only 40 hops in the channel were observed over a 38 second time frame. Each hop was 842 microseconds in duration. This works out to 33.68 ms over 38 seconds, which is within the limits.

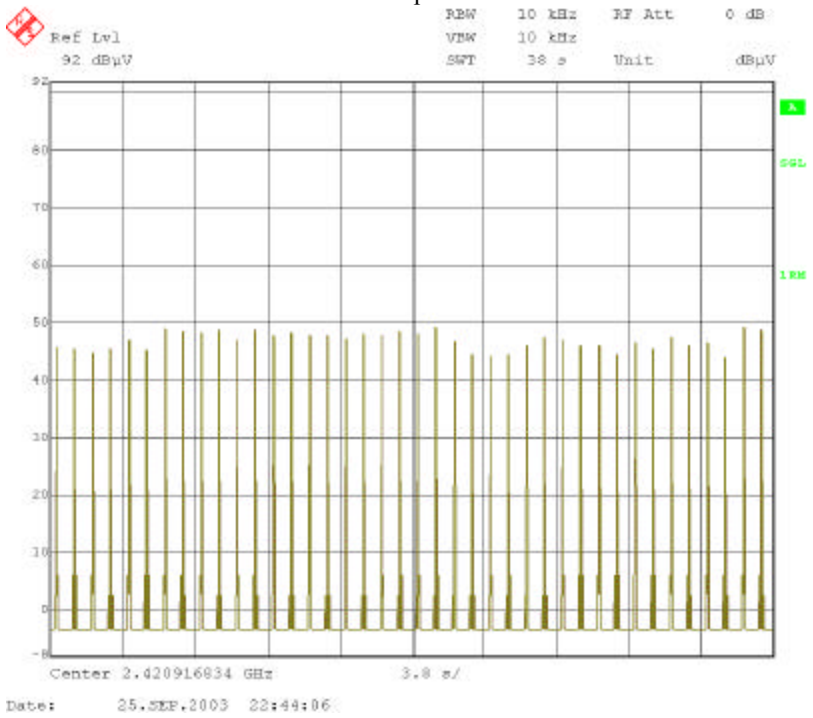
Requirement: Frequency hopping systems that operate in the frequency range from 2.4 to 2.4835 GHz must have an average time of occupancy not exceeding 0.4 seconds in a time interval equal to 0.4 seconds multiplied by the number of hopping channels. With 95 hopping channels this means that the EUT may not transmit in any one channel for longer than 0.4 seconds in a 38 second time period.

Results: Passed

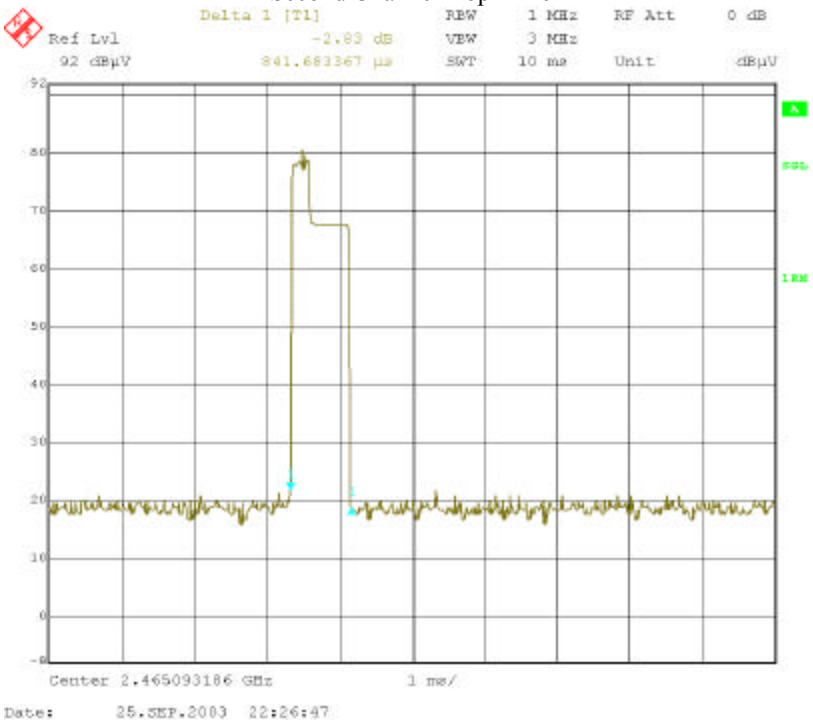
First Channel Hop Duration



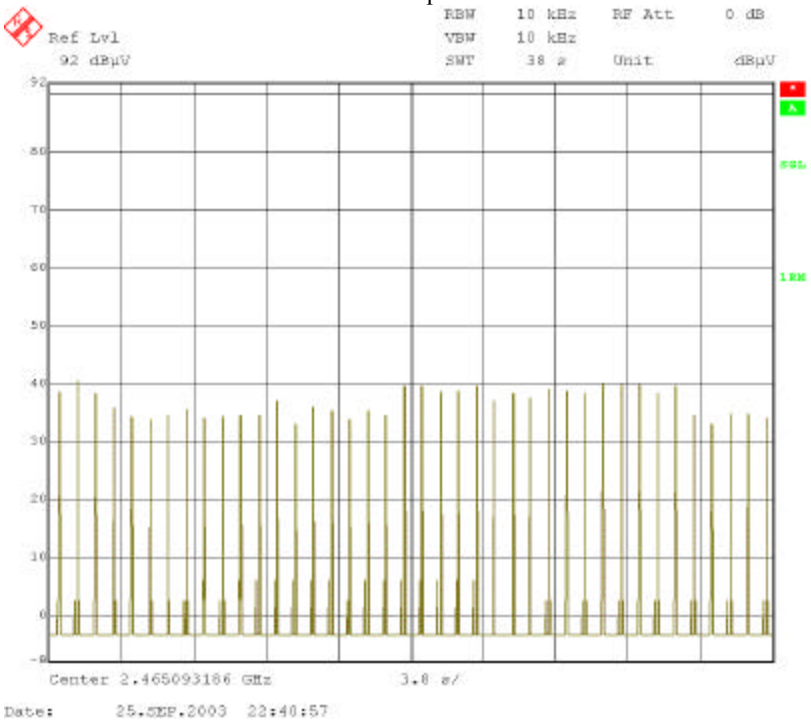
First Channel Hops in 38 Seconds



Second Channel Hop Time



Second Channel Hops in 38 Seconds



5.0 Emissions Mask Requirements at the Fundamental

FCC §90.210(d)

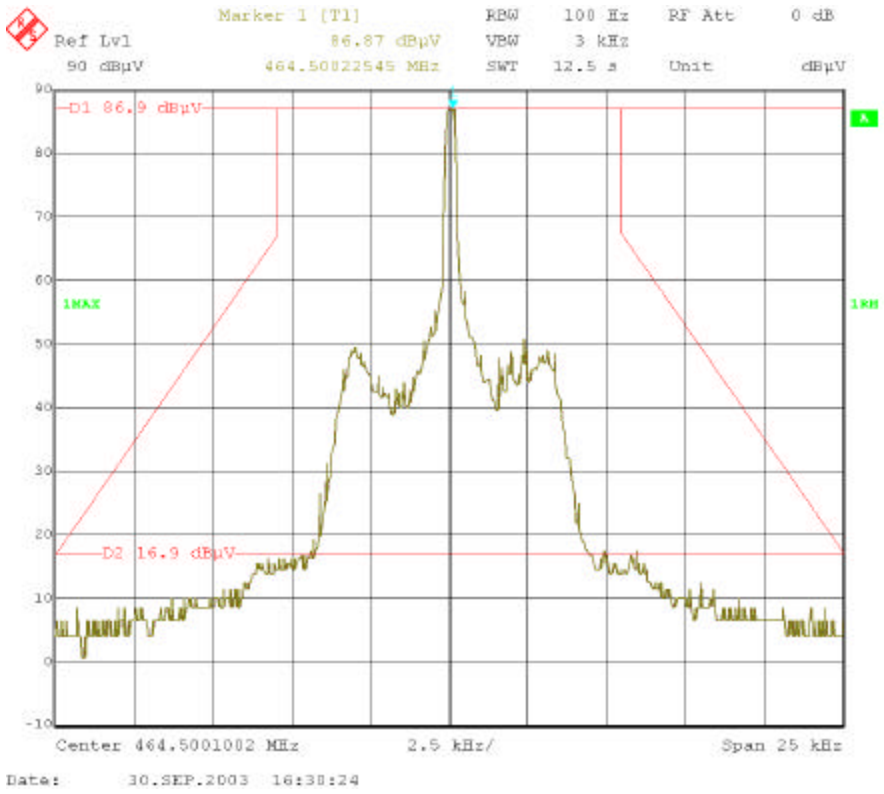
5.1 Test Procedure

The Part 90 Push-To-Talk radio was activated and the fundamental was observed on a spectrum analyzer through sufficient attenuation to prevent overloading the analyzer. The resolution and video bandwidths of the spectrum analyzer were set at 100 Hz. A plot of a 25 kHz span around the fundamental was made for comparison to the emissions mask of FCC §90.210(d).

Requirement: The fundamental emission waveform must be attenuated below the measured fundamental power P in watts by zero dB for frequencies within 5.625 kHz of the fundamental center frequency and by 7.27(f-2.88) dB (f in kHz) in the bands between 5.625 and 12.5 kHz offset from the fundamental center frequency.

5.2 Test Results

Results: Passed



6.0 Field Strength of Spurious Radiation

FCC §2.1053, §15.109, §15.205, §15.247 §90.210(d)

6.1 Test Procedure

Parts 15 & 90 - The transmitter was placed on a wooden turntable and the Part 90 Push-To-Talk radio and the Frequency Hopping Spread Spectrum Radio were activated in turn. The receivers were active during testing. The measurement antenna was placed at a distance of 10 meters from the EUT below 1 GHz, and 3 meters from the EUT above 1 GHz. During the tests, the antenna height and polarization as well as EUT azimuth were varied in order to identify the maximum level of emissions from the EUT. The Field Strength (FS) in the frequency range up to the tenth harmonic of the fundamental frequency was measured.

Part 90 - To satisfy the Part 90 emissions mask requirements, the Radiated Power was measured by the substitution method using a horn antenna or a biconical antenna connected to a signal generator. Power P (in dBm) was calculated as follows:

$$P = P_{sg} - L + G_H - G_d$$

Where G_H is the gain of the transmit horn/biconical antenna attached to the signal generator
L is the loss in the cable between the signal generator and the transmit antenna
P_{sg} is the generator output power (on the end of the cable connected to an antenna)
G_d is 2.14 dBi – the gain of the half-wave dipole.

Part 90 Requirement: For the Part 90 Push-To-Talk radio, the power into a dipole necessary to duplicate spurious emissions and harmonics must be attenuated below the power of the unmodulated carrier (P) on any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth at least (50 + 10 log P) dB. P is the measured RF output power in Watts. This corresponds to an ERP limit of –20 dBm. A table showing ERP values for Part 90 operation harmonics and spurious is shown.

Part 15 FHSS Requirement: For the Part 15 Frequency Hopping Spread Spectrum radio spurious emissions must be attenuated below the level of the fundamental emissions by not less than 20 dB. In the restricted bands of 15.205, compliance with the stricter general limits of 15.209 is required. A table showing compliance of all spurious emissions with the 15.209 limits is provided. Note that no spurious emissions were detected above 1 GHz during Frequency Hopping operation, so only spurious below 1 GHz is shown.

Part 15 Unintentional Radiators Requirement: For the receivers and digital devices, the spurious emissions must meet the general limits of 15.109 Class B, which correspond to the general limits of 15.209. A table showing compliance of all spurious emissions with the 15.109 limits is provided.

Frequency Range (MHz)	Field Strength (dBmV/m)	Measurement Distance (m)
30-88	40.0	3
88-216	43.5	3
216-960	46.0	3
Above 960	54.0	3

6.2 Test Results

Results: Pass

Part 90 Spurious and Harmonic Emissions
Performed 9/26/2003
Equipment: ROS001, CBL027, CBL028, CBL029, CBL030, PRE8, WEI8, HORN1, HORN2, HEW62, ANT1, LOG4

Frequency (MHz)	Description	Value (dBm)	Limit (dBm)
929.00	Harmonic	-28.38	-20
1323.44	Spurious	-51.378	-20
1390.18	Harmonic	-40.578	-20
1471.74	Spurious	-54.097	-20
1857.31	Harmonic	-47.373	-20
2317.03	Harmonic	-39.828	-20
2784.17	Harmonic	-38.573	-20
3251.30	Harmonic	-34.707	-20
3718.44	Harmonic	-32.487	-20
4178.16	Harmonic	-33.156	-20
4645.29	Harmonic	-35.916	-20

Part 15 Spurious Emissions

Radiated Emissions / Interference

Company: Motorola, Inc. Model #: CLS 1450C
Engineer: Nicholas Abbondante Location: Site 2 Serial #: 134ABC0005
Project #: 3046378 Pressure: 29.62inHg Receiver: HP 8542E
Date: 8/5 & 6/2003 Temp: 22c Antenna: LOG2 11-5-03 V10.ant LOG2 11-5-03 H10.ant
Standard: FCC Part 15 Subpart B Humidity: 71% PreAmp: None
Class: B Group: None Cable(s): 2C, 10MPRIME 9-19-03.cbl None
Limit Distance: 3 meters Test Distance: 10 meters
Voltage/Frequency: 120V / 60 Hz Frequency Range: 30 MHz - 1 GHz

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	63.070	17.2	7.0	1.5	0.0	-10.5	36.1	40.0	-3.9	+
H	211.200	16.5	10.4	2.6	0.0	-10.5	40.0	43.5	-3.5	+
H	214.100	13.1	10.5	2.7	0.0	-10.5	36.7	43.5	-6.8	
V	277.100	10.1	13.2	3.0	0.0	-10.5	36.7	46.0	-9.3	
V	342.000	10.1	15.1	3.4	0.0	-10.5	39.0	46.0	-7.0	
V	707.800	5.9	21.6	5.2	0.0	-10.5	43.2	46.0	-2.8	+

+ - Note that these emissions fall within our range of radiated emissions measurement uncertainty, which is +/- 4 dB.

6.3 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
AVF = Duty Cycle 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:

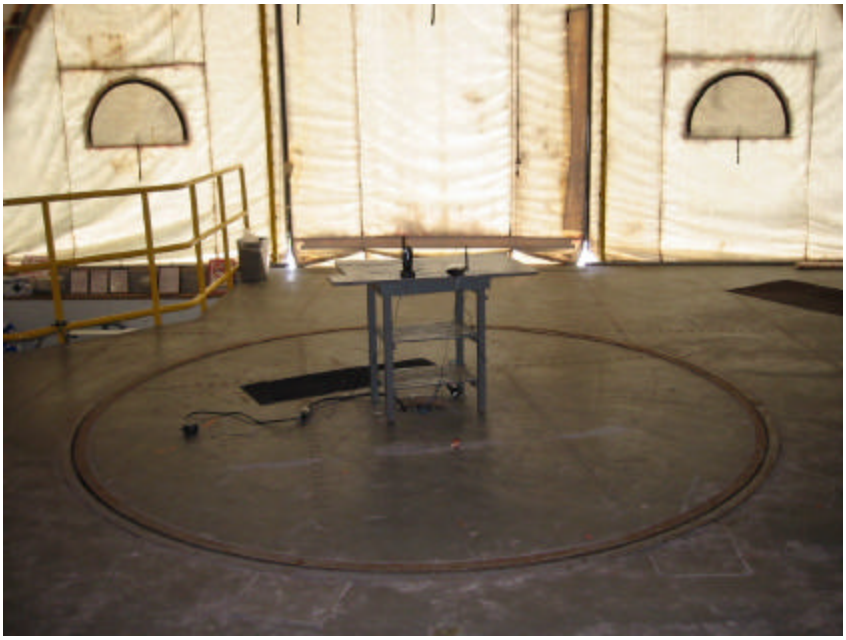
For the fundamental field strength measurement at 8.4 (distance = 3 meters) see table [1].

NF = NF = RF + AF + CF + AVF + DF = 62.9 + 13.7 + 2.1 + (–10.0) + 0.0 = 68.7 dBµV/m

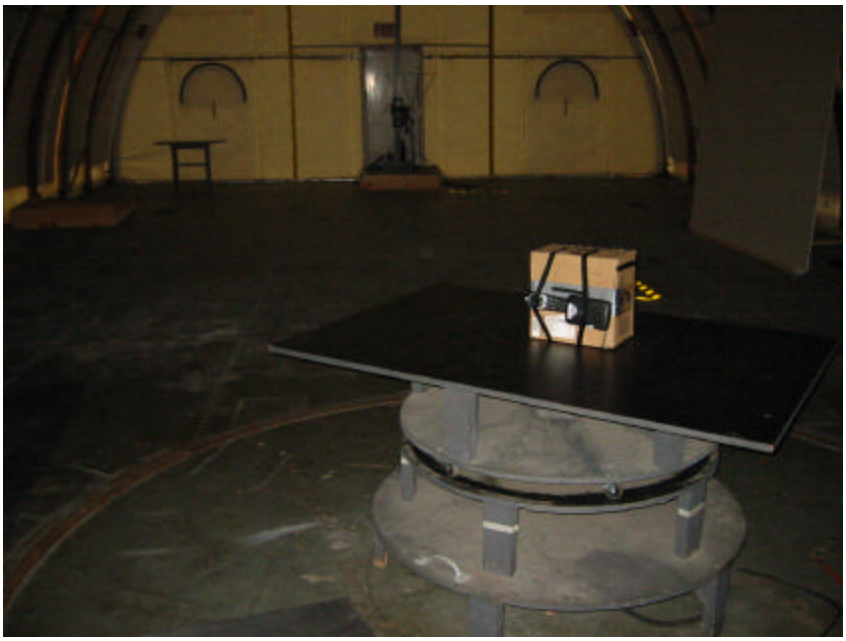
$UF = 10^{(68.7\ dB\mu V / 20)} = 2722.7\ \mu V/m$

6.4 Configuration Photographs – Radiated Emissions

Unintentional Radiator Spurious Test Setup, Front View



Unintentional Radiator Spurious Test Setup, Rear View



Transmitter Spurious Test Setup, Front View

Transmitter Spurious Test Setup, Back View

7.0 Line-Conducted Emissions

FCC § 15.107, § 15.207

7.1 Test Procedure

Conducted emissions are measured in the frequency range of 150 kHz to 30 MHz on AC power lines. Interference voltages are measured with a LISN and a spectrum analyzer or receiver. The handset and base were placed 40cm from a vertical ground plane on a non-conductive table at an 80cm height over a conductive ground plane. A peak as well as average detector was used, with peak compared to quasi-peak limits.

Requirement: Line-conducted emissions must not exceed the CISPR 22 limits.

Frequency (MHz)	**Class B Limit dB(㎶V)**	
	Quasi-Peak	Average
0.150 – 0.5	66 – 56*	56 – 46*
0.5– 5	56	46
5– 30	60	50

*-Decreases linearly with the logarithm of the frequency

7.2 Test Results

Conducted Emissions / Interference

Company:	Motorola, Inc.		Model #:	CLS 1450C Base	
Engineer:	Nicholas Abbondante	Location: Site 2	Serial #:	134ABC0005	
Project #:	3046379	Pressure: 1013mB	Receiver:	R&S FSEK-30	
Date:	09/30/03	Temp: 22c	Cable:	CBL310E 1-8-04.cbl	
Standard:	FCC Part 15/CISPR22	Humidity: 56%	LISN 1, 2:	LISN1 [1] 3-11-04.lsn	LISN1 [2] 3-11-04.lsn
Class:	B	Group: None	LISN 3, N:	None	None
Preamp:	None		Attenuator:	DS24 1-7-04.att	
Voltage/Frequency:	120V / 60Hz		Frequency Range:	0.15 - 30 MHz	

Net is the sum of worst-case lisn, cable, & attenuator losses, preamp gain, and initial reading

Frequency MHz	Reading Line 1 dB(uV)	Reading Line 2 dB(uV)	Reading Line 3 dB(uV)	Reading Neutral dB(uV)	Quasi-Peak Net dB(uV)	Quasi-Peak Limit dB(uV)	Quasi-Peak Margin dB
0.177	31.5	30.1			53.9	64.6	-10.7
1.112	11.0	8.6			31.9	56.0	-24.1
9.570	8.3	10.3			31.5	60.0	-28.5
13.640	24.9	28.1			49.4	60.0	-10.6
17.600	16.2	23.0			44.5	60.0	-15.5
18.940	24.8	25.6			47.1	60.0	-12.9

Frequency MHz	Reading Line 1 dB(uV)	Reading Line 2 dB(uV)	Reading Line 3 dB(uV)	Reading Neutral dB(uV)	Average Net dB(uV)	Average Limit dB(uV)	Average Margin dB
0.177	25.4	24.5			47.8	54.6	-6.8
1.112	5.8	6.1			27.1	46.0	-18.9
9.570	1.2	1.6			22.7	50.0	-27.3
13.640	21.7	22.3			43.6	50.0	-6.4
17.600	13.1	16.4			37.8	50.0	-12.2
18.940	24.7	21.7			46.2	50.0	-3.8

Conducted Emissions / Interference

Company:	Motorola, Inc.			Model #:	CLS 1450C Handset Charger
Engineer:	Nicholas Abbondante	Location:	Site 2	Serial #:	134ABC0005
Project #:	3046379	Pressure:	1013mB	Receiver:	R&S FSEK-30
Date:	09/30/03	Temp:	22c	Cable:	CBL310E 1-8-04.cbl
Standard:	FCC Part 15/CISPR22	Humidity:	56%	LISN 1, 2:	LISN1 [1] 3-11-04.lsn LISN1 [2] 3-11-04.lsn
Class:	B	Group:	None	LISN 3, N:	None None
Preamp:	None			Attenuator:	DS24 1-7-04.att
Voltage/Frequency:	120V / 60Hz			Frequency Range:	0.15 - 30 MHz

Net is the sum of worst-case lisn, cable, & attenuator losses, preamp gain, and initial reading

Frequency MHz	Reading Line 1 dB(uV)	Reading Line 2 dB(uV)	Reading Line 3 dB(uV)	Reading Neutral dB(uV)	Peak Net dB(uV)	Peak Limit dB(uV)	Peak Margin dB
0.177	29.9	27.5			52.3	64.6	-12.3
1.112	9.2	7.6			30.1	56.0	-25.9
13.630	24.5	22.0			45.8	60.0	-14.2
17.590	24.1	21.1			45.6	60.0	-14.4
18.987	22.7	20.2			44.2	60.0	-15.8
29.640	6.3	5.9			28.0	60.0	-32.0

Frequency MHz	Reading Line 1 dB(uV)	Reading Line 2 dB(uV)	Reading Line 3 dB(uV)	Reading Neutral dB(uV)	Average Net dB(uV)	Average Limit dB(uV)	Average Margin dB
0.177	28.4	22.5			50.8	54.6	-3.8
1.112	6.3	5.6			27.2	46.0	-18.8
13.630	20.7	16.5			42.0	50.0	-8.0
17.590	17.2	15.1			38.6	50.0	-11.4
18.987	20.3	18.9			41.8	50.0	-8.2
29.640	-9.5	-2.2			21.3	50.0	-28.7

7.3 Configuration Photographs – Line-Conducted Emissions