

Type Acceptance Test Report

Multimode PCS Repeater FCC Rule Parts: 2, 15 & 24

ACS Report Number: 03-0089-24TA

Manufacturer: EMS Wireless
Model: Link2Cell

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This report contains 16 pages

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1.0 GENERAL

1.1 Introduction

The purpose of this report is to demonstrate compliance with the relevant portions of Parts 2, 15 and 24 of the FCC's Code of Federal Regulations.

1.2 Product Description

The Link2cell is a low-power cellular enhancer that consists of a bi-directional amplifier device (BDA), which can mutually communicate by radio frequency signals with a base station and a cellular telephone in close proximity. The cellular enhancer device consists of two separate signaling paths, with an amplification stage and antennas at both ends for the reception and transmission of radio frequency signals. The enhancement is the increase of signal power levels to allow cellular telephone usage in a small office or home office environment where the original cellular signals are weak. The device consists of a 4 port BDA with distinct and separate cross polarized uplink and downlink elements for both the donor and server antennas. The donor antenna downlink radio frequency input is vertically polarized while the donor antenna uplink radio frequency output is horizontally polarized. On the server antenna, the downlink radio frequency output is horizontally polarized while the server uplink radio frequency input is vertically polarized. The symmetry of the antennas provide maximum isolation. Both donor to server isolation and uplink to downlink isolation is achieved by this antenna configuration. The cross polarized donor and server antennas provide isolation between uplink and downlink paths and eliminate the need for donor and server duplexers; thereby providing both a cost savings and a reduction in noise figure and group delay.

Features

- Plug and play capability - No installation required
- Aesthetically pleasing design with antennas enclosed
- Provides coverage to all 1900 MHz system protocols
- Improves signal coverage in locations up to 5,000 sq. ft
- 1850 thru 1910 MHz uplink = 28 dBm power; 1930 thru 1990 MHz downlink = 1.5 dbm power
- Affordably priced
- Cascade up to four units
- Easily visible status LED indicators

Applicable Locations:

- Offices
- Small Businesses
- Small Retail Stores
- Homes

Detailed photographs of the EUT are filed separately with this filing.

1.2.1 Intended Use

Used to enhance PCS signals in areas of weak coverage. Designed to mount in a window or on a wall.

1.2.2 Technical Specifications

Table 1.2.2-1: Specifications

PARAMETER	UPLINK	DOWNLINK
Frequency	1850-1910MHz	1930-1990MHz
RF Transmit Power	+15dBm	+2dBm
RF Gain	53dB	53dB
Gain Flatness	+/- 2dB	+/- 2dB
Gain Range	50dB	50dB
Spurious Output@ Rated Power	</= -13dBm FCC Reg.	</= -60dBc </= -13dBm FCC Reg.
CDMA ACPR	</= -45dBm@±885KHz </= -56dBm@±1.25MHz	</= -45dBm@±885KHz </= -56dBm@±1.25MHz
1dB Compression	+22dBm	+22dBm
IP3	+41dBm	+41dBm
	UPLINK/DONOR	DOWNLINK/SERVER
Antenna Gain	+13dBi	+13dBi
EIRP Transmit Power	+28dBm	+15dBm
System Gain	+79dB	+79dB

2.0 LOCATION OF TEST FACILITY

All testing was performed by qualified ACS personnel located at the following address:

ACS, Inc.
5015 B.U. Bowman Drive
Buford, GA 30518

2.1 DESCRIPTION OF TEST FACILITY

Both the Open Area Test Site(OATS) and Conducted Emissions site have been fully described, submitted to, and accepted by the FCC, Industry Canada and the Japanese Voluntary Control Council for Interference by information technology equipment.

The following certification numbers have been issued in recognition of these accreditations and certifications:

FCC Registration Number: 89450
Industry Canada Lab Code: IC 4175
VCCI Member Number: 1831

- VCCI OATS Registration Number R-1526
- VCCI Conducted Emissions Site Registration Number: C-1608

2.1.1 Open Area Test Site

The open area test site consists of a 40' x 66' concrete pad covered with a perforated electro-plated galvanized sheet metal. The perforations in the sheet metal are 1/8" holes that are staggered every 3/16". The individual sheets are placed to overlap each other by 1/4" and are riveted together to provide a continuous seam. Rivets are spaced every 3" in a 3 x 20 meter perimeter around the antenna mast and EUT area. Rivets in the remaining area are spaced as necessary to properly secure the ground plane and maintain the electrical continuity.

The entire ground plane extends 12' beyond the turntable edge and 16' beyond the antenna mast when set to a 10 meter measurement distance. The ground plane is grounded via 4 - 8' copper ground rods, each installed at a corner of the ground plane and bound to the ground plane using 3/4" stainless steel braided cable.

The turntable is an all aluminum 10' flush mounted table installed in an all aluminum frame. The table is remotely operated from inside the control room located 40' from the range. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane during operation.

Adjacent to the turntable is a 7' x 7' square and 4' deep concrete pit used for support equipment if necessary. The pit is equipped with 5 - 4" PVC chases from the pit to the control room that allow for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit. The pit is covered with 2 sheets of 1/4" diamond style reinforced steel sheets. The sheets are painted to match the perforated steel ground plane, however the underside edges have been masked off to maintain the electrical continuity of the ground plane. All reflecting objects are located outside of the ellipse defined in ANSI C63.4.

A diagram of the Open Area Test Site is shown in Figure 2.1-1 below:

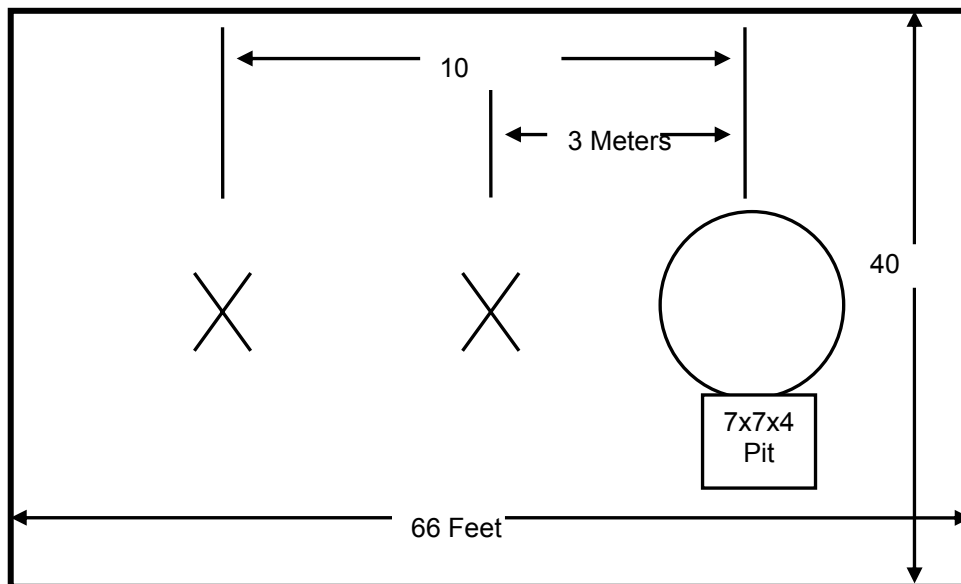


Figure 2.1-1: Open Area Test Site

2.1.2 Conducted Emissions Test Site Description

The AC mains conducted EMI site is a shielded room with the following dimensions:

- Height: 3.0 Meters
- Width: 3.6 Meters
- Length: 4.9 Meters

The room is manufactured by Rayproof Corporation and installed by Panashield, Inc. Earth ground is provided to the room via an 8' copper ground rod. Each panel of the room is connected electrically at intervals of 4".

Power to the room is filtered to prevent ambient noise from coupling to the EUT and measurement equipment. Filters are models 1B42-60P manufactured by Rayproof Corporation.

The room is of sufficient size to test table top and floor standing equipment in accordance with section 6.1.4 of ANSI C63.4.

A diagram of the room is shown below in figure 2.1.2-1:

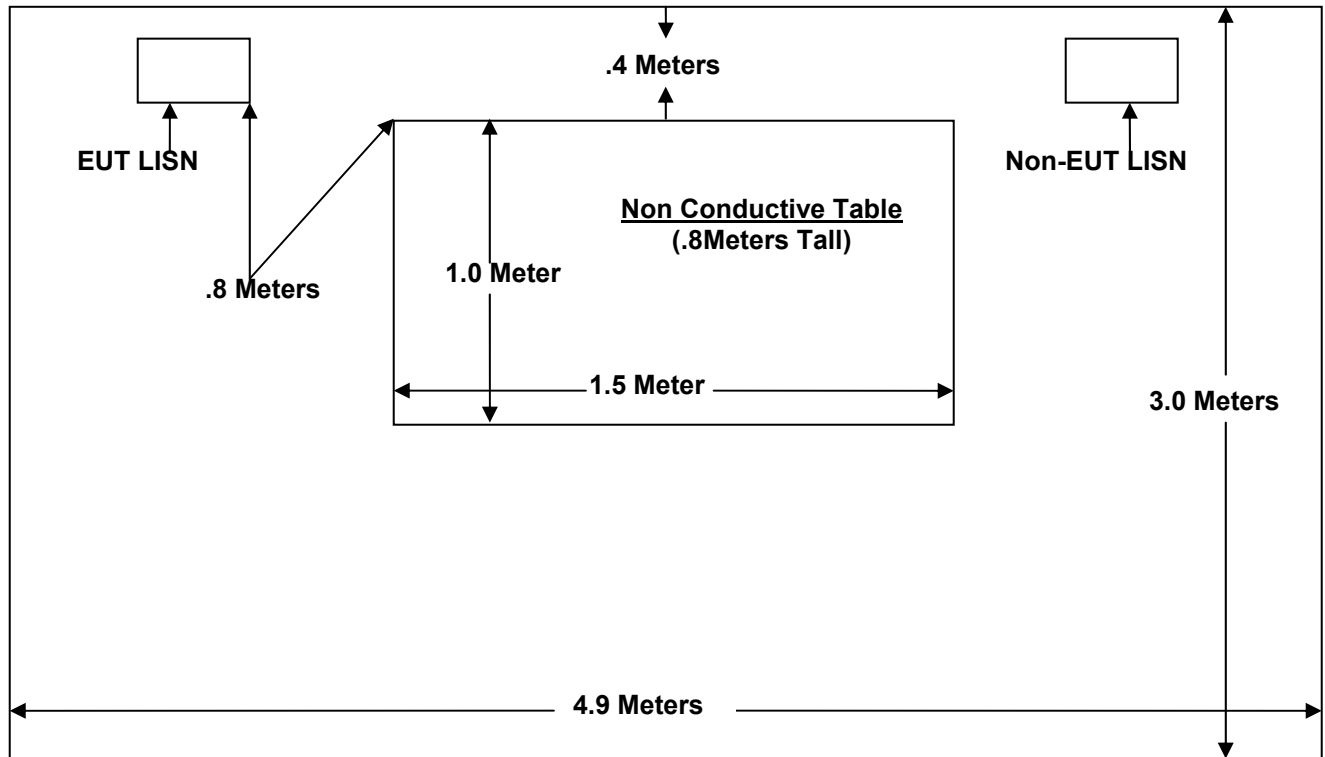


Figure 2.1-2: AC Mains Conducted EMI Site

3.0 APPLICABLE STANDARD REFERENCES

The following standards were used:

- ❖ ANSI C63.4-1992: Method of Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the 9KHz to 40GHz
- ❖ US Code of Federal Regulations (CFR): Title 47, Part 2, Subpart J: Equipment Authorization Procedures (October 2002)
- ❖ US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators (October 2002)
- ❖ US Code of Federal Regulations (CFR): Title 47, Part 24, Subpart E: Broadband PCS (October 2002)
- ❖ FCC OET Bulletin 65 Appendix C - Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields
- ❖ ANSI/TIA/EIA – 603 – A – 2001: Land Mobile or PM Communications Equipment and Performance Standards (August 15, 2001)

4.0 LIST OF TEST EQUIPMENT

All test equipment used for regulatory testing is calibrated yearly or according to manufacturer's specifications.

Equipment Calibration Information					
ACS #	Mfg.	Eq. type	Model	S/N	Cal. Due
4	Rohde & Schwarz	Spectrum Analyzer	ESMI	833827/003	8/16/03
3	Rohde & Schwarz	Display Unit	ESDI	839379/011	8/16/03
2	Rohde & Schwarz	Spectrum Analyzer	ESMI	839587/003	12/23/03
1	Rohde & Schwarz	Display Unit	ESDI	839379/011	12/26/03
26	Chase	Bi-Log Antenna	CBL6111	1044	8/26/03
25	Chase	Bi-Log Antenna	CBL6111	1043	9/19/03
71	Chase	LISN	ALN2070A	1028	8/23/03
152	EMCO	LISN	3825/2	9111-1905	12/11/03
153	EMCO	LISN	3825/2	9411-2268	12/11/03
30	Spectrum Technologies	Horn Antenna	DRH-0118	970102	9/17/03
16	ACS	Cable	RG8	16	9/17/03
23	ACS	Cable	RG8	23	1/3/04
24	ACS	Cable	Heliac	24	04/07/04
5	ACS	Cable	LL-335	None	7/31/03
6	ACS	Cable	LL-335	None	7/31/03
22	Agilent	Pre-Amplifier	8449B	3008A0052 6	9/21/03
73	Agilent	Pre-Amplifier	8447D	272A05624	04/15/04
30	Spectrum Technologies	Horn Antenna	DRH-0118	970102	9/17/03
105	Microwave Circuits	High Pass Filter	H1G810G1	2123-01 DC0225	6/19/03

Table 4-1: Test Equipment

5.0 SYSTEM BLOCK DIAGRAM

Table 5.0: System Block Diagram

Diagram Number	Manufacturer	Equipment Type	Model Number	Serial Number	FCC ID
1	EMS Wireless	EUT	Link2Cell	None	NUW0B2L2C1900
2	Agilent	RF Signal Generator	E4432B	None	None
3	Spectrum Technologies	Horn Antenna	DRH-0118	970102	None
4	Ault	AC/DC PS	P48091000A300G	0027	None

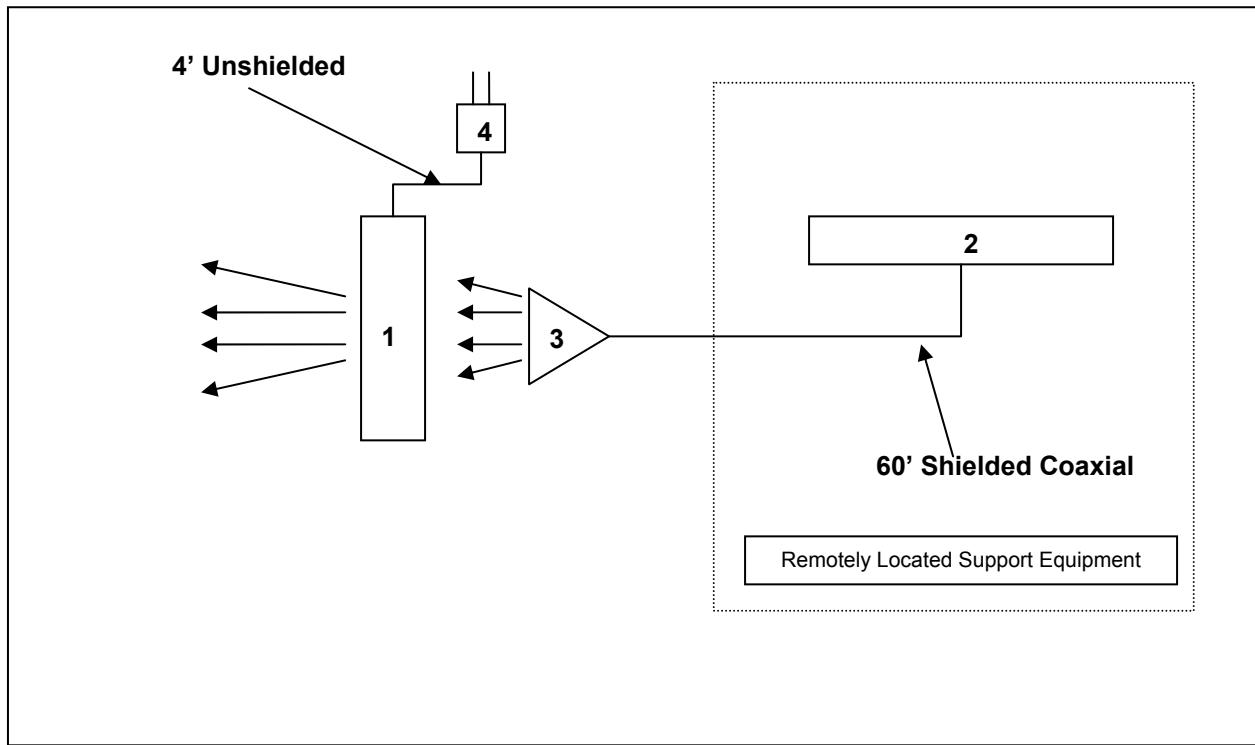


Figure 5-1: EUT Test Setup

6.0 SUMMARY OF TESTS

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

6.1 Power Line Conducted Emissions - FCC Section 15.207

6.1.1 Test Methodology

ANSI C63.4 sections 6 and 7 were the guiding documents for this evaluation. Conducted emissions were performed from 150kHz to 30MHz with the spectrum analyzer's resolution bandwidth set to 9kHz and the video bandwidth set to 30kHz.

6.1.2 Test Results

Results of the test are shown below in figures 6.1.2-1 and 6.1-2 and tables 6.1.2-1 and 6.1.2-2.

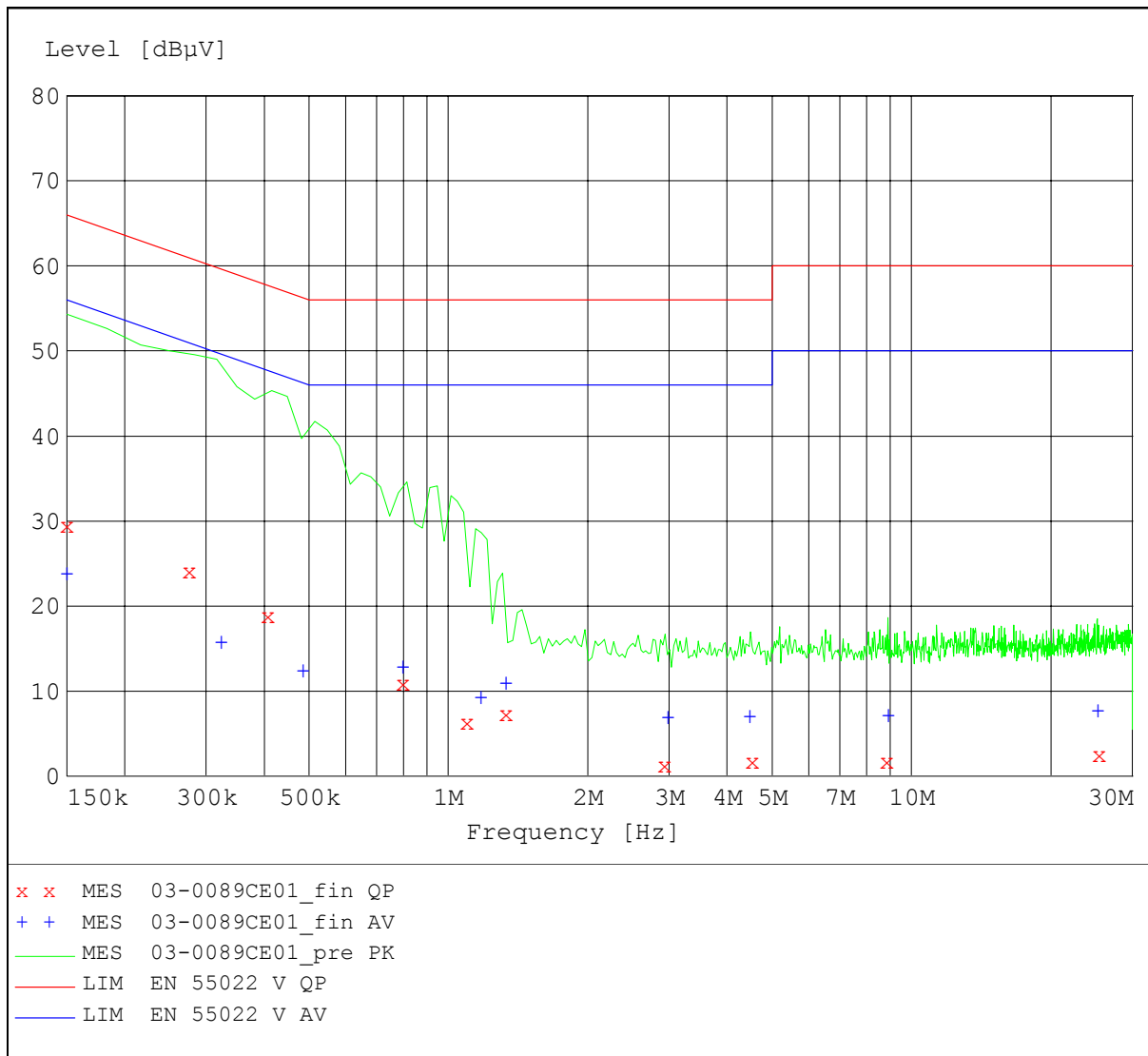


Figure 6.1.2-1: Line 1

Table 6.1.2-1: Line 1 Conducted EMI Results (Quasi-Peak)

Frequency MHz	Level dB μ V	Transd dB	Limit dB μ V	Margin dB	Line
0.15	29.6	10.7	66.0	36.3	L1
0.276	24.2	10.2	60.9	36.6	L1
0.408	19.0	9.9	57.6	38.6	L1
0.798	11.0	9.9	56.0	44.9	L1
1.098	6.4	9.8	56.0	49.5	L1
1.332	7.4	9.7	56.0	48.5	L1
2.928	1.4	9.7	56.0	54.5	L1
4.53	1.8	9.9	56.0	54.1	L1
8.85	1.8	10.1	60.0	58.1	L1
25.428	2.6	10.6	60.0	57.3	L1

Table 6.1.2-2: Line 1 Conducted EMI Results (Average)

Frequency MHz	Level dB μ V	Transd dB	Limit dB μ V	Margin dB	Line
0.15	23.9	10.7	56	32	L1
0.324	15.8	10.3	49.6	33.7	L1
0.486	12.4	9.9	46.2	33.7	L1
0.798	12.9	9.9	46	33	L1
1.176	9.3	9.8	46	36.6	L1
1.332	11	9.7	46	34.9	L1
2.982	6.9	9.7	46	39	L1
4.482	7.1	9.9	46	38.8	L1
8.916	7.2	10.1	50	42.7	L1
25.278	7.8	10.6	50	42.1	L1

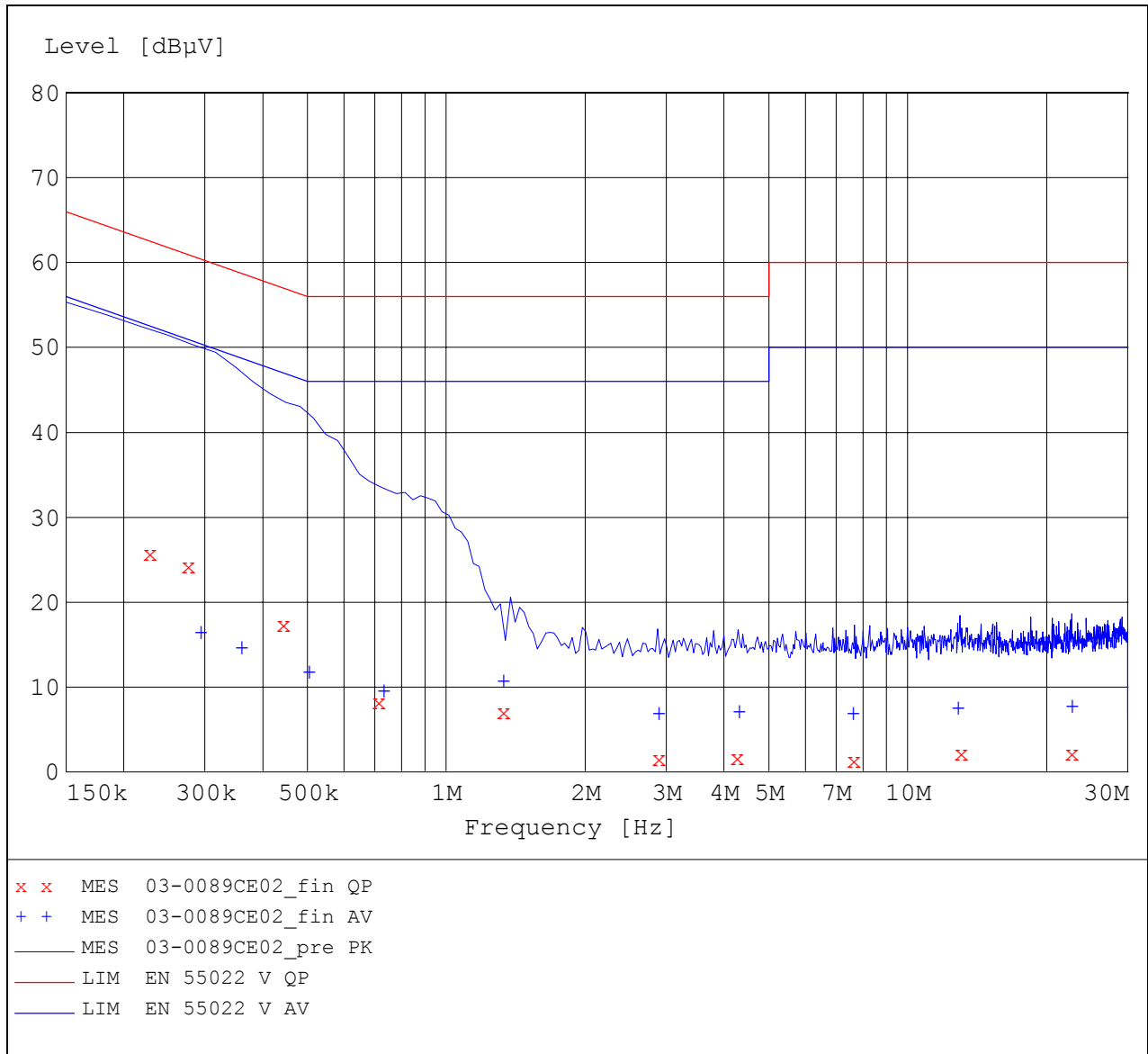


Figure 6.1.2-2: Line 2

Table 6.1.2-3: Line 2 Conducted EMI Results (Quasi-Peak)

Frequency MHz	Level dB μ V	Transd dB	Limit dB μ V	Margin dB	Line
0.228	25.8	10.1	62.5	36.6	N
0.276	24.3	10.2	60.9	36.6	N
0.444	17.4	9.9	56.9	39.5	N
0.714	8.3	9.9	56	47.6	N
1.332	7.1	9.7	56	48.8	N
2.886	1.6	9.7	56	54.3	N
4.266	1.7	9.9	56	54.2	N
7.644	1.4	9.9	60	58.5	N
13.05	2.3	10.3	60	57.6	N
22.704	2.3	10.6	60	57.6	N

Table 6.1.2-3: Line 2 Conducted EMI Results (Average)

Frequency MHz	Level dB μ V	Transd dB	Limit dB μ V	Margin dB	Line
0.294	16.5	10.3	50.4	33.8	N
0.36	14.6	10.1	48.7	34	N
0.504	11.8	9.9	46	34.1	N
0.732	9.5	9.9	46	36.4	N
1.332	10.7	9.7	46	35.2	N
2.892	6.9	9.7	46	39	N
4.314	7.1	9.9	46	38.8	N
7.62	7	9.9	50	42.9	N
12.882	7.5	10.3	50	42.4	N
22.788	7.7	10.6	50	42.2	N

6.2 Radiated Emissions - FCC Section 15.209(Unintentional Radiation)

6.2.1 Test Methodology

ANSI C63.4 Sections 6 and 8 were the guiding documents for this evaluation. Radiated emissions tests were performed over the frequency range of 30MHz to 1000. Measurements of the radiated field strength were made at a distance of 3m from the boundary of the equipment under test (EUT) and the receiving antenna. The antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. Radiated measurements were made with the Spectrum Analyzer's resolution bandwidth set to 120KHz for measurements above 30MHz.

The EUT was caused to go into a "Receive Only" mode of operation for this test.

6.2.2 Test Results

Results of the test are given in Table 6.2.2-1 below:

Table 6.2.2-1: Radiated Emissions Tabulated Data(Unintentional Radiators)

Frequency (MHz)	Uncorrected Reading (dBµV)	Antenna Polarity (H/V)	Antenna Height (cm)	Turntable Position (°)	Total Correction Factor (dB)	Corrected Reading (dBµV)	Limit (dBµV)	Margin (dB)	Results
32.2	10	V	100	0	18.96	28.96	40	11.0	Pass
42.9	5	V	100	0	13.52	18.52	40	21.5	Pass
86	19	V	100	0	10.14	29.14	40	10.9	Pass
115.1	25.1	V	100	0	13.41	38.51	43.5	5.0	Pass
152.9	19	V	100	0	13.50	32.50	43.5	11.0	Pass
207.8	11	V	100	0	12.47	23.47	43.5	20.0	Pass
315.6	48.2	V	100	0	-10.39	37.81	46	8.2	Pass
479.4	24.58	V	100	0	-5.32	19.26	46	26.7	Pass
702.53	25.98	V	100	0	-0.64	25.34	46	20.7	Pass
926.7	26.8	V	100	0	1.79	28.59	46	17.4	Pass

6.3 Peak Output Power Requirement - FCC Section 2.1046 & 24.232

6.3.1 Test Methodology

TIA/EIA-603-A, section 2.2.1 was the guiding document for this evaluation. The EUT was caused to generate a CW signal and two tone carrier in each transmission mode on low middle and high channels in the band.

6.3.2 Test Results

Results are given in table's 6.3.2-1 and 6.3.2-2 below.

Table 6.3.2-1: Peak Output Power - Uplink

Transmission Mode	Frequency (MHz)	Output Power (dBm)
CW	1850	11.92
	1880	11.57
	1910	11.46
TDMA	1850	12.30
	1880	12.75
	1910	12.07
GSM	1850	8.23
	1880	8.16
	1910	8.13
CDMA	1850	0.34
	1880	0.31
	1910	4.98

Table 6.3.2-2: Peak Output Power - Downlink

Transmission Mode	Frequency (MHz)	Output Power (dBm)
CW	1930	-1.69
	1960	-0.92
	1990	-0.78
TDMA	1930	-0.94
	1960	-0.57
	1990	-0.26
GSM	1930	-4.13
	1960	-4.26
	1990	-4.54
CDMA	1930	-12.12
	1960	-12.18
	1990	-12.17

6.4 Occupied Bandwidth – FCC Section 2.1049

6.4.1 Test Methodology

TIA/EIA-603-A section 2.2.11 was the guiding document for this evaluation. The carrier signal was modulated with a signal equivalent to 16dB higher than the 50% modulation level. The test was repeated for each transmission mode and for uplink and downlink signal directions.

6.4.2 Test Results

Refer to Appendix C for plots.

Table 6.4.2-1: Occupied Bandwidth - Uplink

Transmission Mode	Frequency (MHz)	Bandwidth (kHz)	Appendix C Plot Number
TDMA	1850	33.25	67
	1880	33.25	70
	1910	33.5	73
GSM	1850	322.5	68
	1880	322.5	71
	1910	327.5	74
CDMA	1850	1430	69
	1880	1430	72
	1910	1440	75

Table 6.4.2-2: Peak Output Power - Downlink

Transmission Mode	Frequency (MHz)	Bandwidth (kHz)	Appendix C Plot Number
TDMA	1930	33.0	76
	1960	33.25	79
	1990	33.25	82
GSM	1930	322.5	77
	1960	327.5	80
	1990	325.0	83
CDMA	1930	1420	78
	1960	1420	81
	1990	1420	84

6.5 Spurious Emissions

6.5.1 RF Conducted Spurious Emissions – FCC Section 2.1051 & 24.238

6.5.1.1 Test Methodology

TIA/EIA-603-A was the guiding document for this evaluation. The EUT was investigated for conducted spurious emissions from 30MHz to 20GHz, 10 times the highest fundamental frequency. Each transmission mode, uplink and downlink, were investigated. For each measurement, the spectrum analyzer's VBW was set to 300kHz and the RBW was set to 1MHz.

6.5.1.2 Test Results

The limit for this test is determined by the formula $43+\log(P_{\text{watts}})$ or -13dBm. Refer to Appendix A and B for uplink and downlink plots respectively.

Table 6.5.1.2-1: Conducted Spurious Emissions

Transmission Mode	Frequency (MHz)	Conducted Power (dBm)
Uplink	1850	0.34
	1880	0.31
	1910	4.98
Downlink	1930	-12.12
	1960	-12.18
	1990	-12.17

Results: Pass

6.5.2 Radiated Spurious Emissions – FCC Section 2.1053 & 24.236

6.5.2.1 Test Methodology

ANSI C63.4 Section 13.1.4 was the guiding document for this evaluation. Radiated emissions tests were made over the frequency range of 30MHz to 20GHz, 10 times the highest fundamental frequency on the high mid and low channels.

The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. For frequencies below 1000MHz, quasi-peak measurements were made using a resolution bandwidth (RBW) of 120kHz and a video bandwidth (VBW) of 300kHz. For frequencies above 1000MHz, average measurements were made using an RBW of 1MHz and a VBW of 10Hz and peak measurements were made with RBW of 1MHz and a VBW of 1MHz.

6.5.2.2 Test Results

The limit for this test is determined by the formula $43+\log(P_{\text{watts}})$ or -13dBm = 94dBuV. Pre-scans to determine the worst case transmission modes were performed on all transmission modes for both uplink and downlink configurations. Based on these pre-scans, it was determined that the CDMA mode exhibited the worst case emissions. The final data reported in table 6.5.2.2-1 was taken in the CDMA mode and is representative of the two other modes.

Radiated spurious emissions found in the band of 30MHz to 20GHz are reported in Table 6.5.2.2-1. Plots of these emissions are also presented separately in Appendix D of this filing.

Table 6.5.2.2-1: Radiated Spurious Emissions

Frequency (MHz)	Level (dBuV)	Detector (P/A)	Antenna Polarity (H/V)	Turntable Position (o)	Correction Factors (dB)	Corrected Level (dBuV)	Limit (dBuV)	Margin (dB)
CDMA Mode Uplink Transmission Path – Low Channel								
3700	39.77	P	H	0	5.09	44.86	94	49.14
5550	42.13	P	H	0	9.82	51.95	94	42.05
CDMA Mode Uplink Transmission Path – Middle Channel								
3700	40.9	P	H	359	5.09	45.99	94	48.01
5550	43.05	P	H	359	9.82	52.87	94	41.13
CDMA Mode Uplink Transmission Path – High Channel								
3820	45.66	P	H	352	5.52	51.18	94	42.82
5730	43.4	P	H	352	9.82	53.22	94	40.78
CDMA Mode Downlink Transmission Path – Low Channel								
3860	41.3	P	H	349	5.6616	46.96	94	47.04
5790	40.48	P	H	358	9.82	50.3	94	43.70
7720	42.01	P	H	357	13.02	55.03	94	38.97
9650	42.31	P	H	360	12.96	55.27	94	38.73
CDMA Mode Downlink Transmission Path – Middle Channel								
5880	41.62	P	H	0	9.82	51.44	94	42.56
7840	42.34	P	H	2	13.02	55.36	94	38.64
CDMA Mode Uplink Transmission Path – High Channel								
5970	41.58	p	H	0	9.82	51.4	94	42.6
7960	42.49	p	H	0	13.02	55.51	94	38.49

6.5.2.3 Sample Calculation:

$$R_C = R_U + CF_T$$

Where:

- CF_T = Total Correction Factor (AF+CA+AG)-DC(Average Measurements Only)
- R_U = Uncorrected Reading
- R_C = Corrected Level
- AF = Antenna Factor
- CA = Cable Attenuation
- AG = Amplifier Gain
- DC = Duty Cycle Correction Factor

7.0 CONCLUSION

In the opinion of ACS, Inc. the Link2Cell Broadband PCS repeater, manufactured by EMS Wireless meets the relevant requirements of FCC Parts 2, 15 and 24.