



www.nemko.com

Nemko Canada Inc., 303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Report number: 141817-1TRFWL

Apparatus: Calamp Sentry 4G

Applicant: Calamp Corporation
200-5500 avenue Royalmount
Mont-Royal, QC
Canada H4P 1H7

FCC ID: EOT-140919300

Test specification:

Title 47-Telecommunication

Chapter I - Federal Communications Commission

Subchapter A - General

Part 15 - Radio Frequency Devices

Subpart C - Intentional Radiators

- **§15.247- Operation within the bands 902–928 MHz, 2400–2483.5 MHz and 5725–5850 MHz**

Reviewed by: Kevin Ma
Signature
Kevin Ma, Wireless/EMC Specialist

February 25, 2010
Date

Tested by: Andrey Adelberg, Senior Wireless/EMC Specialist

Nemko Canada Inc. authorizes the applicant to reproduce this report provided it is reproduced in its entirety and for use by the company's employees only. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

Nemko Canada Inc. accepts no responsibility for damages, if any suffered by any third party as a result of decisions made or actions based on this report.

This report shall not be reproduced except in full without the written approval of the testing laboratory.



Nemko Canada Inc., a testing laboratory, is accredited by the Standards Council of Canada.

The tests included in this report are within the scope of this accreditation.



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Table of contents

Section 1: Report summary	3
Section 2: Equipment under test	4
2.1 Identification of equipment under test (EUT)	4
2.2 Accessories and support equipment	4
2.3 EUT description	5
2.4 Technical specifications of the EUT	5
2.5 EUT setup diagram.....	6
2.6 Operation of the EUT during testing	6
2.7 Modifications incorporated in the EUT.....	6
Section 3: Test conditions	7
3.1 Deviations from laboratory tests procedures	7
3.2 Test conditions, power source and ambient temperatures.....	7
3.3 Measurement uncertainty	8
3.4 Test equipment.....	8
Section 4: Result summary	9
4.1 FCC Part 15 Subpart C, 15.247: Test results.....	9
Appendix A: Test results	10
Clause 15.31(e) Variation of the power source	10
Clause 15.31(m) Number of operating frequencies	11
Clause 15.203 Antenna requirement.....	12
Clause 15.207(a) Conducted limits	13
Clause 15.111 Antenna power conduction limits for receivers.....	17
Clause 15.247(a)(2) Minimum 6 dB bandwidth for digital modulation systems.....	19
Clause 15.247(b)(3) and (4) Maximum peak conducted output power for systems using digital modulation.....	22
Clause 15.247(d) Spurious emissions.....	30
Clause 15.247(e) Power spectral density.....	36
Appendix B: Block diagrams of test set-ups.....	39



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Section 1: Report summary

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Section 1: Report summary

This report contains an assessment of apparatus against specifications based upon tests carried out on samples submitted at Nemko Canada Inc.

These tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 15; Subpart C. Radiated tests were conducted in accordance with ANSI C63.4-2003.

Test specification:

FCC Part 15 Subpart C, 15.247

Operation within the bands 902–928 MHz, 2400–2483.5 MHz and 5725–5850 MHz.

Compliance status:	Complies
Exclusions:	None
Non-compliances:	None
Report release history:	Original release
Test location:	Nemko Canada Inc. 303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2
Registration number:	176392 (3 m Semi anechoic chamber)

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contained in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

Nemko Canada Inc. authorizes the applicant to reproduce this report provided it is reproduced in its entirety and for use by the company's employees only.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Nemko Canada Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Section 2: Equipment under test

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Section 2: Equipment under test

2.1 Identification of equipment under test (EUT)

The following information identifies the EUT under test:

Type of equipment:	Wireless 802.16e router
Product marketing name:	CalAmp
Brand name:	Sentry 4G
Model number:	140-9193
Serial number:	000002
Nemko sample number:	1
FCC ID:	EOT-140919300
Date of receipt:	January 5, 2010

2.2 Accessories and support equipment

The following information identifies accessories used to exercise the EUT during testing:

Item # 1

Type of equipment:	WWAN antenna
Brand name:	PCTEL
Model name or number:	MAX9105
Nemko sample number:	10, 11
Connection port:	TNC
Cable length and type:	5.2 m

Item # 2

Type of equipment:	WiFi antenna
Brand name:	PCTEL
Model name or number:	2.4Mobile-3
Nemko sample number:	6, 7
Connection port:	Reversed SMA
Cable length and type:	5.2 m

Item # 3

Type of equipment:	GPS antenna
Brand name:	PCTEL
Model name or number:	3226MSMA
Nemko sample number:	5
Connection port:	SMA
Cable length and type:	5.2 m



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Section 2: Equipment under test

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Section 2: Equipment under test, continued

2.3 EUT description

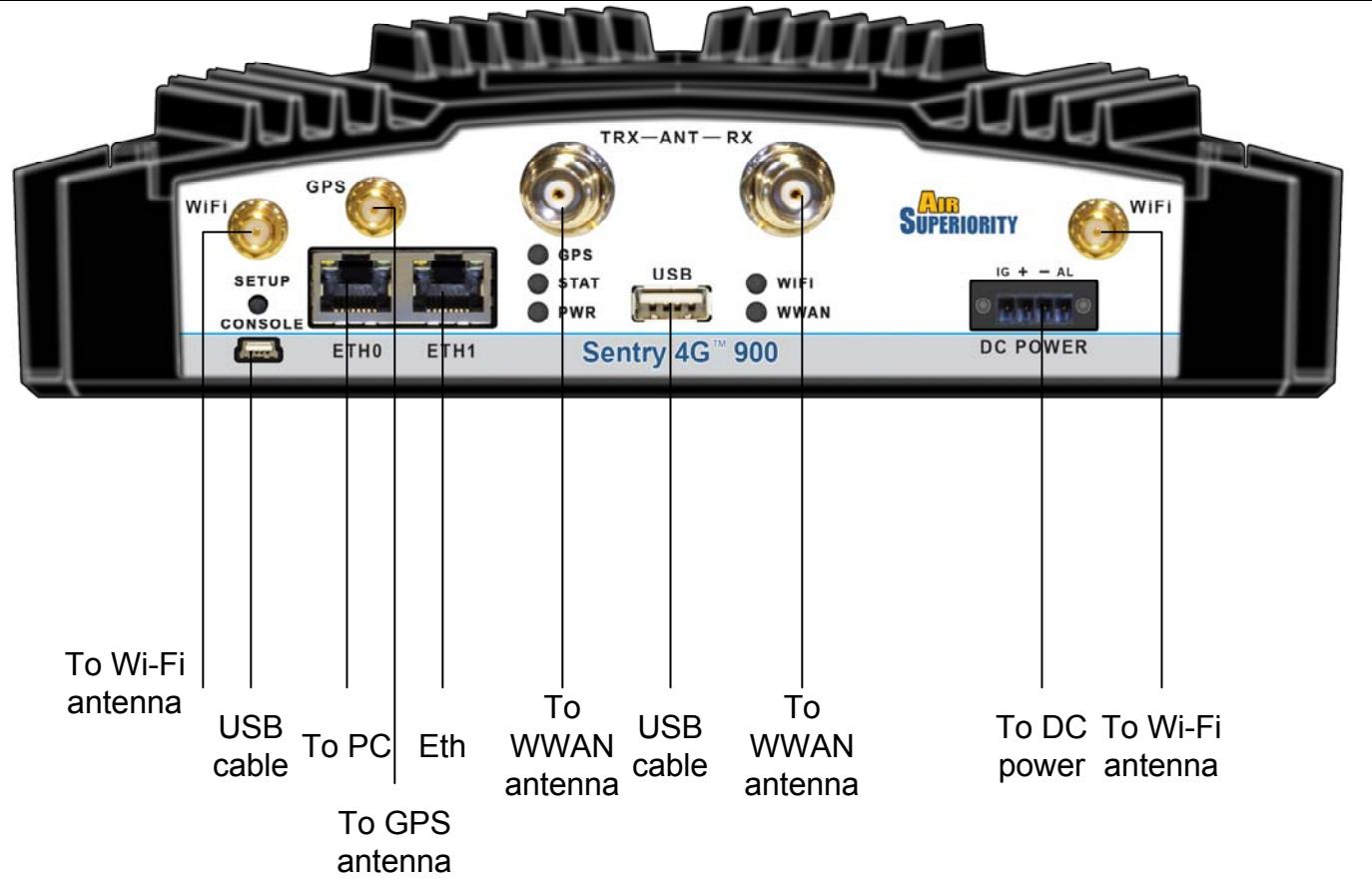
The Sentry 4G-900 is a broadband router operating in the 900 MHz ISM band. It is aimed at industrial, monitoring and control market as well as mobile public safety market. The WWAN interface is provided through a 802.16e-2005 interface. A WiFi option allows a second wireless interface.

2.4 Technical specifications of the EUT

Operating band:	902–928 MHz
Operating frequency:	903.75–926.25 MHz (3.5 MHz channel) 904.50–925.50 MHz (5 MHz channel) 905.50–924.50 MHz (7 MHz channel) 907.00–923.00 MHz (10 MHz channel)
Modulation type:	QPSK, 16-QAM, 64-QAM
Channel spacing:	3.5 MHz; 5 MHz; 7 MHz; 10 MHz
99 % bandwidth:	3.221 MHz (3.5 MHz channel) 4.471 MHz (5 MHz channel) 6.514 MHz (7 MHz channel) 9.103 MHz (10 MHz channel)
Emission designator:	3M22W7D (3.5 MHz channel) 4M47W7D (5 MHz channel) 6M51W7D (7 MHz channel) 9M10W7D (10 MHz channel)
Antenna data:	5 dBd
Antenna type:	External Antenna Removable antenna supplied and type tested with the radio equipment (Equipment that has an external 50 Ω RF connector)
Power source	10–30 VDC from DC

Section 2: Equipment under test, continued

2.5 EUT setup diagram



2.6 Operation of the EUT during testing

The EUT was controlled from PC with Telnet session.

2.7 Modifications incorporated in the EUT

There were no modifications performed to the EUT during this assessment.



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Section 3: Test conditions

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Section 3: Test conditions

3.1 Deviations from laboratory tests procedures

No deviations were made from laboratory test procedures.

3.2 Test conditions, power source and ambient temperatures

Normal temperature, humidity and air pressure test conditions	Temperature: 15–30 °C Relative humidity: 20–75 % Air pressure: 86–106 kPa When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.
Power supply range:	The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages $\pm 5\%$, for which the equipment was designed.



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Section 3: Test conditions
Report Number: 141817-1TRFWL
Specification: FCC 15.247

Section 3: Test conditions, continued

3.3 Measurement uncertainty

Nemko Canada measurement uncertainty has been calculated using guidance of UKAS LAB 34:2003 and TIA-603-B Nov 7, 2002. All calculations have been performed to provide a confidence level of 95 % and can be found in Nemko Canada document MU-003.

3.4 Test equipment

Equipment	Manufacturer	Model No.	Asset/Serial No.	Next cal.
3 m EMI Test Chamber	TDK	SAC-3	FA002047	May 06/10
Flush Mount Turntable	Sunol	FM2022	FA002082	NCR
Bilog	Sunol	JB3	FA002108	Jan. 18/11
Controller	Sunol	SC104V	FA002060	NCR
Mast	Sunol	TLT2	FA002061	NCR
Receiver/Spectrum Analyzer	Rohde & Schwarz	ESU 26	FA002043	Dec. 16/09
Receiver/Spectrum Analyzer	Rohde & Schwarz	ESU 40	FA002071	Nov. 30/10
Horn Antenna #1	EMCO	3115	FA000649	Feb 9/10
1 – 18 GHz Amplifier	JCA	JCA118-503	FA002091	Oct 07/10

Note: N/A = Not Applicable, NCR = No Cal Required, COU = CAL On Use



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Section 4: Result summary

Report Number: 141817-1TRFWL

Specification: FCC Part 15.247

Section 4: Result summary

4.1 FCC Part 15 Subpart C, 15.247: Test results

The column headed 'Required' indicates whether the associated clauses were invoked for the apparatus under test. The following abbreviations are used:

N	No : not applicable / not relevant.
Y	Yes : Mandatory i.e. the apparatus shall conform to these tests.
N/T	Not Tested, mandatory but not assessed. (See report summary)

Part	Test description	Required	Result
General requirements for FCC Part 15			
§15.31(e)	Variation of power source	Y	Pass
§15.31(m)	Number of operating frequencies	Y	Pass
§15.203	Antenna requirement	Y	Pass
§15.111	Antenna power conduction limits for receivers	Y	Pass
§15.207(a)	Conducted limits	Y	Pass
Specific requirements for FCC Part 15 Subpart C, 15.247			
§15.247(a)(1)	Frequency hopping systems	---	---
§15.247(a)(1)(i)	Frequency hopping systems operating in the 902–928 MHz band	N	
§15.247(a)(1)(ii)	Frequency hopping systems operating in the 5725–5850 MHz band	N	
§15.247(a)(1)(iii)	Frequency hopping systems operating in the 2400–2483.5 MHz band	N	
§15.247(a)(2)	Minimum 6 dB bandwidth for digital modulation systems	Y	Pass
§15.247(b)(1)	Maximum peak output power of Frequency hopping systems operating in the 2400–2483.5 MHz band and 5725–5850 MHz band	N	
§15.247(b)(2)	Maximum peak output power of Frequency hopping systems operating in the 902–928 MHz band	N	
§15.247(b)(3)	Maximum peak output power of systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands	Y	Pass
§15.247(b)(4)	Maximum peak output power	Y	Pass
§15.247(c)(1)	Fixed point-to-point Operation with directional antenna gains greater than 6 dBi	N	
§15.247(c)(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	N	
§15.247(d)	Spurious emissions	Y	Pass
Notes: None			



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Appendix A: Test results

Clause 15.31(e) Variation of the power source

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85 % and 115 % of the nominal rated supply voltage. For battery-operated equipment, the equipment tests shall be performed using a new battery.

Test date: January 12, 2010

Test results: Pass

Test data

- Transmit output power was measured while supply voltage was varied from 8.5 VDC to 34.5 VDC (85 % to 115 % of the nominal rated supply voltage).
- No change in transmit output power was observed.



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Clause 15.31(m) Number of operating frequencies

Measurements on intentional radiators or receivers, other than TV broadcast receivers, shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table:

Frequency range over which device operates	Number of frequencies	Location in the range of operation
1 MHz and less	1	Middle
1 to 10 MHz	2	1 near top and 1 near bottom
More than 10 MHz	3	1 near top, 1 near middle and 1 near bottom

Test date: January 12, 2010

Test results: Pass

Test data

The frequency band is 26 MHz therefore number of testing frequencies is as follows:

3.5 MHz channel:

Low frequency / channel	903.75 MHz
Mid frequency / channel	915.00 MHz
High frequency / channel	926.25 MHz

10 MHz channel:

Low frequency / channel	907 MHz
High frequency / channel	923 MHz

Lowest and highest channel bandwidths have been chosen to show compliance with output power, PSD and spurious emissions requirements. 5 and 7 MHz channels' results are within 3.5 and 10 MHz measurement results' range.

Clause 15.203 Antenna requirement

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

Test date: January 28, 2010

Test results: Pass

Test data

- The EUT is professionally installed.

Detailed photo of RF connector





Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Clause 15.207(a) Conducted limits

An intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of emission (MHz)	Conducted limit (dB μ V)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

*-Decreases with the logarithm of the frequency.

Test date: February 24, 2010

Test results: Pass

Special notes

Port under test: AC Mains port of external power supply.

Preview measurements:

0.15 MHz to 30 MHz

Receiver settings:

- Peak and average detector
- 9 kHz RBW

– Spectral plots have been corrected for transducer factors; cable loss, LISN, and attenuators.

– Emissions detected within 6 dB of limit were re-measured with a quasi peak or average detector for a final measurement.

Final measurement:

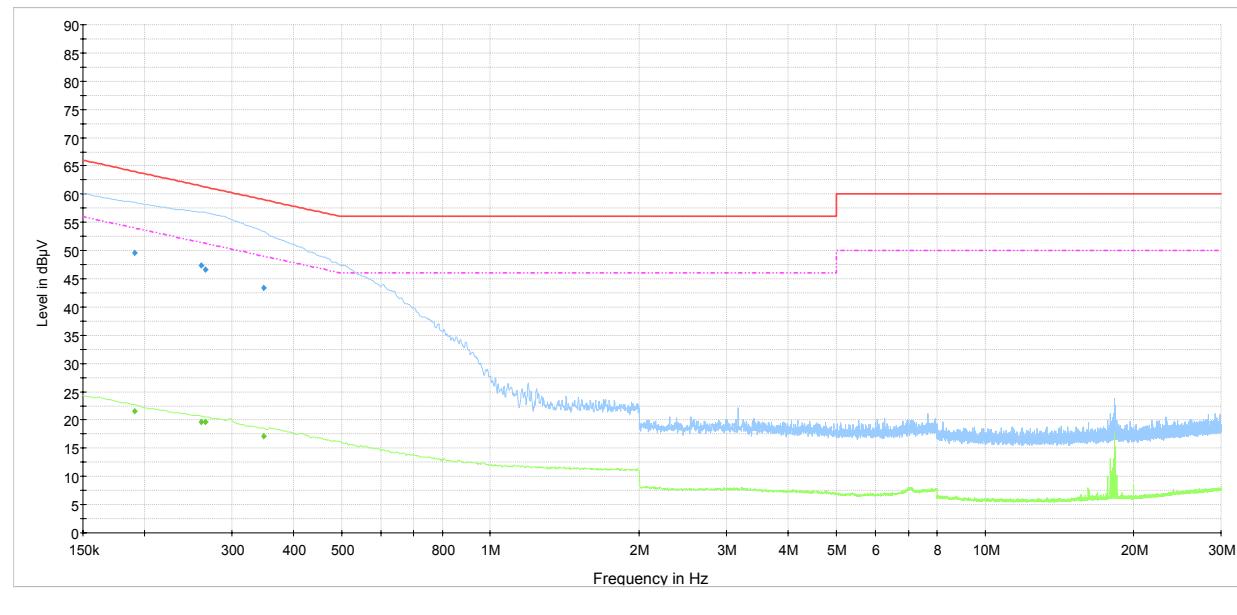
0.15 MHz to 30 MHz

Receiver settings:

- Q-Peak and average detector
- 9 kHz RBW

Clause 15.207(a) Conducted limits, continued

Test data



Conducted emissions on phase line
 CISPR 22 Mains QP Class B LimitLine
 CISPR 22 Mains AV Class B LimitLine
 Preview Result 1
 Preview Result 2
 Final Result 1
 Final Result 2

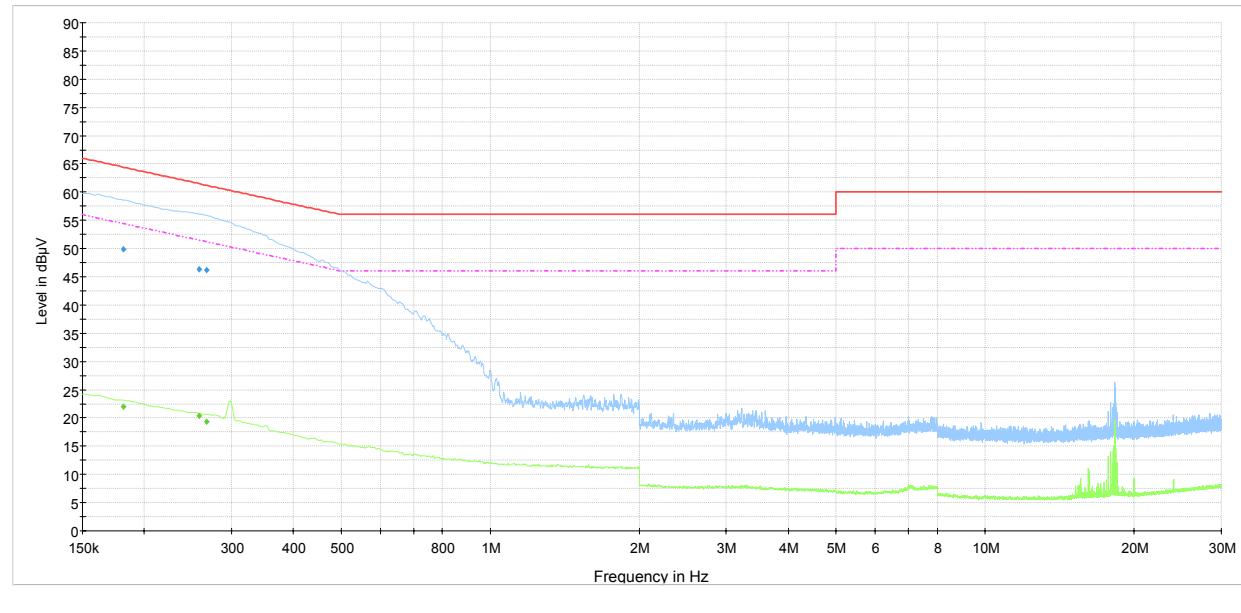
Tabular data

Frequency (MHz)	Q-Peak result (dB μ V)	Meas. time (ms)	Bandwidth (kHz)	Filter	Conductor	Correction (dB)	Margin (dB)	Limit (dB μ V)
0.190500	49.5	100.0	9.000	On	L1	10.2	14.5	64.0
0.260250	47.3	100.0	9.000	On	L1	10.0	14.1	61.4
0.264750	46.7	100.0	9.000	On	L1	10.0	14.6	61.3
0.348000	43.4	100.0	9.000	On	L1	10.0	15.6	59.0
Frequency (MHz)	Average result (dB μ V)	Meas. time (ms)	Bandwidth (kHz)	Filter	Conductor	Correction (dB)	Margin (dB)	Limit (dB μ V)
0.190500	21.6	100.0	9.000	On	L1	10.2	32.4	54.0
0.260250	19.7	100.0	9.000	On	L1	10.0	31.7	51.4
0.264750	19.6	100.0	9.000	On	L1	10.0	31.7	51.3
0.348000	17.1	100.0	9.000	On	L1	10.0	31.9	49.0

Note: Correction factor includes cable loss, LISN, and attenuator.

Clause 15.207(a) Conducted limits, continued

Test data, continued



Tabular data

Frequency (MHz)	Q-Peak result (dB μ V)	Meas. time (ms)	Bandwidth (kHz)	Filter	Conductor	Correction (dB)	Margin (dB)	Limit (dB μ V)
0.181500	49.8	100.0	9.000	On	N	10.2	14.6	64.4
0.258000	46.4	100.0	9.000	On	N	10.0	15.1	61.5
0.267000	46.1	100.0	9.000	On	N	10.0	15.1	61.2
Frequency (MHz)	Average result (dB μ V)	Meas. time (ms)	Bandwidth (kHz)	Filter	Conductor	Correction (dB)	Margin (dB)	Limit (dB μ V)
0.181500	22.0	100.0	9.000	On	N	10.2	32.4	54.4
0.258000	20.4	100.0	9.000	On	N	10.0	31.1	51.5
0.267000	19.4	100.0	9.000	On	N	10.0	31.8	51.2

Note: Correction factor includes cable loss, LISN, and attenuator.



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Clause 15.207(a) Conducted limits, continued

Set up photo





Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Clause 15.111 Antenna power conduction limits for receivers

(a) In addition to the radiated emission limits, receivers that operate (tune) in the frequency range 30 to 960 MHz and CB receivers that provide terminals for the connection of an external receiving antenna may be tested to demonstrate compliance with the provisions of §15.109 with the antenna terminals shielded and terminated with a resistive termination equal to the impedance specified for the antenna, provided these receivers also comply with the following: With the receiver antenna terminal connected to a resistive termination equal to the impedance specified or employed for the antenna, the power at the antenna terminal at any frequency within the range of measurements specified in §15.33 shall not exceed 2.0 nW.

(b) CB receivers and receivers that operate (tune) in the frequency range 30 to 960 MHz that are provided only with a permanently attached antenna shall comply with the radiated emission limitations in this part, as measured with the antenna attached.

Test date: February 1, 2010

Test results: Pass

Test data

The test was performed with the correlation with the RSS-Gen requirements.

The test was performed using a peak detector with 100 kHz RBW.

Where applicable measurements were performed using a peak detector with 3 kHz RBW. The bandwidth correction factor of

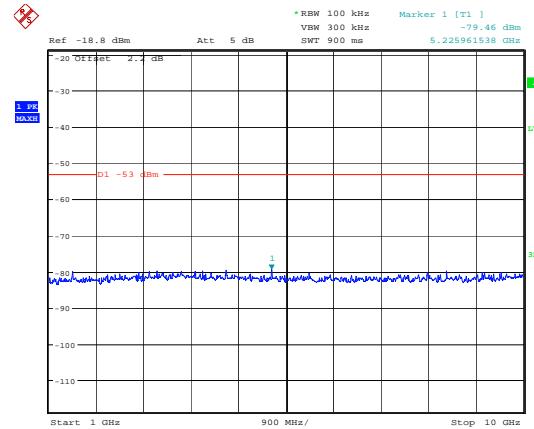
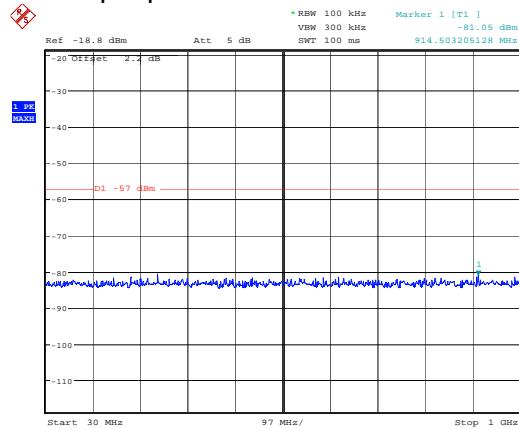
$10 \times \log_{10} \left(\frac{4 \text{ kHz}}{3 \text{ kHz}} \right) = 1.24 \text{ dB}$ was added to the result in order to compensate the lower RBW than required.

Only worst case results presented.

Clause 15.111 Antenna power conduction limits for receivers, continued

Test data

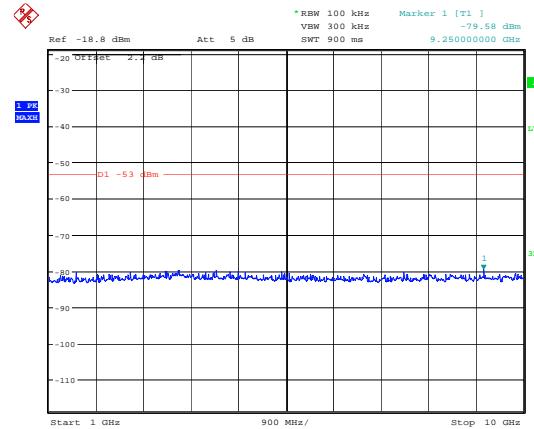
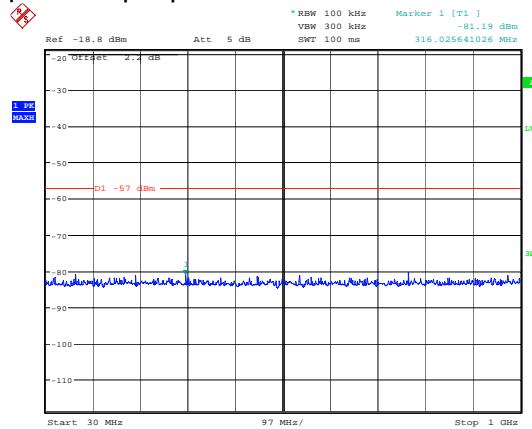
Rx port sample plots on middle channel:



Date: 1.FEB.2010 09:36:53

Date: 1.FEB.2010 09:37:48

TRX port sample plots on middle channel:



Date: 1.FEB.2010 09:39:20

Date: 1.FEB.2010 09:38:50



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Clause 15.247(a)(2) Minimum 6 dB bandwidth for digital modulation systems

Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

Test date: January 12, 2010

Test results: Pass

Special notes

- The peak detector was used with 100 kHz/300 kHz RBW/VBW
- The span was wider than RBW.



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Clause 15.247(a)(2) Minimum 6 dB bandwidth for digital modulation systems, continued

Test data

Occupied bandwidth measurement

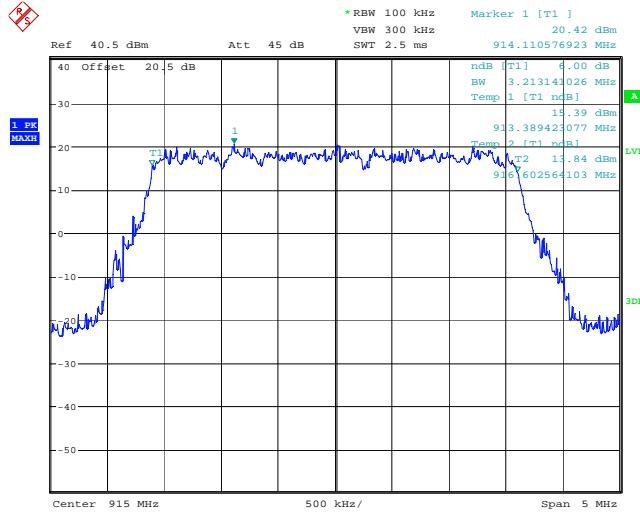
Frequency, MHz	6 dB bandwidth, MHz	Limit, MHz	Margin, MHz
3.5 MHz channel			
QPSK			
903.75	3.197	0.5	2.697
915.00	3.213	0.5	2.713
926.25	3.197	0.5	2.697
16-QAM			
903.75	3.221	0.5	2.721
915.00	3.197	0.5	2.697
926.25	3.237	0.5	2.737
64-QAM			
903.75	3.189	0.5	2.689
915.00	3.173	0.5	2.673
926.25	3.157	0.5	2.657
10 MHz channel			
QPSK			
907.00	9.207	0.5	8.707
923.00	9.183	0.5	8.683
16-QAM			
907.00	9.207	0.5	8.707
923.00	9.207	0.5	8.707
64-QAM			
907.00	9.159	0.5	8.659
923.00	9.135	0.5	8.635
99 % OBW measurement:			
Channel bandwidth, MHz		99 % bandwidth, MHz	
3.5		3.221	
5.0		4.471	
7.0		6.514	
10.0		9.103	

Clause 15.247(a)(2) Minimum 6 dB bandwidth for digital modulation systems, continued

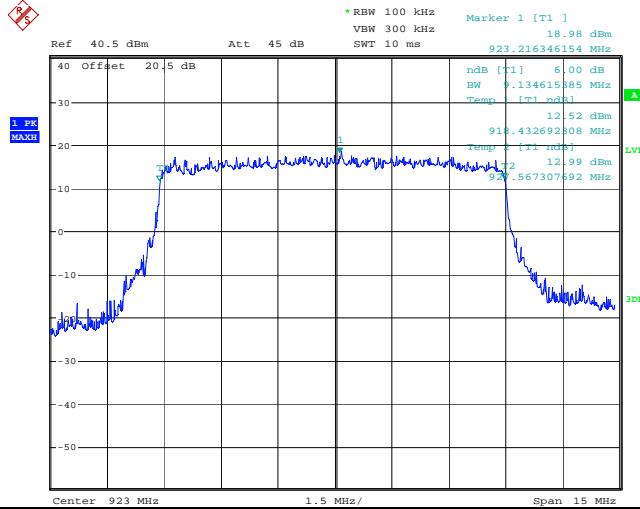
Test data, continued

Sample plots:

6 dB bandwidth on Low 3.5 MHz channel:



6 dB bandwidth on High 10 MHz channel:





Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Clause 15.247(b)(3) and (4) Maximum peak conducted output power for systems using digital modulation

The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(3) For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz and 5725–5850 MHz bands: 1 W. As an alternative to a peak power measurement, compliance with the 1 W limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the *maximum conducted output power* is the highest total transmit power occurring in any mode.

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

- (i) Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.
- (ii) Systems operating in the 5725–5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.
- (iii) Fixed, point-to-point operation, as used in paragraphs (b)(3)(i) and (b)(3)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

Test date: January 12, 2010

Test results: Pass

Special notes

- The test was performed using FCC guidelines of “Measurement of digital transmission systems operating under section 15.247”, from March 23, 2005.
- Power option 2 was used for the power output measurements.
- Test method 2 was chosen for the average power measurements:
RBW was set wider than emission bandwidth, VBW was set 3 RBW. Sweep time was set as a transmission pulse duration. Sample detector mode was used. Average tracing over 100 sweeps. Peak level on the plot was measured.

Clause 15.247(b)(3) and (4) Maximum peak conducted output power for systems using digital modulation, continued

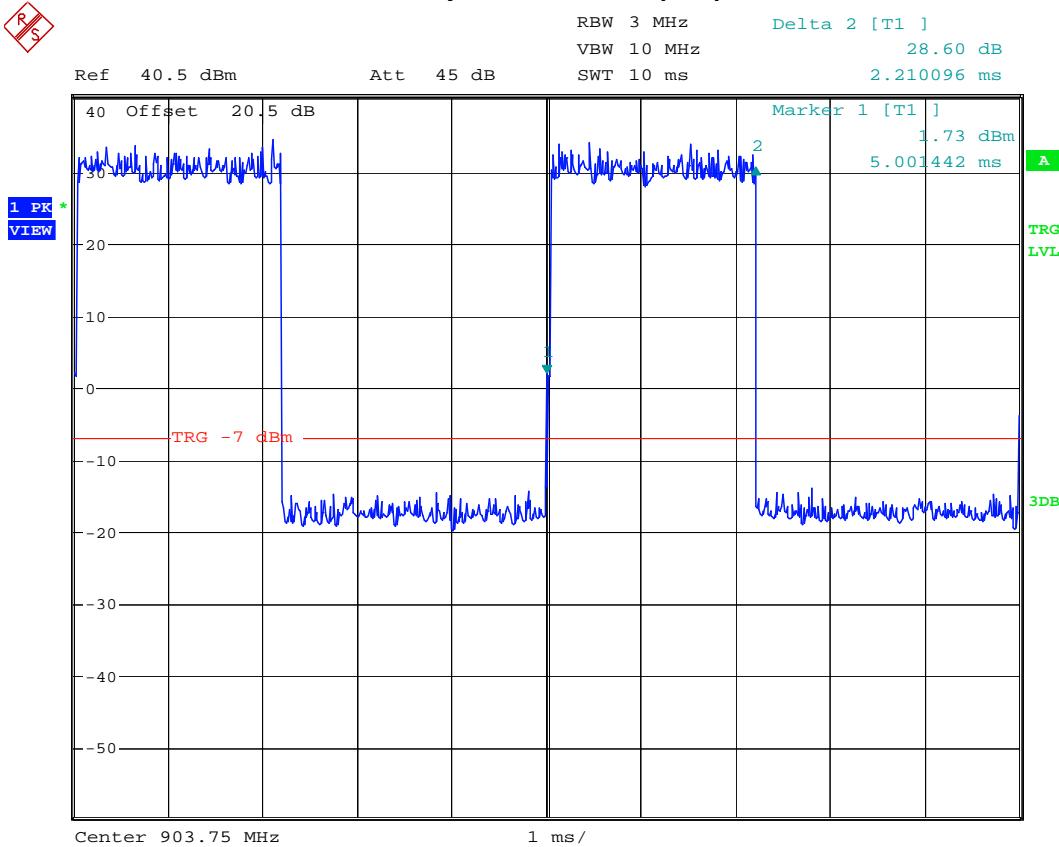
Test data

Test method choosing:

The Sweep time is 2.5 ms under following conditions:

- The RBW was set 1 MHz.
- Span was wider than emission bandwidth.
- Automatic settings were used for analyzer sweep time.
-

Transmission pulse duration ("T") for 3.5 MHz channel:



Date: 12.JAN.2010 13:44:12

Sweep time (2.5 ms) > T (2.2 ms), but
 Emission bandwidth \leq largest available RBW (with available VBW > RBW) therefore Method #2 was chosen.

Clause 15.247(b)(3) and (4) Maximum peak conducted output power for systems using digital modulation, continued

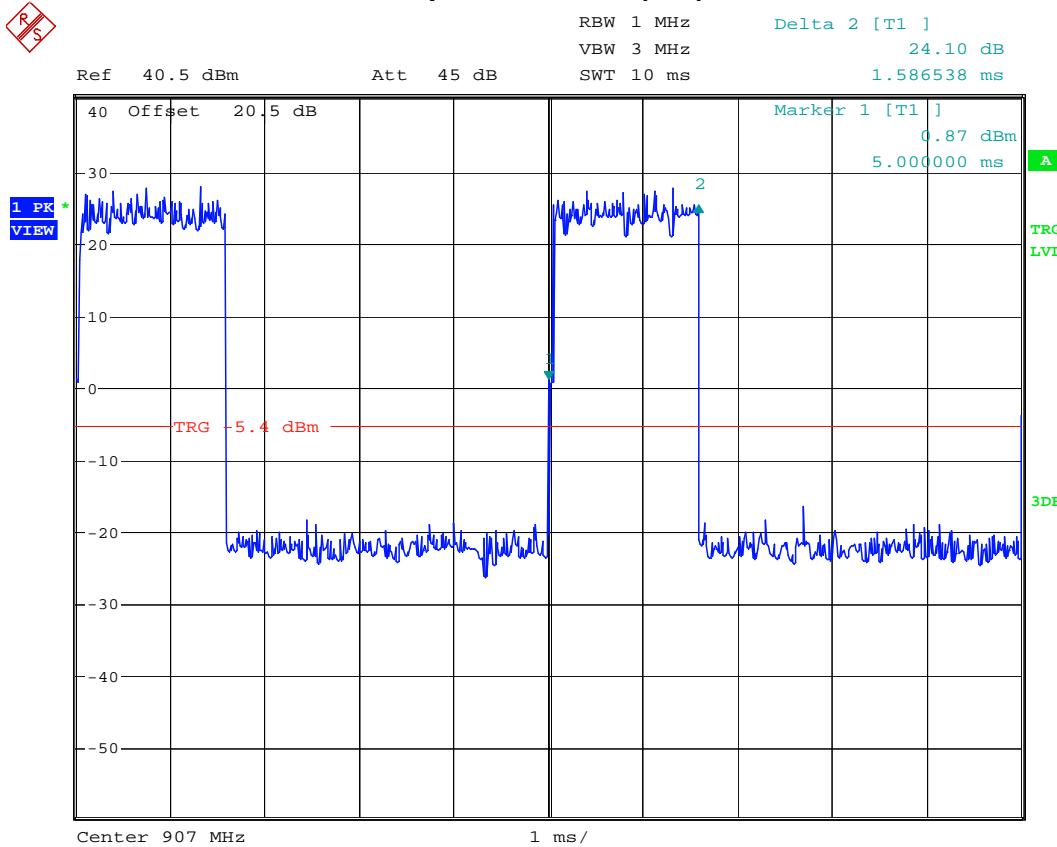
Test data, continued

Test method choosing:

The Sweep time is 2.5 ms under following conditions:

- The RBW was set 1 MHz.
- Span was wider than emission bandwidth.
- Automatic settings were used for analyzer sweep time.
-

Transmission pulse duration ("T") for 10 MHz channel:



Date: 12.JAN.2010 15:31:46

Sweep time (2.5 ms) > T (1.6 ms), but

Emission bandwidth \leq largest available RBW (with available VBW > RBW) therefore Method #2 was chosen.



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Clause 15.247(b)(3) and (4) Maximum peak conducted output power for systems using digital modulation, continued

Test data, continued

Conducted output power measurement

Frequency, MHz	Conducted output power, dBm	Limit, dBm	Margin, dB
3.5 MHz channel			
QPSK			
903.75	24.88	28.85	3.97
915.00	23.51	28.85	5.34
926.25	24.74	28.85	4.11
16-QAM			
903.75	24.22	28.85	4.63
915.00	23.19	28.85	5.66
926.25	24.50	28.85	4.35
64-QAM			
903.75	24.05	28.85	4.80
915.00	23.91	28.85	4.94
926.25	24.42	28.85	4.43
5 MHz channel			
QPSK			
902.50	25.52	28.85	3.33
915.00	24.71	28.85	4.14
925.50	25.73	28.85	3.12
16-QAM			
902.50	25.36	28.85	3.49
915.00	24.34	28.85	4.51
925.50	25.55	28.85	3.30
64-QAM			
902.50	25.24	28.85	3.61
915.00	25.11	28.85	3.74
925.50	25.36	28.85	3.49

Note: antenna gain is 5 dBd (7.15 dBi) that is 1.15 dB higher than 6 dBi requirement; therefore output power limit has been reduced by 1.15 dB.



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Clause 15.247(b)(3) and (4) Maximum peak conducted output power for systems using digital modulation, continued

Test data, continued

Conducted output power measurement, continued

Frequency, MHz	Conducted output power, dBm	Limit, dBm	Margin, dB
7 MHz channel			
QPSK			
905.50	26.79	28.85	2.06
915.00	25.93	28.85	2.92
924.50	27.00	28.85	1.85
16-QAM			
905.50	26.62	28.85	2.23
915.00	25.54	28.85	3.31
924.50	26.81	28.85	2.04
64-QAM			
905.50	26.49	28.85	2.36
915.00	26.35	28.85	2.50
924.50	26.61	28.85	2.24
10 MHz channel			
QPSK			
907.00	27.91	28.85	0.94
923.00	27.70	28.85	1.15
16-QAM			
907.00	27.85	28.85	1.00
923.00	27.64	28.85	1.21
64-QAM			
907.00	27.62	28.85	1.23
923.00	27.23	28.85	1.62

Note: antenna gain is 5 dBd (7.15 dBi) that is 1.15 dB higher than 6 dBi requirement; therefore output power limit has been reduced by 1.15 dB.



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Clause 15.247(b)(3) and (4) Maximum peak conducted output power for systems using digital modulation, continued

Test data, continued

EIRP calculation

Frequency, MHz	EIRP, dBm	Limit, dBm	Margin, dB
3.5 MHz channel			
QPSK			
903.75	32.03	36.00	3.97
915.00	30.66	36.00	5.34
926.25	31.89	36.00	4.11
16-QAM			
903.75	31.37	36.00	4.63
915.00	30.34	36.00	5.66
926.25	31.65	36.00	4.35
64-QAM			
903.75	31.20	36.00	4.80
915.00	31.06	36.00	4.94
926.25	31.57	36.00	4.43
5 MHz channel			
QPSK			
902.50	32.67	36.00	3.33
915.00	31.86	36.00	4.14
925.50	32.88	36.00	3.12
16-QAM			
902.50	32.51	36.00	3.49
915.00	31.49	36.00	4.51
925.50	32.70	36.00	3.30
64-QAM			
902.50	32.39	36.00	3.61
915.00	32.26	36.00	3.74
925.50	32.51	36.00	3.49

Notes: antenna gain is 5 dBd (7.15 dBi)

EIRP [dBm] = conducted output power [dBm] + antenna gain [dBi]



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Clause 15.247(b)(3) and (4) Maximum peak conducted output power for systems using digital modulation, continued

Test data, continued

EIRP calculation, continued

Frequency, MHz	EIRP, dBm	Limit, dBm	Margin, dB
7 MHz channel			
QPSK			
905.50	33.94	36.00	2.06
915.00	33.08	36.00	2.92
924.50	34.15	36.00	1.85
16-QAM			
905.50	33.77	36.00	2.23
915.00	32.69	36.00	3.31
924.50	33.96	36.00	2.04
64-QAM			
905.50	33.64	36.00	2.36
915.00	33.50	36.00	2.50
924.50	33.76	36.00	2.24
10 MHz channel			
QPSK			
907.00	35.06	36.00	0.94
923.00	34.85	36.00	1.15
16-QAM			
907.00	35.00	36.00	1.00
923.00	34.79	36.00	1.21
64-QAM			
907.00	34.77	36.00	1.23
923.00	34.38	36.00	1.62

Notes: antenna gain is 5 dBd (7.15 dBi)

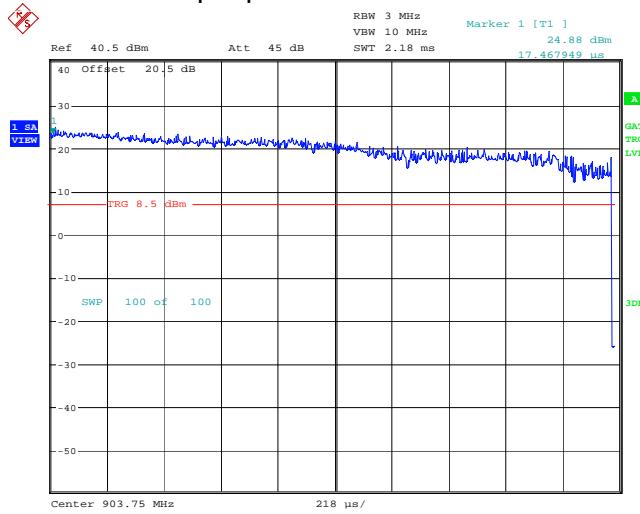
EIRP [dBm] = conducted output power [dBm] + antenna gain [dBi]

Clause 15.247(b)(3) and (4) Maximum peak conducted output power for systems using digital modulation, continued

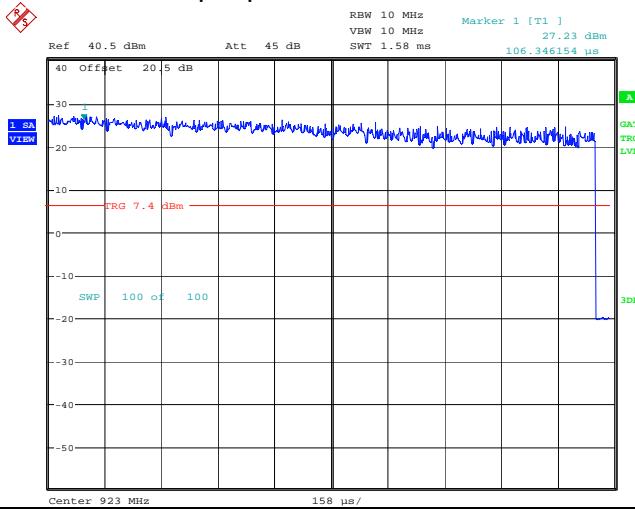
Test data, continued

Sample plots:

Output power of 3.5 MHz channel:



Output power of 10 MHz channel:





Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Clause 15.247(d) Spurious emissions

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)):

Frequency (MHz)	Field strength		Measurement distance (m)
	(μ V/m)	(dB μ V/m)	
0.009–0.490	2400/F	67.6–20log(F)	300
0.490–1.705	24000/F	87.6–20log(F)	30
1.705–30.0	30	29.5	30
30–88	100	40.0	3
88–216	150	43.5	3
216–960	200	46.0	3
above 960	500	54.0	3

Notes:

- F = fundamental frequency in kHz
- In the emission table above, the tighter limit applies at the band edges.
- For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test.

Test date: January 12 and 28, 2010

Test results: Pass



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Clause 15.247(d) Spurious emissions, continued

Special notes

- The spectrum was searched from 30 MHz to the 10th harmonic.
- Radiated measurements were performed at a distance of 3 m.
- Radiated measurements were performed:
 - within 30–1000 MHz range: using a quasi-peak detector with 120 kHz/300 kHz RBW/VBW,
 - above 1 GHz: using peak detector with 1 MHz/3 MHz RBW/VBW for peak results
 - and using average detector with 1 MHz/3 MHz RBW/VBW for average results for non-pulsed emissions
 - and using duty cycle correction factor for average results for pulsed emissions
- Only the worst data presented in the test report.
- Conducted measurements were performed using peak detector with 100 kHz/300 kHz RBW/VBW.

§ 15.205 Restricted bands of operation.

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	Above 38.6
13.36–13.41			

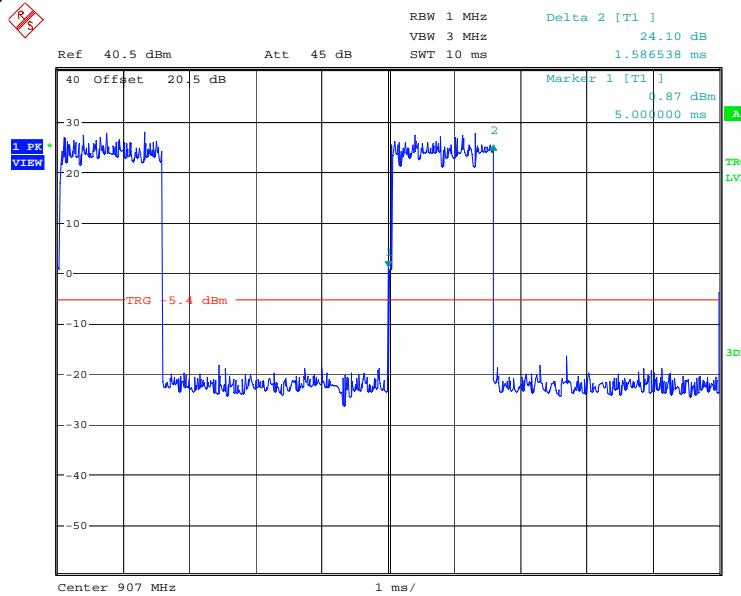
Clause 15.247(d) Spurious emissions, continued

Test data

Duty cycle/average factor calculations

§15.35(c) When the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds.

Duty cycle/average factor calculations:



Date: 12.JAN.2010 15:31:46

$$\text{Duty cycle/average factor} = 20 \times \log_{10} \left(\frac{T_x_{100ms}}{100ms} \right)$$

Tx = 2×1.586 ms within 10 ms, therefore 20×1.586 ms within 100 ms.

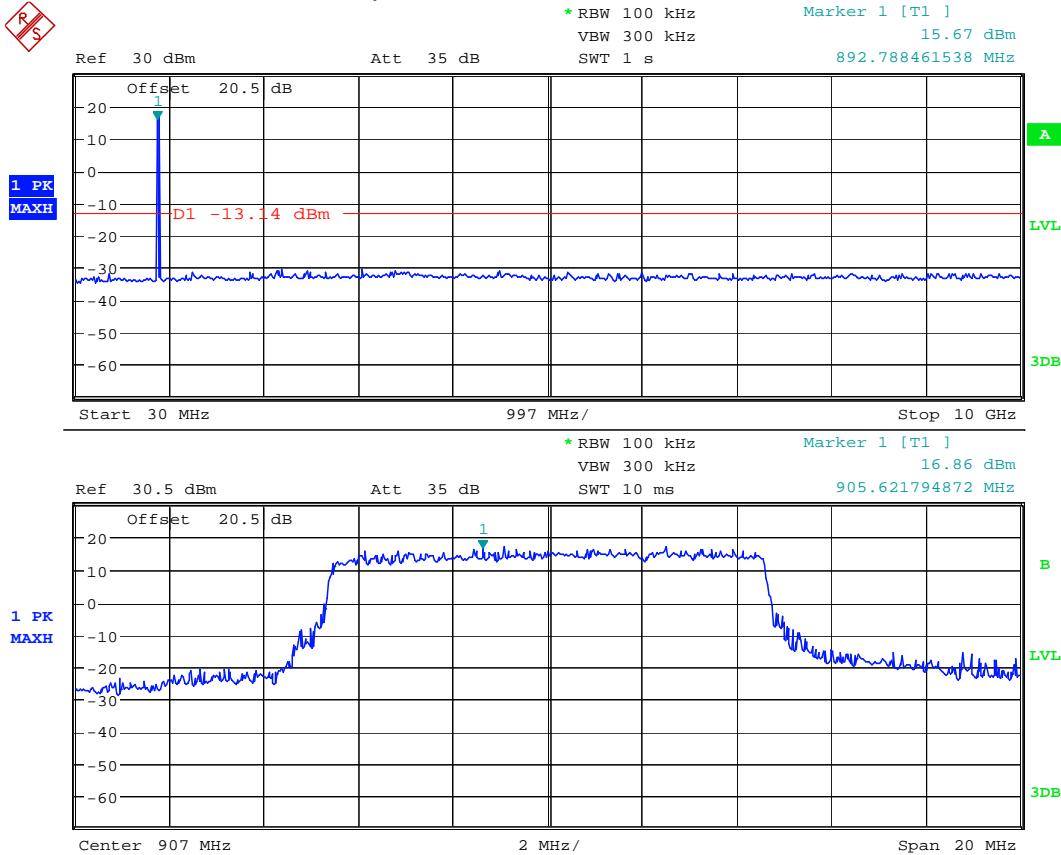
 Average factor: $20 \times \log(0.3172) = -9.97 \text{ dB}$

Clause 15.247(d) Spurious emissions, continued

Test data, continued

Sample plot:

Conducted spurious emissions for 10 MHz channel:



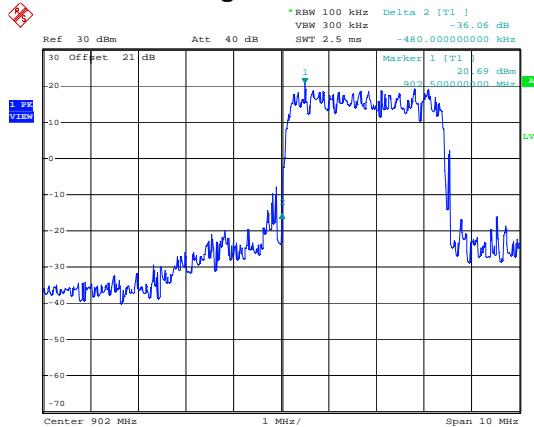
Date: 12.JAN.2010 16:21:05

Clause 15.247(d) Spurious emissions, continued

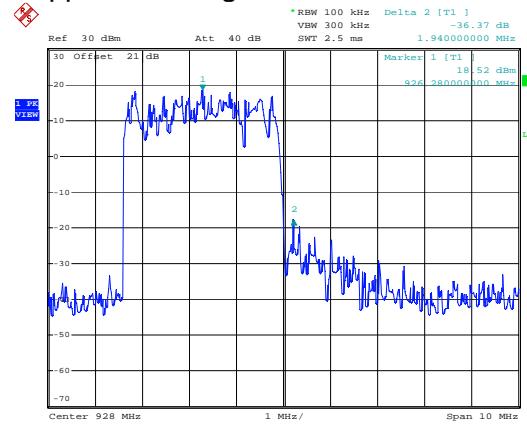
Test data, continued

Band edge emissions sample plots:

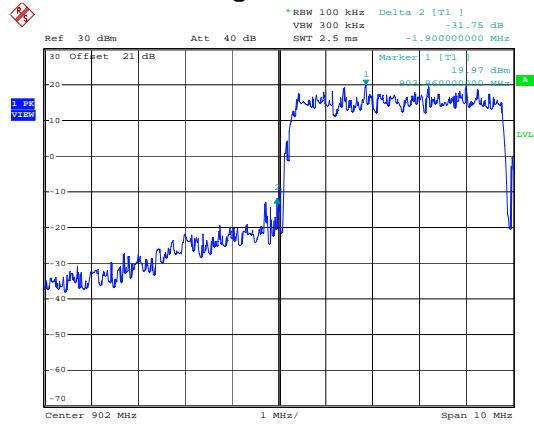
Lower band edge for 3.5 MHz channel:



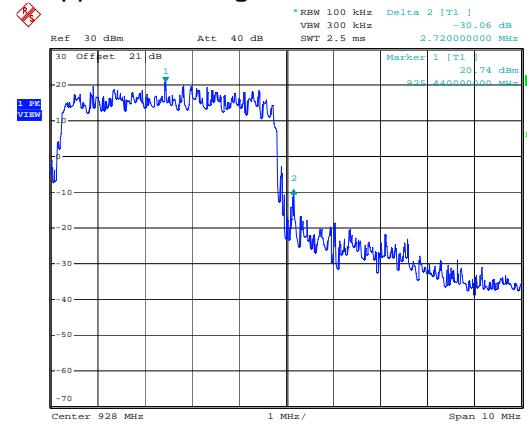
Upper band edge for 3.5 MHz channel:



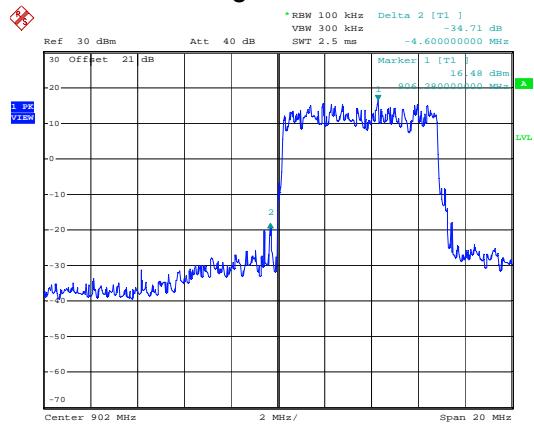
Lower band edge for 5 MHz channel:



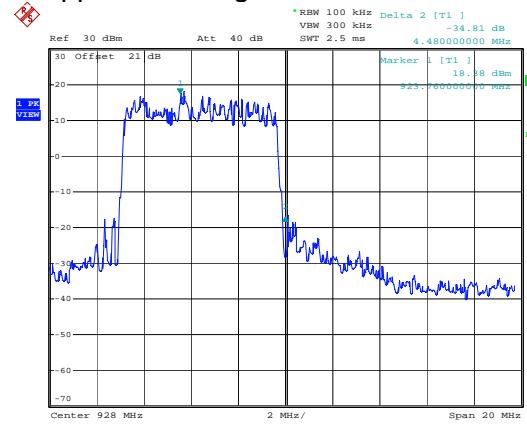
Upper band edge for 5 MHz channel:



Lower band edge for 7 MHz channel:



Upper band edge for 7 MHz channel:

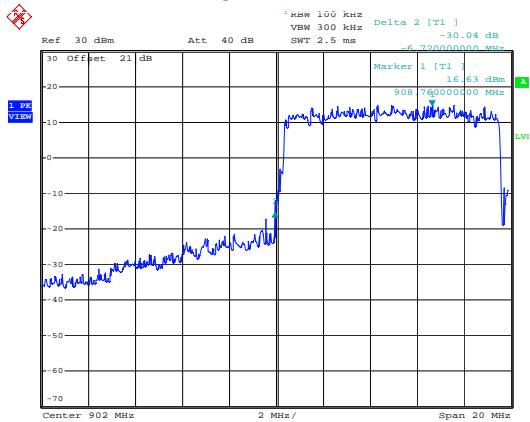


Clause 15.247(d) Spurious emissions, continued

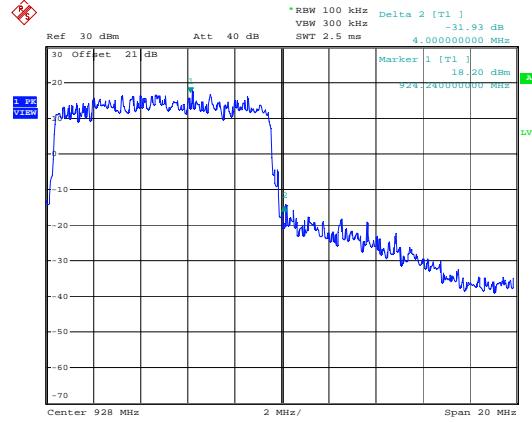
Tabular data

Band edge emissions sample plots, continued.

Lower band edge for 10 MHz channel:



Upper band edge for 10 MHz channel:



Below 1 GHz:

Frequency (MHz)	Polarization (V/H)	Quasi-Peak field strength (dB μ V/m)	Correction (dB)	Margin (dB)	Limit (dB μ V/m)
140.000	H	42.3	13.2	1.2	43.5
200.000	H	42.6	15.5	0.9	43.5
220.040	H	45.8	16.2	0.2	46.0
240.040	H	37.5	17.4	8.5	46.0
260.000	H	45.4	18.7	0.6	46.0
280.000	H	43.9	20.3	2.1	46.0
300.000	H	44.9	23.2	1.1	46.0
319.960	H	34.8	15.7	11.2	46.0
1000.000	H	46.3	26.4	7.7	54.0

Above 1 GHz:

Freq. (MHz)	Polarization (V/H)	Peak field strength (dB μ V/m)	Correction (dB)	Peak margin (dB)	Peak limit (dB μ V/m)	Avg field strength (dB μ V/m)	Avg limit (dB μ V/m)	Avg margin (dB)
1133.200	H	51.1	-18.6	22.9	74.0	49.6	54.0	4.4
1200.000	H	51.6	-18.3	22.4	74.0	45.2	54.0	8.8
1333.600	H	49.3	-18.4	24.7	74.0	47.1	54.0	6.9
1400.000	H	54.7	-18.2	19.3	74.0	50.5	54.0	3.5
1533.200	H	51.3	-18.0	22.7	74.0	49.6	54.0	4.4
1600.000	H	54.2	-17.9	19.8	74.0	50.0	54.0	4.0
1667.200	V	49.1	-17.4	24.9	74.0	47.0	54.0	7.0
2666.400	H	47.5	-12.4	26.5	74.0	43.3	54.0	10.7

Note: Correction factor includes antenna, cable loss, amplifier, and attenuators.

Test was performed on low, mid and high channels of 3.5 and 10 MHz channel bandwidths at the maximum transmit power. All detected emissions have been recorded.



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Clause 15.247(e) Power spectral density

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

Test date: January 12, 2010

Test results: Pass

Special notes

- Emission peak was located and zoomed in. RBW was set to 3 kHz, VBW was set > RBW. Sweep time was set to Span/3 kHz. Peak level was measured.



Nemko Canada Inc.,
303 River Road, R.R. 5, Ottawa, Ontario, Canada, K1V 1H2

Appendix A: Test results

Report Number: 141817-1TRFWL

Specification: FCC 15.247

Clause 15.247(c) Power spectral density, continued

Test data

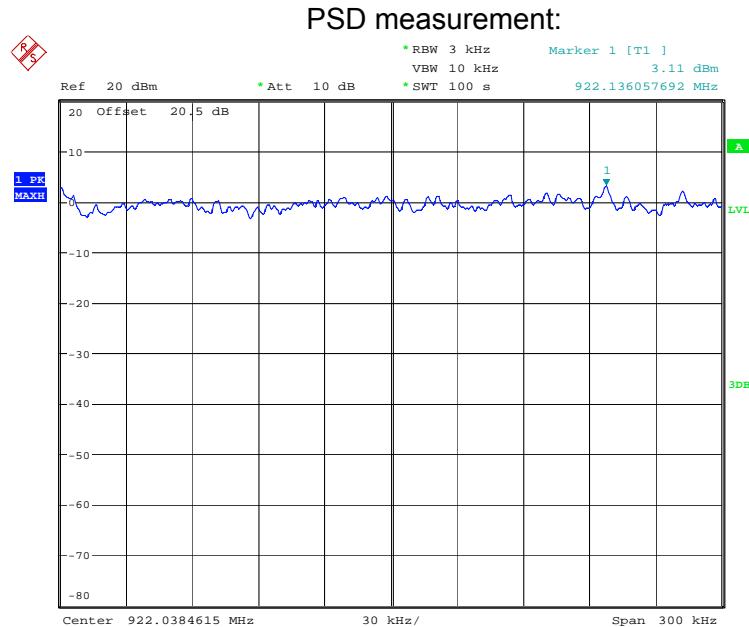
Conducted measurements:

Frequency, MHz	PSD, dBm/3 kHz	Limit, dBm/3 kHz	Margin, dB
3.5 MHz channel			
QPSK			
903.75	0.21	8.00	7.79
915.00	-0.61	8.00	8.61
926.25	0.62	8.00	7.38
16-QAM			
903.75	0.10	8.00	7.90
915.00	-0.93	8.00	8.93
926.25	0.38	8.00	7.62
64-QAM			
903.75	-0.07	8.00	8.07
915.00	-0.21	8.00	8.21
926.25	0.30	8.00	7.70
10 MHz channel			
QPSK			
907.00	3.79	8.00	4.21
923.00	3.58	8.00	4.42
16-QAM			
907.00	3.73	8.00	4.27
923.00	3.52	8.00	4.48
64-QAM			
907.00	3.50	8.00	4.50
923.00	3.11	8.00	4.89

Clause 15.247(c) Power spectral density, continued

Test data

Sample plot:



Date: 12.JAN.2010 16:04:37

Note: 3.5 MHz and 10 MHz channels were assessed using same settings

Appendix B: Block diagrams of test set-ups

Radiated emissions set-up

