

FCC part 15 testing for Grayhill Inc. Model: EZCom-IP

FCC ID: NMAEZCOMWL24IP
GRANTEE: Grayhill Inc.
561 Hillgrove Avenue
LaGrange, IL 60525-5997
FRN: 0004277307

TEST SITE: Grayhill Inc.
561 Hillgrove Avenue &
LaGrange, IL 60525-5997

FINAL TEST DATE: January 21st 2000
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TEST ENGINEER: Chris Anderson & Jack Steiner

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Operational Description

The EZCom-IP device is a 2.4GHz direct sequence spread spectrum radio for transport of TCP/IP information packets. The radio's intended use for the device is industrial telemetry. The device performs as an IP router and has a single Ethernet port for network connection. The device examines the destination address of each information packet it sees on either the radio port or the Ethernet port and decides to ignore, respond to or forward the packet.

The radio uses PSK modulation with a baseband symbol rate of 1 million symbols per second. To spread the power over frequency an 11 bit pseudo-random code is logical XOR'ed with each symbol. This gives an RF symbol rate of 11 million symbols per second. 11 chips per bit yields a theoretical processing gain of $10 \cdot \log(11/1) = 10.4\text{dB}$. 11 Msps assuming rectangular baseband pulses would yield a bandwidth of approximately 22MHz. The RF section of the device consists of dual conversion super heterodyne transmitter and receiver sections with a PIN diode attenuator for transmit power control. The device runs on 12VDC provided by an external AC-DC power supply running at 110VAC and delivering 12VDC at up to 2.5A. The device is manufactured by Phihong as model # PSA-30U-120P.

It is Grayhill's intent to sell the radio and antennas to end users though the use of a professional installer is highly recommended. Per 15.203 the antenna connector for the radio is a reverse polarity TNC style connector to ensure use of only approved antenna / cable assemblies.

List of Tested Antenna Configurations

- 1) Maxrad 8dBi omni-directional monopole antenna with 25 ft of Times Microwave LMR-400 coax with a loss of 1.8dB.
- 2) Maxrad 2dBi omni-directional monopole attached to the antenna connector of the radio.

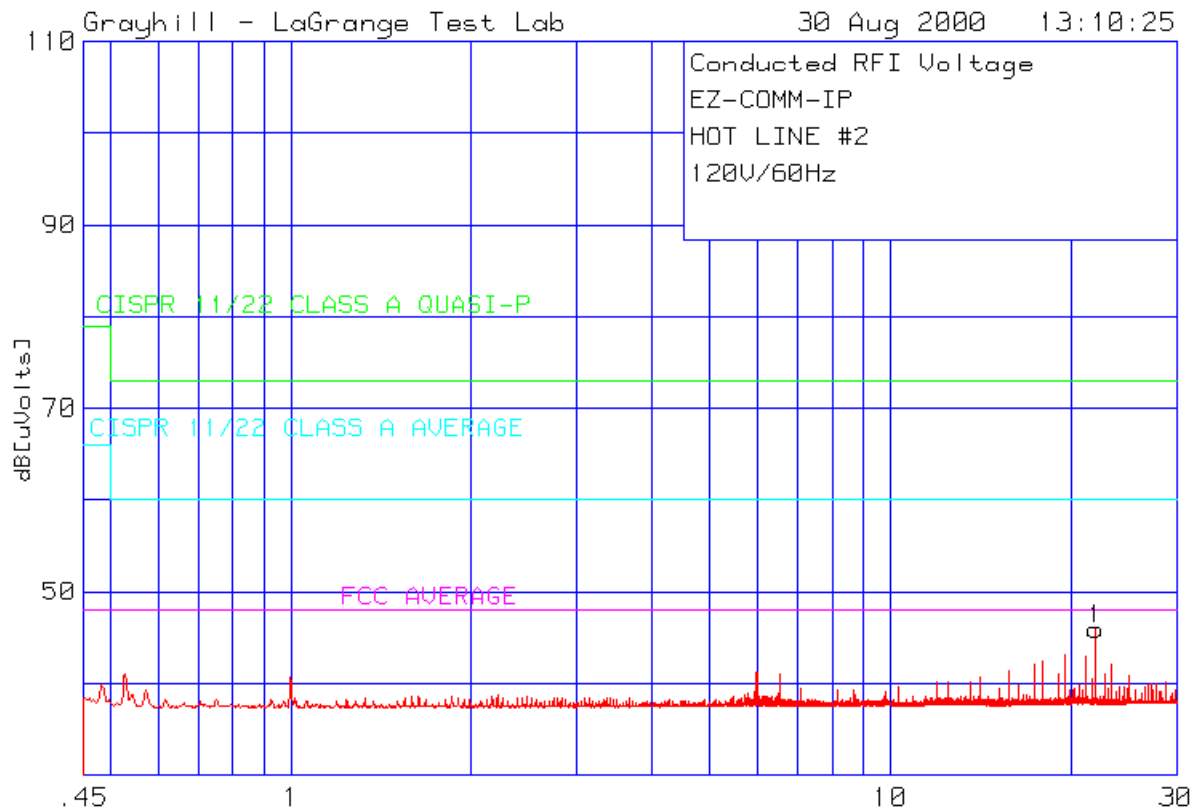
Antenna	Indoor/Outdoor	Cable loss	EIRP
8dBi	Outdoor-Fixed	1.8dB	33.4dBm
2dBi	Indoor-Fixed	0dB	27.4dBm

As the radio transmits 350 mW or 25.4dBm the listed antenna's gain of 8dBi brings ERP (neglecting coax loss) to 33.4dBm.

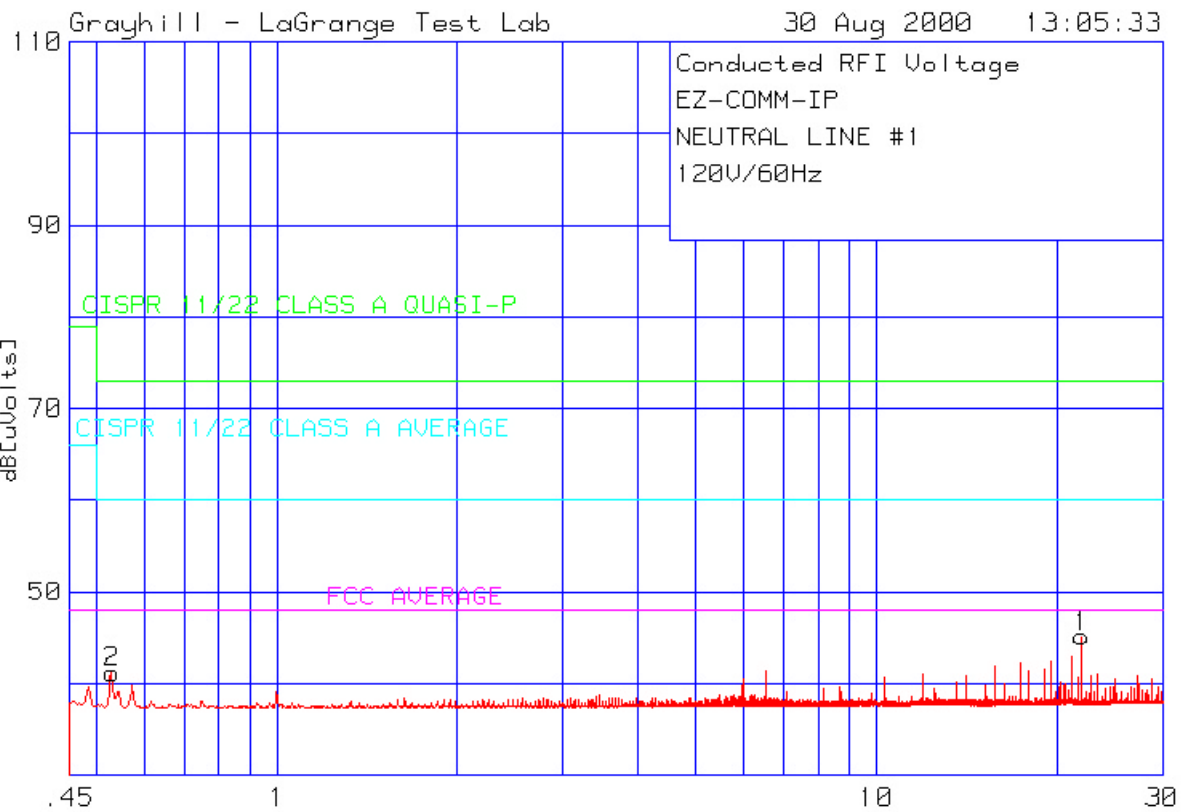
Test Summary

AC Conducted:	Pass	-15dB avg @.543MHz Neutral
6dB Bandwidth:	Pass	6dB BW => 7MHz
Output Power:	Pass	Peak of 25.4dBm @2.442GHz
Conducted Emissions:	Pass	Highest out of band signal was 42dB below fundamental.
Spectral Power Density:	Pass	Highest PSD in a 3kHz band averaged over 1 second was 6.72dBm.
Processing Gain:	Pass	81.2% of the data points yield 10dB or better.
Res. Band Emissions:	Pass	Highest restricted band emission was 270μV/meter @ 3 meters.

Conducted AC Emission Scan §15.207(a)



EZ-COMM-IP HOT LINE #2 120V/60Hz					
Marker #	Test Frequency (MHz)	Meter Reading (dB(uV))	Gain/Loss Factor (dB)	Transducer Factor (dB)	FCC Limit (dB(uV))
1	21.99933	35.59 avg	0.3	10	47.95

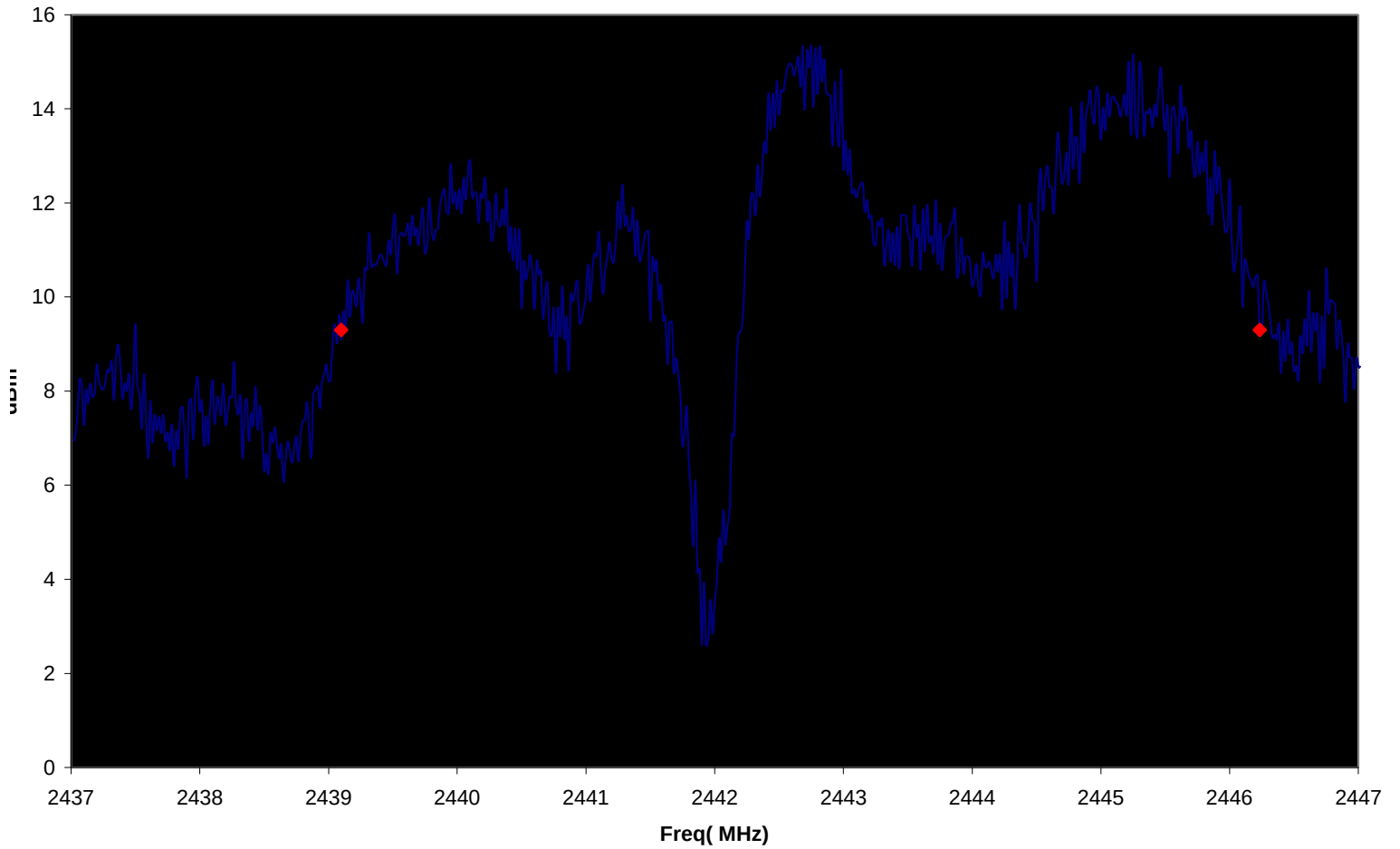


EZ-COMM-IP NEUTRAL LINE #1 120V/60Hz						
Marker #	Test Frequency	Meter Reading	Gain/Loss Factor	Transducer Factor	FCC Limit	
	(MHz)	(dB(uV))	(dB)	(dB)	(dB(uV))	
1	21.99933	34.81 avg	0.3	10	47.95	
2	0.52959	31.23 avg	0	10	47.95	

Certification and cal info?

6dB Bandwidth Verification §15.247(a)(2)

6dB Bandwidth Verification §15.247(a)(2)



The diamond markers are 7.1MHz apart at 9.3dBm. Taken with an HP8561E RBW=100KHz, span=10MHz, RL=+15dBm Att.= auto.

Conducted Output Power Measurement §15.247(b)(1)

This test was performed with an HP8900D and HP84811A power sensor with 20dB attenuator. The radio was placed in continuous transmit (100% duty cycle) mode for this test and no duty cycle compensation was used on the power meter. The powers shown include the loss of the attenuator.

2418MHz	25.44dBm
2442MHz	25.40dBm
2465MHz	25.48dBm

The radio has 255 levels of power control, with the highest level available to the user factory set with the above power meter to the levels shown. As such the levels above will be the highest levels available from the radio. The user has no means for adjusting the power calibration.

Conducted Emissions from the Antenna Port §15.247(c)

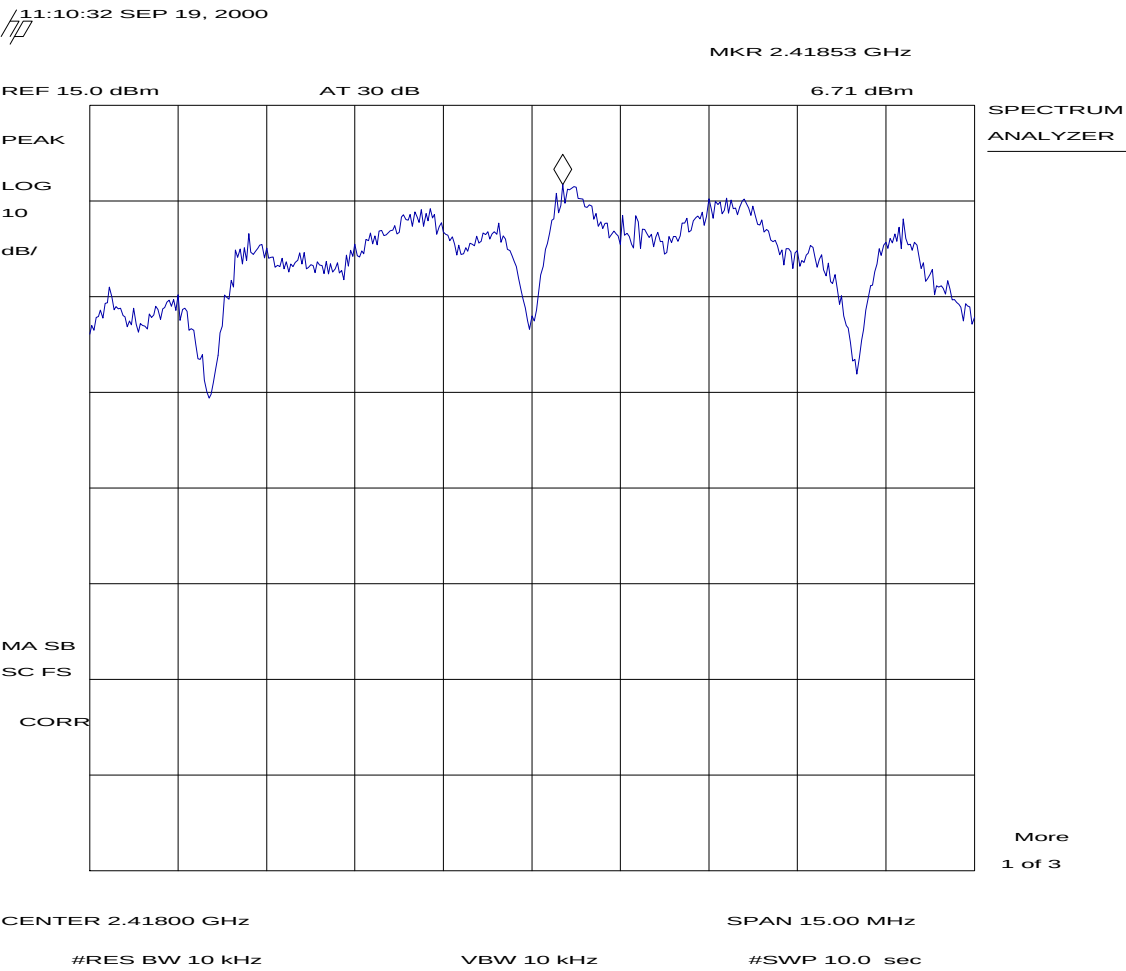
This test was performed at UL's Northbrook test facility by UL personnel. The graphs and data are attached.

COND SPURIOUS.GIF
COND SPURIOUS.TXT

Graph of conducted emissions from ant. port 1GHz to 25GHz.
Data for above.

Peak Power Spectral Density §15.247(d)

These measurements were taken using an HP8594E spectrum analyzer and HP EMP-441 power meter to ensure the output level was at the same as shown in the conducted output power measurement. For the max, mid and min frequency the first plot shows the 15MHz span centered on the channel. The second graph shows the 30kHz span with 3kHz RBW per 15.247(d). The marker in each graph is at the peak of the graph, with it's frequency and amplitude shown in the upper right of the plot.



11:10:51 SEP 19, 2000

MKR 2.41852500 GHz

REF 10.0 dBm

AT 20 dB

6.71 dBm

PEAK

LOG

2

dB/

MA SB

SC FS

CORR

SPECTRUM
ANALYZER

More
1 of 3

CENTER 2.41852500 GHz

SPAN 30.00 kHz

#RES BW 3.0 kHz

VBW 3 kHz

#SWP 10.0 sec

11:09:49 SEP 19, 2000

MKR 2.44268 GHz

REF 15.0 dBm

AT 30 dB

6.72 dBm

PEAK

LOG

10

dB/

MA SB

SC FS

CORR

SPECTRUM
ANALYZER

More
1 of 3

CENTER 2.44200 GHz

SPAN 15.00 MHz

#RES BW 10 kHz

VBW 10 kHz

#SWP 10.0 sec

11:10:08 SEP 19, 2000

MKR 2.44267500 GHz

REF 10.0 dBm

AT 20 dB

6.72 dBm

SPECTRUM
ANALYZER

PEAK

LOG

2

dB/

MA SB

SC FS

CORR

More

1 of 3

CENTER 2.44267500 GHz

SPAN 30.00 kHz

#RES BW 3.0 kHz

VBW 3 kHz

#SWP 10.0 sec

11:09:06 SEP 19, 2000

MKR 2.46571 GHz

REF 15.0 dBm

AT 30 dB

6.07 dBm

PEAK

LOG

10

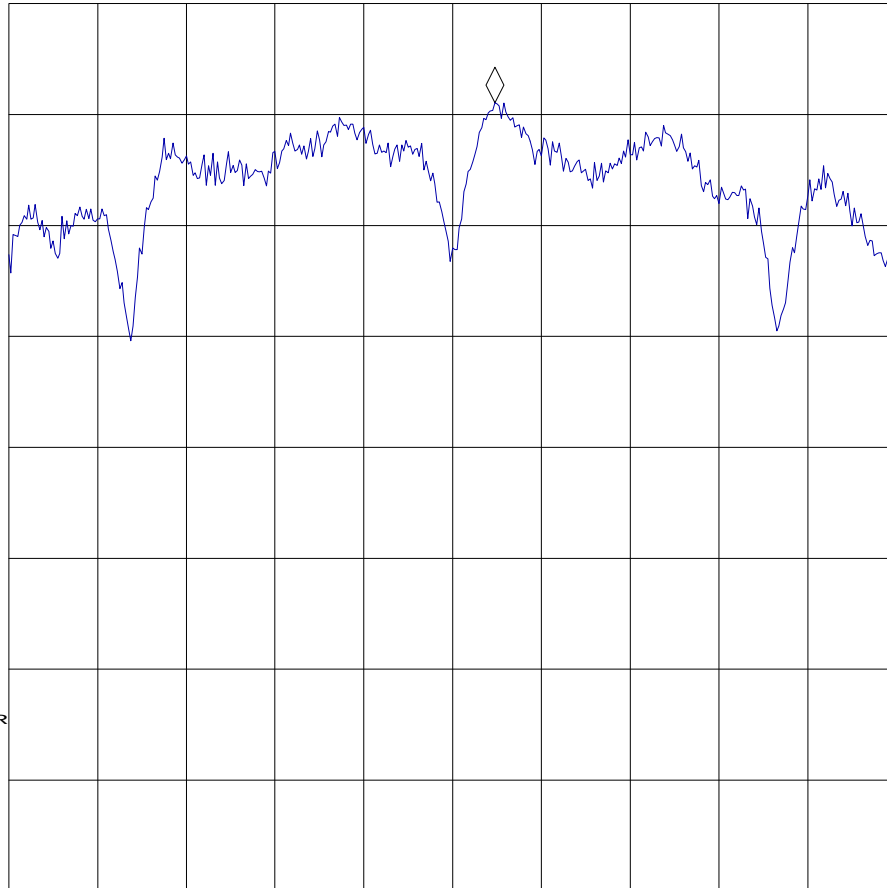
dB/

MA SB

SC FS

CORR

SPECTRUM
ANALYZER



More
1 of 3

CENTER 2.46500 GHz

SPAN 15.00 MHz

#RES BW 10 kHz

VBW 10 kHz

#SWP 10.0 sec

11:09:24 SEP 19, 2000

MKR 2.46571250 GHz

REF 10.0 dBm

AT 20 dB

6.07 dBm

SPECTRUM
ANALYZER

PEAK

LOG

2

dB/

MA SB

SC FS

CORR

More
1 of 3

CENTER 2.46571250 GHz

SPAN 30.00 kHz

#RES BW 3.0 kHz

VBW 3 kHz

#SWP 10.0 sec

Processing Gain §15.247(e)

Data points were taken across the 17MHz 3dB bandwidth of the radio's IF filter. This produced 340 data points, 64 of which showed processing gain including a system loss of 2dB greater than the 10dB requirement. Dropping the lowest 20% of the data points, all remaining data passes so the device passes.

2422525	17.90778
2422575	17.77856
2422625	17.27934
2422675	17.34011
2422725	16.86089
2422775	16.57167
2422825	16.15245
2422875	16.34323
2422925	15.874
2422975	15.23478
2423025	15.47556
2423075	15.67634
2423125	15.46712
2423175	15.31789
2423225	15.53867
2423275	15.39945
2423325	15.29023
2423375	15.33101
2423425	15.62178
2423475	14.86256
2423525	15.21334
2423575	14.92412
2423625	14.8149
2423675	14.85567
2423725	14.41645
2423775	14.41723
2423825	14.49801
2423875	14.60879
2423925	15.04956
2423975	14.13034
2424025	15.30112
2424075	15.9419
2424125	15.47268
2424175	15.65345
2424225	15.40423
2424275	15.75501
2424325	15.51579
2424375	15.83657
2424425	16.10734
2424475	15.28812
2424525	15.8989
2424575	15.57968
2424625	15.35046
2424675	15.31123
2424725	14.71201
2424775	14.55279
2424825	14.39357
2424875	14.22435
2424925	14.10512
2424975	13.0159
2425025	14.16668
2425075	14.19746

2425125	14.53824
2425175	14.30901
2425225	14.61979
2425275	14.77057
2425325	14.69135
2425375	14.82213
2425425	14.5729
2425475	13.61368
2425525	14.00446
2425575	13.78524
2425625	13.52602
2425675	13.20679
2425725	12.90757
2425775	13.43835
2425825	12.59913
2425875	12.13991
2425925	10.98068
2425975	9.581462
2426025	10.30224
2426075	9.813018
2426125	9.773796
2426175	10.79457
2426225	10.11535
2426275	10.00613
2426325	9.956908
2426375	10.54769
2426425	12.15846
2426475	10.29924
2426525	11.62002
2426575	11.0408
2426625	11.09158
2426675	11.78235
2426725	12.27313
2426775	11.24391
2426825	12.78469
2426875	12.52547
2426925	11.72624
2426975	10.62702
2427025	11.7378
2427075	11.68858
2427125	11.78936
2427175	11.94013
2427225	11.80091
2427275	11.73169
2427325	12.30247
2427375	12.31325
2427425	12.55402
2427475	12.4048
2427525	12.74558
2427575	12.52636
2427625	12.39714
2427675	12.42791
2427725	11.81869
2427775	13.51947
2427825	11.21025
2427875	11.17103
2427925	10.4218
2427975	10.51258

2428025	9.86336
2428075	9.604138
2428125	9.544916
2428175	8.875694
2428225	10.02647
2428275	8.42725
2428325	8.998028
2428375	7.988806
2428425	7.939584
2428475	10.77036
2428525	8.17114
2428575	7.231918
2428625	8.322696
2428675	8.323474
2428725	8.844252
2428775	8.90503
2428825	12.61581
2428875	9.586586
2428925	9.897364
2428975	9.488142
2429025	13.19892
2429075	12.3897
2429125	9.370476
2429175	10.84125
2429225	10.95203
2429275	11.34281
2429325	11.60359
2429375	13.25437
2429425	12.92514
2429475	12.13592
2429525	13.7967
2429575	14.90748
2429625	15.11826
2429675	13.75903
2429725	15.61981
2429775	15.01059
2429825	14.52137
2429875	14.43215
2429925	14.49292
2429975	14.1237
2430025	15.75448
2430075	14.23526
2430125	14.40604
2430175	12.86681
2430225	12.14759
2430275	13.13837
2430325	13.92915
2430375	11.87993
2430425	12.2207
2430475	11.64148
2430525	12.53226
2430575	14.41304
2430625	13.63382
2430675	12.73459
2430725	10.88537
2430775	10.29615
2430825	9.856928
2430875	10.06771

2430925	10.21848
2430975	10.68926
2431025	9.33004
2431075	8.590818
2431125	7.301596
2431175	7.212374
2431225	5.843152
2431275	9.22393
2431325	6.534708
2431375	6.375486
2431425	6.316264
2431475	5.297042
2431525	6.57782
2431575	8.348598
2431625	9.759376
2431675	-2.85985
2431725	11.04093
2431775	7.88171
2431825	11.90249
2431875	10.03327
2431925	9.564044
2431975	8.774822
2432025	11.6256
2432075	10.92638
2432125	11.54716
2432175	10.61793
2432225	13.07871
2432275	13.32949
2432325	12.22027
2432375	11.81105
2432425	12.38182
2432475	11.8726
2432525	12.70338
2432575	12.47416
2432625	12.42494
2432675	11.51571
2432725	12.40649
2432775	12.45727
2432825	12.77805
2432875	15.37883
2432925	12.7796
2432975	11.76038
2433025	12.65116
2433075	12.43194
2433125	12.71272
2433175	12.30349
2433225	11.36427
2433275	12.77505
2433325	11.65583
2433375	11.68661
2433425	11.56738
2433475	10.30816
2433525	11.03894
2433575	10.19972
2433625	11.0705
2433675	9.601274
2433725	10.59205
2433775	9.08283

2433825	8.433608
2433875	8.324386
2433925	8.995164
2433975	6.985942
2434025	8.64672
2434075	8.527498
2434125	7.838276
2434175	11.48905
2434225	11.30983
2434275	8.28061
2434325	9.331388
2434375	8.632166
2434425	8.592944
2434475	8.303722
2434525	9.5045
2434575	11.33528
2434625	9.626056
2434675	9.866834
2434725	9.987612
2434775	10.31839
2434825	10.58917
2434875	11.20995
2434925	11.66072
2434975	11.4815
2435025	12.50228
2435075	12.93306
2435125	13.01384
2435175	13.42461
2435225	13.68539
2435275	12.81617
2435325	14.26695
2435375	13.15773
2435425	15.2185
2435475	14.39928
2435525	15.36006
2435575	14.60084
2435625	15.61162
2435675	7.062394
2435725	14.24317
2435775	14.12395
2435825	13.77473
2435875	14.79551
2435925	14.91628
2435975	13.01706
2436025	14.07784
2436075	14.64862
2436125	14.1394
2436175	13.97017
2436225	14.59095
2436275	13.91173
2436325	13.70251
2436375	13.64329
2436425	14.18406
2436475	13.37484
2436525	13.65562
2436575	14.0764
2436625	13.10718
2436675	12.23795

2436725	11.31873
2436775	10.75951
2436825	10.74029
2436875	10.49107
2436925	9.771844
2436975	8.492622
2437025	9.2834
2437075	9.854178
2437125	11.16496
2437175	9.945734
2437225	11.39651
2437275	10.23729
2437325	10.21807
2437375	12.73885
2437425	11.72962
2437475	11.3504
2437525	13.02118
2437575	12.88196
2437625	14.16274
2437675	12.98351
2437725	13.22429
2437775	13.41507
2437825	13.17585
2437875	13.90663
2437925	14.2274
2437975	13.87818
2438025	16.06896
2438075	14.82974
2438125	15.14052
2438175	14.54129
2438225	15.21207
2438275	15.38285
2438325	16.05363
2438375	15.92441
2438425	16.60518
2438475	15.44596
2438525	16.66674
2438575	16.72752
2438625	16.9683
2438675	16.29907
2438725	16.80985
2438775	17.08063
2438825	16.49141
2438875	16.82219
2438925	16.50296
2438975	16.24374
2439025	16.68452
2439075	16.5553
2439125	17.08608
2439175	16.92685
2439225	16.43763
2439275	16.42841
2439325	16.28919
2439375	16.33997
2439425	16.67074
2439475	17.04152

Radiated Emissions for a Class A Digital Device

30MHz-1000MHz

This test was performed at UL's Northbrook test facility by UL personnel. The test was performed with the radio not transmitting and an Axis 2100 digital camera sending streaming image data to the radio as a traffic generator. No conducted emissions data for the power supply against FCC class A required as the Conducted AC Emissions Scan showed we below the limits for a class B device.

The data is given in the attached UL report.

Radiated Emissions in Restricted Bands 30MHz – 25GHz §15.247(c), 15.209(a)

This test was performed at UL's Northbrook test facility by UL personnel. All data is given in the attached UL test report.