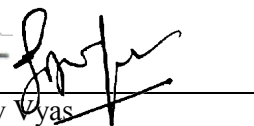
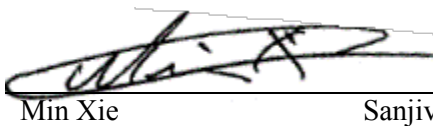


Global EMC Inc. Labs

EMC & RF Test Report

As per
FCC Part 90 Subpart M:2015
&
RSS-137 Issue 2:2009
Location and Monitoring Service (LMS)
Operation in the 902 – 928 MHz Band
on the

MRMF-S with External Amplifier (MRMF-SEA)



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Testing produced for

kapsch >>>

See Appendix A for full customer & EUT details.



Industry
Canada

LAB REGISTRATION
#6844A-3



ACCREDITED
Testing Laboratory
Certificate #2555.01



FCC
REGISTRATION
#377448



R-4023, G-506
T-1246, C-4498

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

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Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Report Scope

This report addresses the EMC verification testing and test results of Kapsch TrafficCom Canada Inc's MRFM-S with External Amplifier (MRMF-SEA), model 802295AA herein referred to as EUT (Equipment Under Test) performed at Global EMC Labs. The EUT is a standard rack mount unit. The EUT comprises a module that plugs into a 19 inch rack assembly and an amplifier assembly which is mounted on standard 19" tray.

The EUT was tested for compliance against the following standards:

FCC Part 90 Subpart M:2015
RSS-137 Issue 2:2009

Test procedures, results, justifications, and engineering considerations, if any, follow later in this report.

The results contained in this report relate only to the item(s) tested.

This report does not imply product endorsement by A2LA or any other accreditation agency, any government, or Global EMC Inc.

Opinions/interpretations expressed in this report, if any, are outside the scope of Global EMC Inc accreditation. Any opinions expressed do not necessarily reflect the opinions of Global EMC Inc, unless otherwise stated.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Summary

The results contained in this report relate only to the item(s) tested.

EUT FCC Certification #, FCC ID:	JQU802295AA
EUT Industry Canada Certification #, IC:	2665A-802295AA
EUT Passed all tests performed.	Yes (see test results summary)
Tests conducted by	Min Xie, Sanjiv Vyas

Client	Kapsch TrafficCom Canada Inc	
Product	MRFM-S with External Amplifier (MRFM-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Test Results Summary

Standard/Method	Description	Limit	Result
FCC 90.205 RSS-137 Clause 6.4	Output Power	30 W	Pass
FCC 90.207 RSS-137 Clause 6.2	Types of Modulation	--	Pass See Justifications
FCC 90.209 RSS-137 Clause 6.1.2	Occupied Bandwidth	902 - 904 MHz: 2 MHz 909.75 - 921.75 MHz 12 MHz	Pass
FCC 90.210 (K) RSS-137 Clause 6.5.3	Spurious antenna port conducted emissions	$55 + 10 \log_{10} P_{max}$ dB.	Pass See Justifications
FCC 90.210 RSS-137 Clause 6.5.3	Spurious radiated emissions	$55 + 10 \log_{10} P_{max}$ dB.	Pass
FCC 90.213 RSS-137 Clause 6.3	Frequency stability	2.5 ppm	Pass
FCC 90.214	Transient Behavior	--	N/A See Justifications
Overall Result			PASS

All tests other than spurious radiated emissions were performed by Min Xie. Spurious radiated emission were performed by Sanjiv Vyas.

If the product as tested or otherwise complies with the specification, the EUT is deemed to comply with the requirement and is deemed a 'PASS' grade. If not 'FAIL' grade will be issued. Note that 'PASS' / 'FAIL' grade is independent of any measurement uncertainties. A 'PASS' / 'FAIL' grade within measurement uncertainty is marked with a '*'.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Justifications, Descriptions, or Deviations

The following justifications for tests not performed or deviations from the above listed specifications apply:

The EUT supports the following 6 protocols: IAG, ATA, SeGo, 6B, 6C and Allegro

1. Kapsch Time Division Multiplex (TDM), hereafter referred to as the “IAG” protocol
2. Allegro
3. Super eGo® (SeGo)
4. ISO-18000-6C a.k.a. EPC Class 1 Gen 2, hereafter referred to as the “6C” protocol
5. ISO-10374 a.k.a. American Association of Railroads (AAR) S-918, a.k.a. American Trucking Association (ATA), hereafter referred to as the “ATA” protocol
6. ISO-18000-6B, hereafter referred to as the “6B” protocol

The EUT only transmits a CW signal in ATA mode and the other five protocols uses Shaped ON-OFF Keying to transmit information. According to FCC 90.207, the EUT have two types of emission:

1. N0N for ATA
2. K1D for the other five protocols

For FCC 90.214, the EUT operates in the 902-928 MHz band, and this requirement is not applicable.

For the requirements of FCC 90.210 (K) and FCC 2.1053 Measurements required: Field strength of spurious radiation. Spurious radiated emissions of the EUT was performed at 3 meters. The limit specified in FCC 90.210 (K) is: On any frequency outside the licensee’s sub-band edges, the peak power of any emission shall be attenuated by $55 + 10 \log(P)$ where P is the highest emission (Watts) of the transmitter. For all intensive purposes, the limit is -25 dBm ERP. The 3 meter field strength limit for the EUT is given below:

$$E(\text{dB}\mu\text{V/m}) = \text{ERIP}(\text{dBm}) + 95.2$$

$$\text{Where EIRP} = \text{ERP} + 2.15$$

$$E(\text{dB}\mu\text{V/m}) = \text{ERP}(\text{dBm}) + 97.35$$

$$E(\text{dB}\mu\text{V/m}) = -25 \text{ dBm} + 97.35 = 72.35 \text{ dBuV}$$

This limit is applicable to all emission at 3 meter measurement distance.

The transmit antenna system used with the model may be selected from any viable antenna for the band as long as two key criteria are satisfied:

- 1) The TX power is controlled to restrict the ERP; and

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

2) The antenna system gain at the second harmonic is at least -14 dB relative to the gain at the fundamental

The Tune-Up procedure provided contains a requirement that the gain of the antenna assembly (cable + antenna) at the 2nd harmonic (G2nd) is at least -14 dB relative to the gain of the fundamental (Gfund). The maximum 2nd harmonic excursion above the limit is 8.5 dB and applying this tune up procedure will attenuate it to a level that is below the FCC Part 90.210 (k)(3) emission mask limit.

The worst case G2nd, according to the Tune Up procedure, is with a Gfund of 4.77 dB (any higher Gain at the fundamental, the output power will need to be roll back to satisfy maximum ERP constraints. With Gfund $\leq$ 4.77 dB; the EUT is operating its maximum possible output; with a Gfund of >4.77 dB, the output will be reduce accordingly. If, for example, Gfund is 5.77 dB then the power output will be reduced by 1 dB). The minimum attenuation at the 2nd harmonic is therefore 9.23 dB and applying this attenuation to the worst case 2nd harmonic will result in a margin of 0.73 dB. When the transmitter is put in service for each site and is tuned according to the Tuning Procedure, it will meet the requirements of FCC Part 90.210(k)(3).

These requirements are specified in the Tuning Procedure accompanying this filing.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Applicable Standards, Specifications and Methods

ANSI C63.4:2009 Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

ANSI/TIA-603-C-2004
Land Mobile FM or PM Communications Equipment Measurement and Performance Standards

CFR 47 FCC Part 2 Subpart J –
Code of Federal Regulations – Equipment Authorization Procedure

CFR 47 FCC Part 90 Code of Federal Regulations – Private Land Mobile Radio Services

FCC KDB 412172 D01 Determining ERP and EIRP v01

ISO 17025:2005 General Requirements for the competence of testing and calibration laboratories

RSS-GEN:2014 Issue 4: General Requirements and Information for the Certification of Radio Apparatus

RSS 137:2009 Issue 2: Spectrum Management and Telecommunications. Radio Standards Specification, Location and Monitoring Service in the Band 902-928 MHz.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Sample calculation(s)

Margin = limit – (received signal + antenna factor + cable loss – pre-amp gain)

Margin = 50.5dBuV/m – (50dBuV + 10dB + 2.5dB – 20dB)

Margin = 8.5 dB

Reference Offset = Attenuator + Cable Loss

Reference Offset = 10 dB + 0.4 dB

Reference Offset = 10.4 dB

Document Revision Status

Revision 1 - May 15, 2015
Initial release

Revision 2 June 2, 2015

Revision 3 September 16, 2015
Apply 2nd harmonic attenuation in Tuning Procedure to 2nd harmonic emission. See Justification section for details.
This revision replaces all previous revisions in their entirety.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Definitions and Acronyms

The following definitions and acronyms are applicable in this report.
See also ANSI C63.14.

AE – Auxillary Equipment.

BW – Bandwidth. Unless otherwise stated, this refers to the 6 dB bandwidth.

EMC – Electro-Magnetic Compatibility

EMI – Electro-Magnetic Immunity

EUT – Equipment Under Test

ITE – Information Technology Equipment with a primary function(s) of entry, storage, display, retrieval, transmission, processing, switching, or control, of data.

LISN – Line impedance stabilization network

NCR – No Calibration Required

RF – Radio Frequency

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Testing Facility

Testing for EMC on the EUT was carried out at Global EMC labs in 11 Gordon Collins, Gormley, Ontario, Canada. The testing lab consists of a 3m semi-anechoic chamber calibrated to be able to allow measurements on an EUT with a maximum width or length of up to 2m and height up to 3m. The chamber is equipped with a turn table that is capable of testing devices up to 3300lb in weight. This facility is capable of testing products that are rated for 120 Vac and 240Vac single phase, or 208 Vac 3 phase input. DC capability is also available. The chamber is equipped with an antenna mast that controls polarization and height from the control room adjoining the shielded chamber. Radiated emissions measurements are performed using a Bilog, and Horn antenna where applicable. Conducted emissions, unless otherwise stated, are performed using a LISN.

Calibrations and Accreditations

The 3m semi-anechoic chamber is registered with Federal Communications Commission (FCC, 377448), Industry Canada (IC, 6844A-3) and VCCI (R-4023, G-506, T-1246, and C-4498). This semi-anechoic chamber complies with the requirements of EN55016-2-3:2006, section 7.5 and the site attenuation requirements of EN55016-1-4. This chamber was additionally calibrated for Normalized Site Attenuation (NSA) using test procedures outlined in ANSI C63.4 "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz". The chamber is lined with ferrite tiles and absorption cones to minimize any undesired reflections. The NSA data is kept on file at Global EMC. For radiated susceptibility testing, a 16 point field calibration has been performed on the chamber. The field uniformity data is kept on file at Global EMC. Global EMC Inc is accredited to ISO 17025 by A2LA with Testing Certificate #2555.01. The laboratories current scope of accreditation listing can be found as listed on the A2LA website. All measuring equipment is calibrated on an annual or bi-annual basis as listed for each respective test.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Testing Environmental Conditions and Dates

Following were the environmental conditions in the facility during time of testing –

Date	Test	Init.	Temperature (°C)	Humidity (%)	Pressure (kPa)
2015/04/02 2015/03/05	Output Power	MX	20-24°C	35 – 41%	96 -102kPa
2015/04/02 2015/03/05	Occupied Bandwidth	MX	20-24°C	35 – 41%	96 -102kPa
2015/04/05-06	Spurious Antenna conducted	MX	20-24°C	35 – 41%	96 -102kPa
2015/03/5	Frequency stability	MX	20-24°C	35 – 41%	96 -102kPa
2015/3/12	Radiated spurious	SV	20-24°C	35 – 41%	96 -102kPa

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Detailed Test Results Section

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Output Power and Antenna Heights

Purpose

The purpose of this test is to ensure that the maximum power conducted to the radiating element does not exceed the limits specified.

Limits

The limits are defined in FCC Part 90.205 (l) and RSS 137 Clause 6.4 as per the following paragraph:

902-928 MHz. LMS systems operating pursuant to subpart M of this part in the 902-927.25 MHz band will be authorized a maximum of 30 watts ERP. LMS equipment operating in the 927.25-928 MHz band will be authorized a maximum of 300 watts ERP. ERP must be measured as peak envelope power. Antenna heights will be as specified in §90.353(h).

Results

The EUT passed.

The EUT supports the following 6 protocols: IAG, ATA, SeGo, 6B, 6C and Allegro. Each protocol have its own frequency channels and frequency ranges. Where a protocol have more than one channel, the Low, middle and high channels were measured. The tables below give the results for each protocol.

The ATA and 6C protocols operate in both sub-bands allocated for non-multilateral LMS transmitters. Output power for both sub-bands were measured.

Antenna selection varies by application. RF cable loss and fixed attenuations (added inline or manually set inside the unit under control of a commanding reader) is used to compensate for transmit antenna system gain so that the ERP for operating band is 30 watts (44.77 dBm) or less. See page Tuning Procedure for further details.

Guidance for antenna height requirement and restrictions on setting module power to meet ERP are given in User Manual.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Table(s)

6B			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Low Channel	911.0	39.57	9.06
Mid Channel	915.0	39.63	9.18
High Channel	919.5	39.73	9.40

6C – 902 – 904 MHz Sub-Band			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Channel	903	39.67	9.27

6C – 909.75 to 921.75 MHz Sub-Band			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Low Channel	910.5	39.71	9.35
Mid Channel	915.0	38.92	7.80
High Channel	920.5	39.07	8.07

Allegro			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Channel	915.75	39.06	8.05

IAG			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Channel	915.75	39.52	8.95

SeGO			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Low Channel	911.5	38.82	7.62
Mid Channel	915.0	39.05	8.04
High Channel	919.5	39.31	8.53

ATA – 902 – 904 MHz Sub-Band			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Low Channel	902.5	38.75	7.50
Mid Channel	903.0	38.84	7.66
High Channel	903.5	38.92	7.80

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

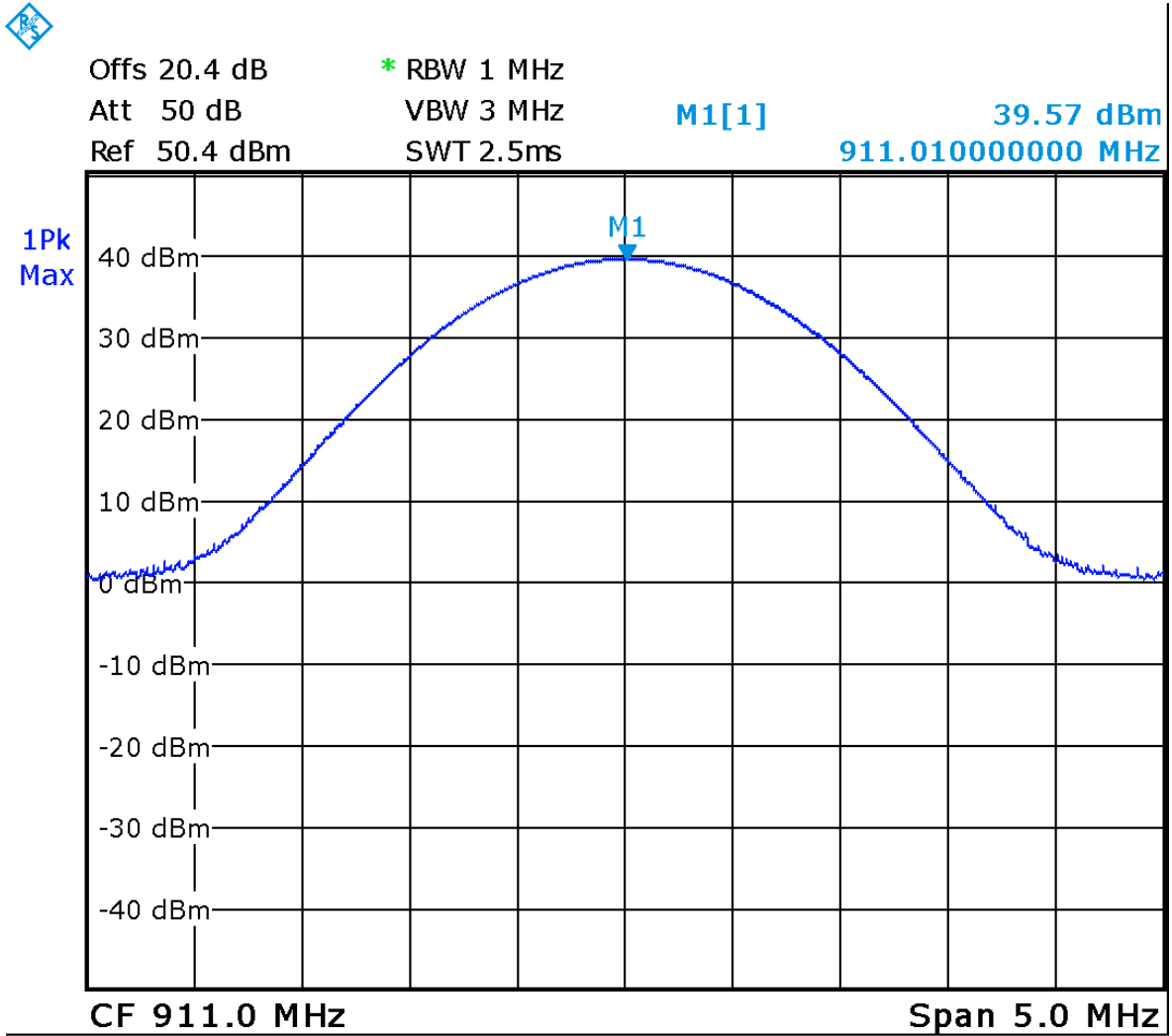
ATA – 909.75 – 921.75 MHz Sub-Band			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Low Channel	910	39.15	8.22
Mid Channel	915	39.03	8.00
High Channel	921.5	39.60	9.12

Graph(s)

The graphs below show examples of the Peak Power during the operation of the device. Measurements were performed using a spectrum analyzer with a Peak detector of 1 MHz RBW and the VBW is at least 3 x RBW. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

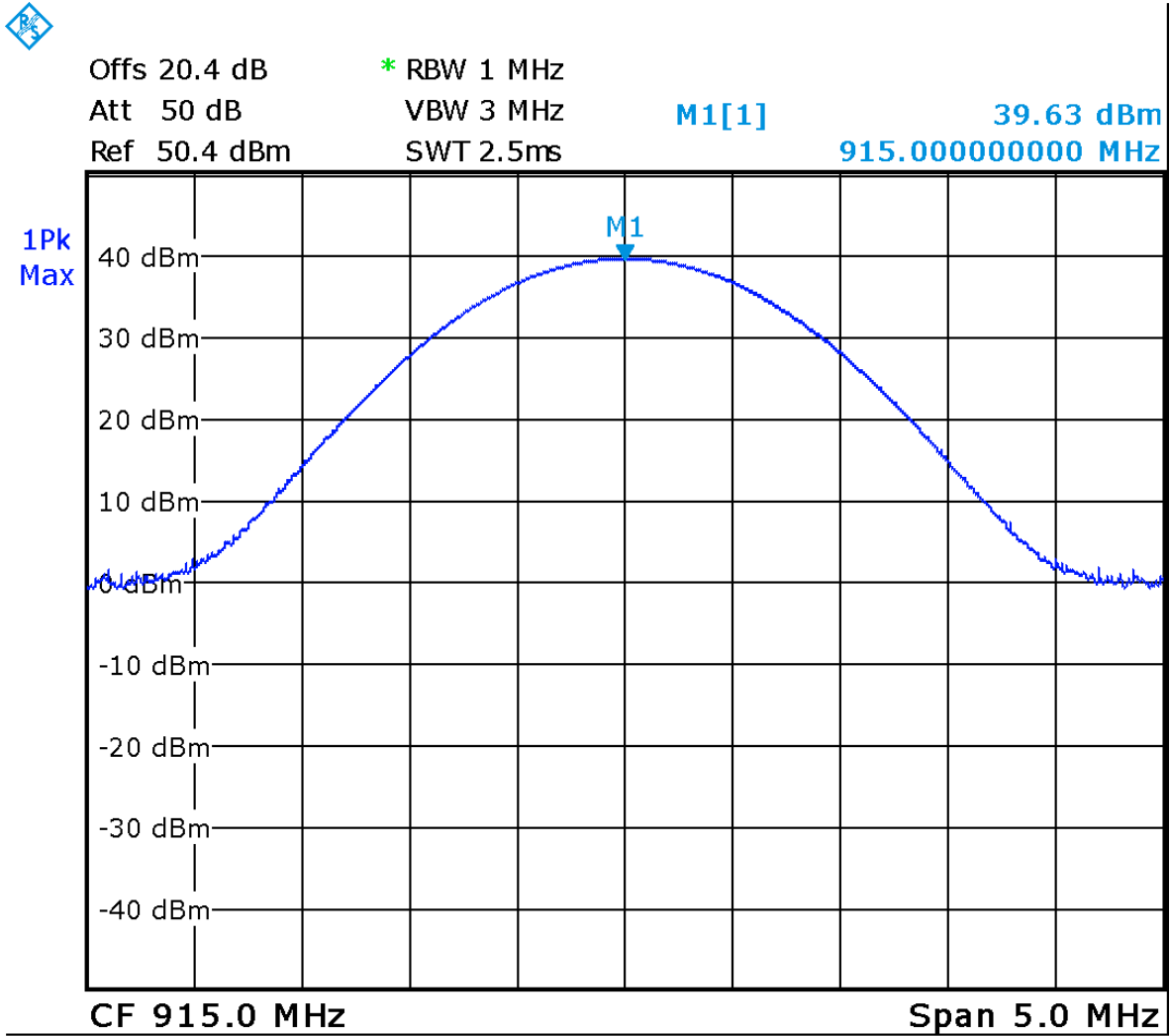
Protocol: 6B
Low Channel



Date: 2.APR.2015 09:44:38

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

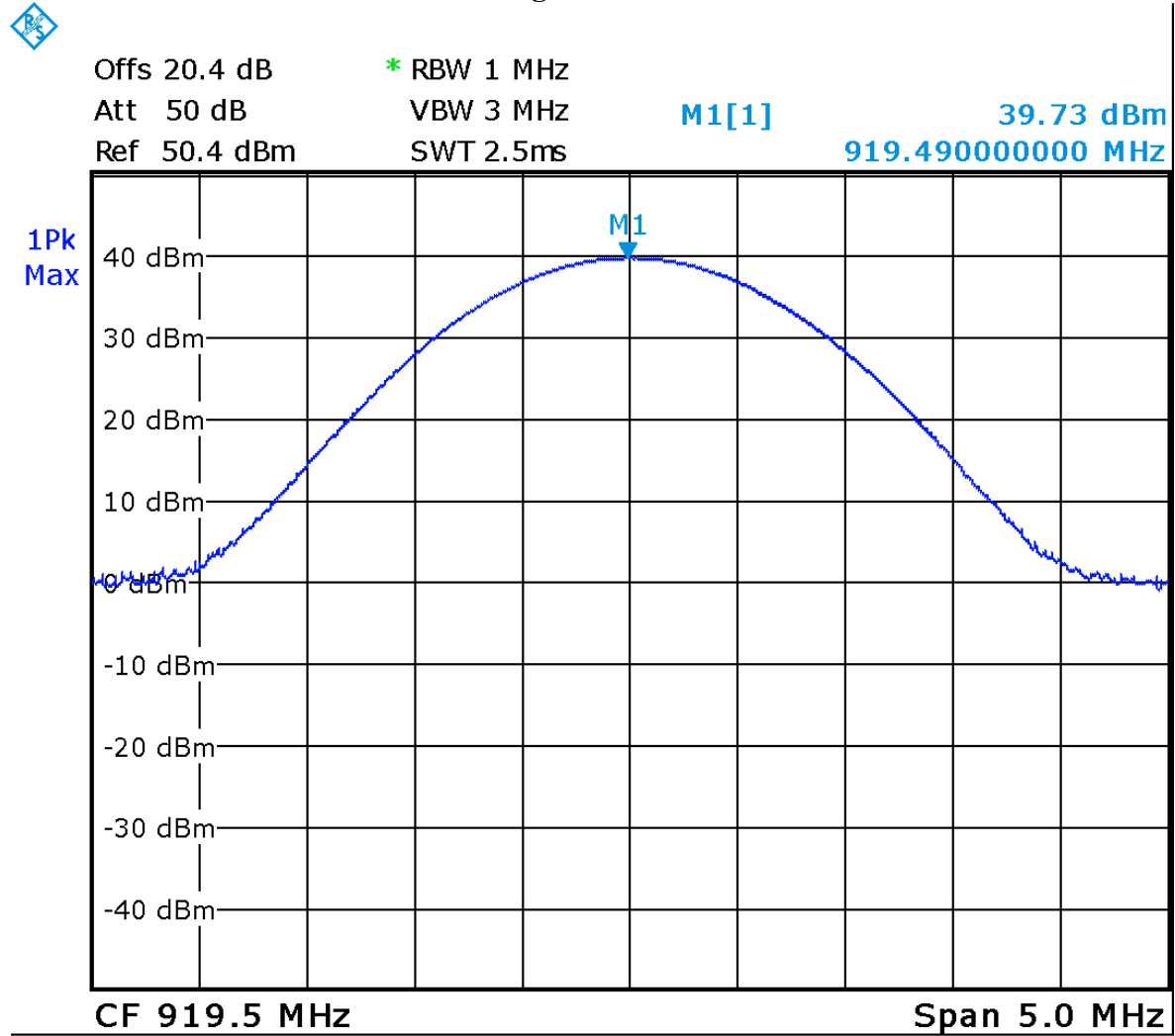
Protocol: 6B
Mid Channel



Date: 2.APR.2015 09:55:34

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

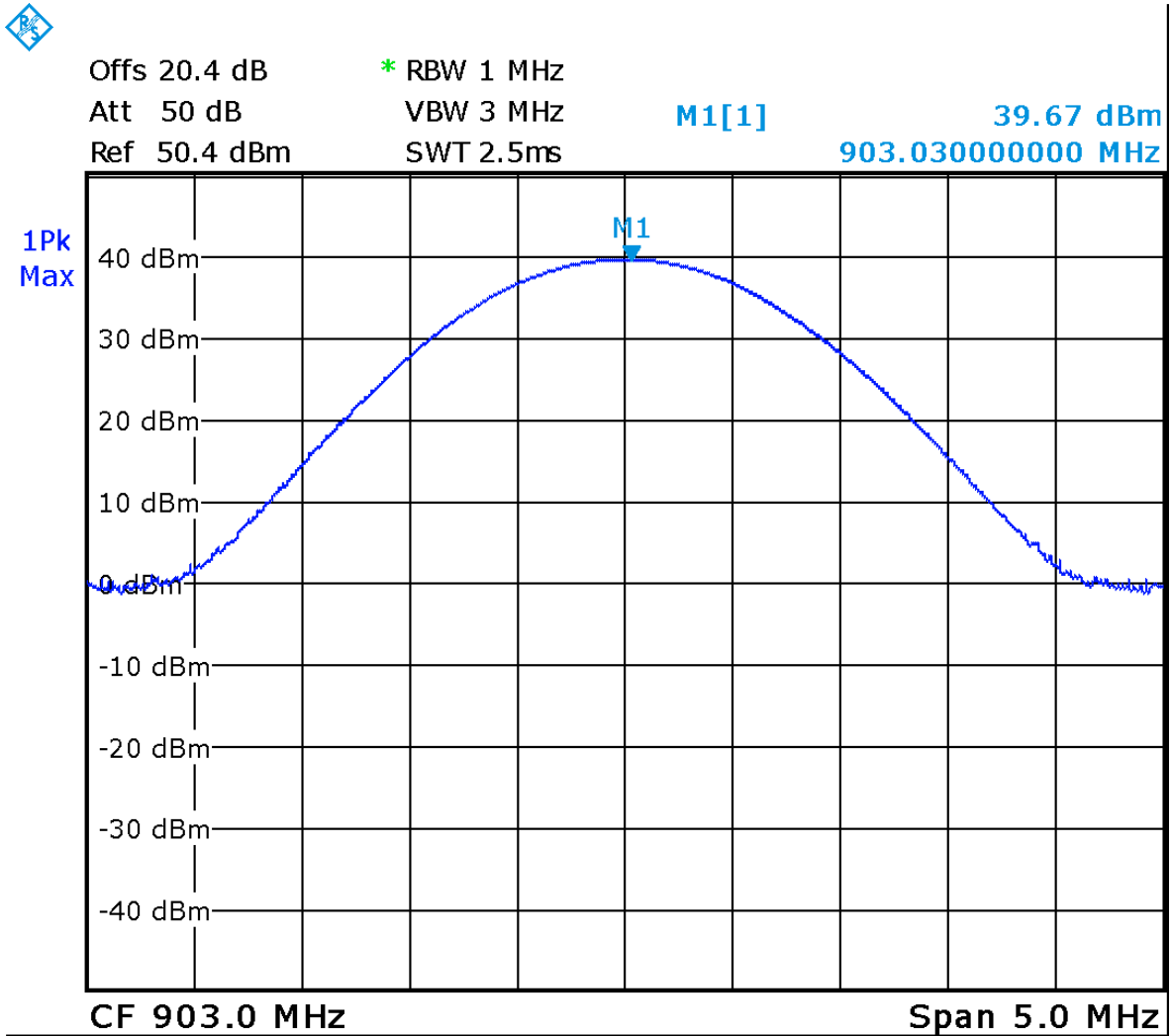
Protocol: 6B
High Channel



Date: 2.APR.2015 09:56:56

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

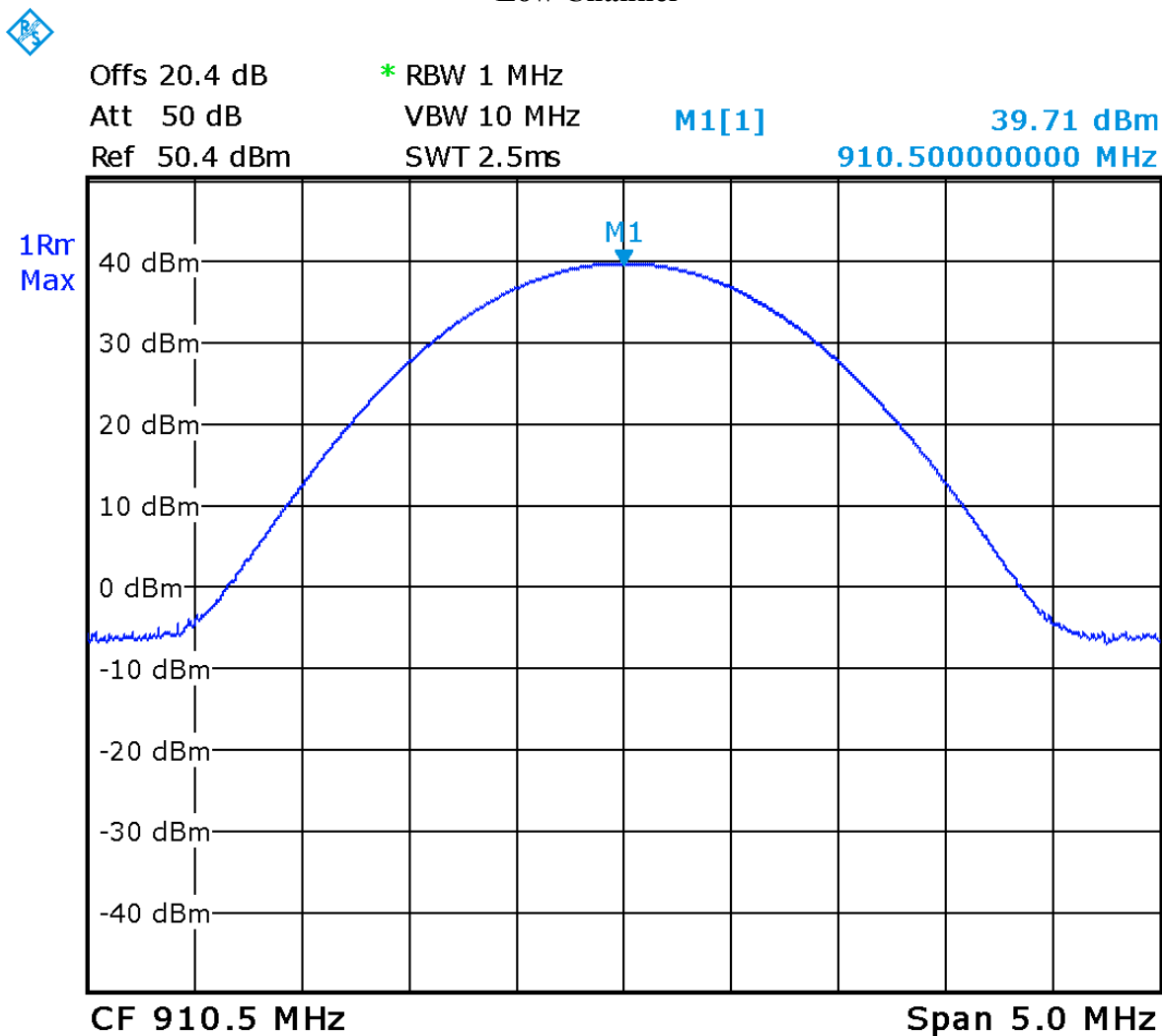
Protocol: 6C: 902 – 904 MHz Sub-Band



Date: 5.MAR.2015 11:43:51

Client	Kapsch TrafficCom Canada Inc	
Product	MRFM-S with External Amplifier (MRFM-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

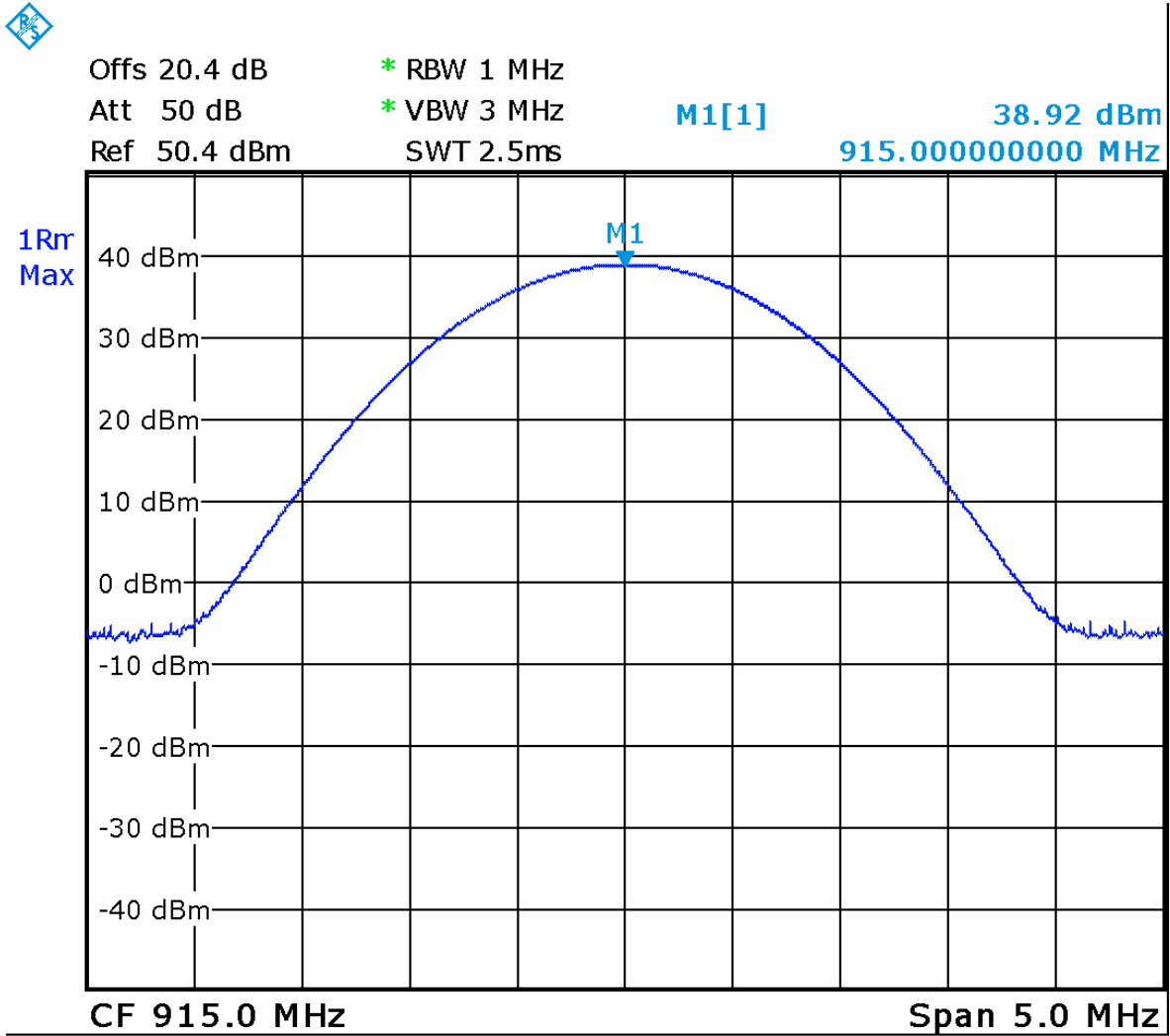
**Protocol: 6C: 909.75 – 921.75 MHz Sub-Band
Low Channel**



Date: 5.MAR.2015 11:59:22

Client	Kapsch TrafficCom Canada Inc	
Product	MRFM-S with External Amplifier (MRFM-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

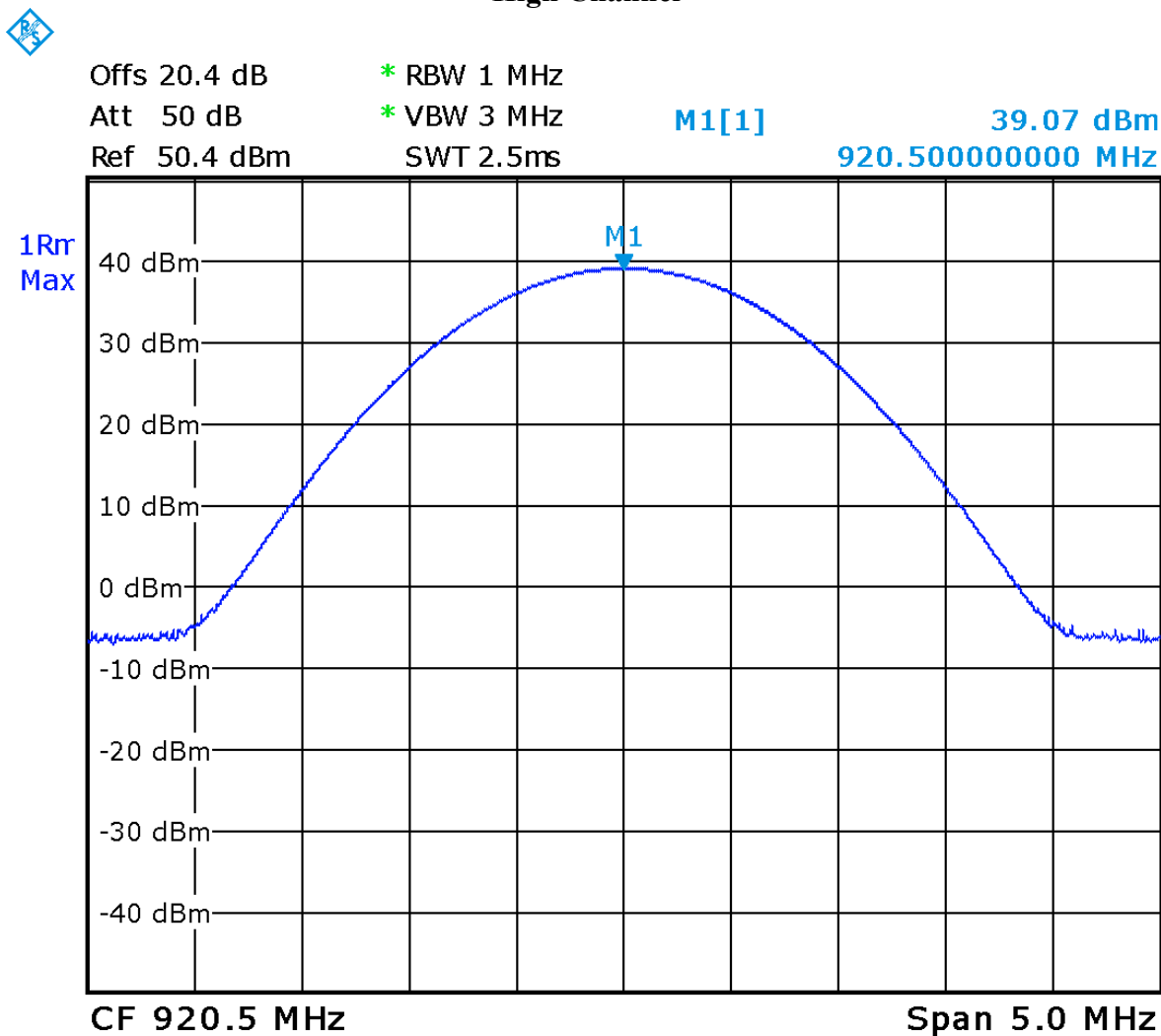
**Protocol: 6C: 909.75 – 921.75 MHz Sub-Band
Mid Channel**



Date: 5.MAR.2015 12:23:53

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

**Protocol: 6C: 909.75 – 921.75 MHz Sub-Band
High Channel**



Date: 5.MAR.2015 12:17:02

Note: See 'Appendix B – EUT & Test Setup Photographs' for photos showing the test set-up.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration date	Next calibration due date	Asset #
Spectrum Analyzer	ESL 6	Rohde & Schwarz	15-Nov-2013	15-Nov-2015	GEMC 160
Power Attenuator 20 dB	25-A-FFN-20	Bird / Hutton	NCR	NCR	GEMC 49
RF Cable 1m	LMR-400-1M-50OHM-MN-MN	LexTec	NCR	NCR	GEMC 29

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Occupied Bandwidth

Purpose

The purpose of this test is to ensure that the bandwidth occupied exceeds a stated minimum. This helps ensure the utilization of the frequency allocation is sufficiently wide. This also helps prevent corruption of data by ensuring adequate data separation to distinguish the reception of the intended information.

Limits

The Limit is as specified in FCC Part 90.209 and RSS-137 Clause 6.1.2.

The maximum authorized bandwidth shall be 12 MHz for non-multilateration LMS operations in the band 909.75-921.75 MHz and 2 MHz in the band 902.00-904.00 MHz. The maximum authorized bandwidth for multilateration LMS operations shall be 5.75 MHz in the 904.00-909.75 MHz band; 2 MHz in the 919.5-921.75 MHz band; 5.75 MHz in the 921.75-927.25 MHz band and its associated 927.25-927.50 MHz narrowband forward link; and 8.00 MHz if the 919.75-921.75 MHz and 921.75-927.25 MHz bands and their associated 927.25-927.50 MHz and 927.50-927.75 MHz narrowband forward links are aggregated.

Results

The EUT passed.

Each of the 6 supported protocol was tested. Where a protocol have more than one channel, the Low, middle and high channels were measured. The table below gives the results for each protocol.

The ATA and 6C protocols operate in both non- multilateration LMS sub-bands and the other 4 protocols operate in the 909.75 – 921.75 MHz sub-band.

Client	Kapsch TrafficCom Canada Inc	
Product	MRFM-S with External Amplifier (MRFM-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Tables

6B		
Channel	Frequency (MHz)	99% Bandwidth (kHz)
Low Channel	911.0	491.02
Mid Channel	915.0	491.02
High Channel	919.5	502.99

6C – 902 – 904 MHz Sub-Band		
Channel	Frequency (MHz)	99% Bandwidth (kHz)
Channel	903	590.82

6C – 909.75 – 921.75 Sub-Band		
Channel	Frequency (MHz)	99% Bandwidth (kHz)
Low Channel	910.5	594.81
Mid Channel	915.0	594.81
High Channel	920.5	596.81

Allegro		
Channel	Frequency (MHz)	99% Bandwidth (kHz)
Channel	915.75	750.50

IAG		
Channel	Frequency (MHz)	99% Bandwidth (kHz)
Channel	915.75	890.22

SeGO		
Channel	Frequency (MHz)	99% Bandwidth (kHz)
Low Channel	911.5	638.72
Mid Channel	915.0	642.71
High Channel	919.5	654.69

ATA – 902 – 904 MHz Sub-Band		
Channel	Frequency (MHz)	99% Bandwidth (kHz)
Low Channel	902.5	219.56
Mid Channel	903.0	219.56
High Channel	903.5	219.56

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

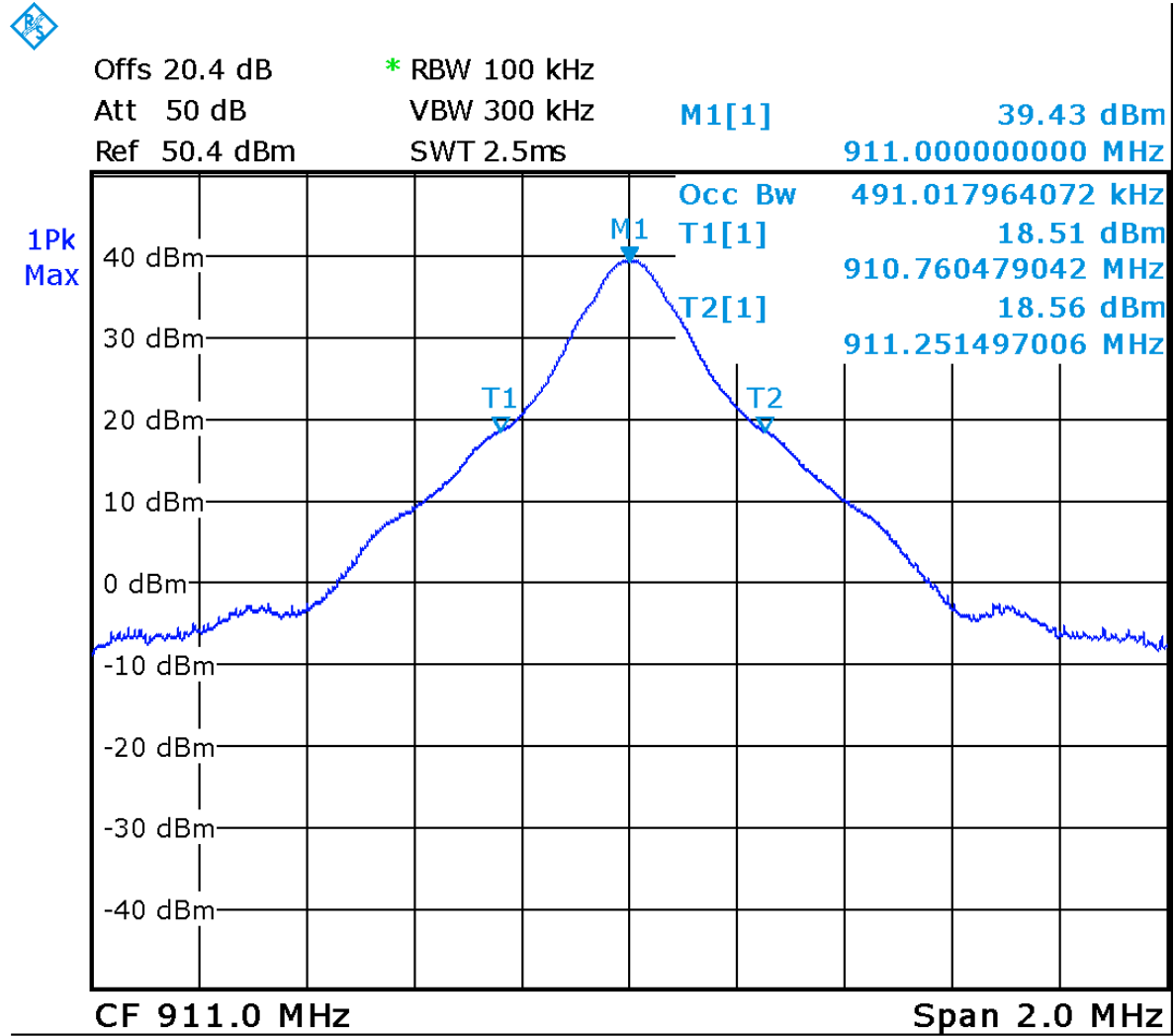
ATA – 909.75 – 921.75 MHz Sub-Band		
Channel	Frequency (MHz)	99% Bandwidth (kHz)
Low Channel	910.0	221.56
Mid Channel	915.0	221.56
High Channel	921.5	221.56

Graph(s)

The graphs showed below shows the OBW during the operation of the device. This is measured by a max hold on the spectrum analyzer and the highest resolution bandwidth that is sufficiently low to exhibit the 99% bandwidth of a channel during operation of the EUT. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

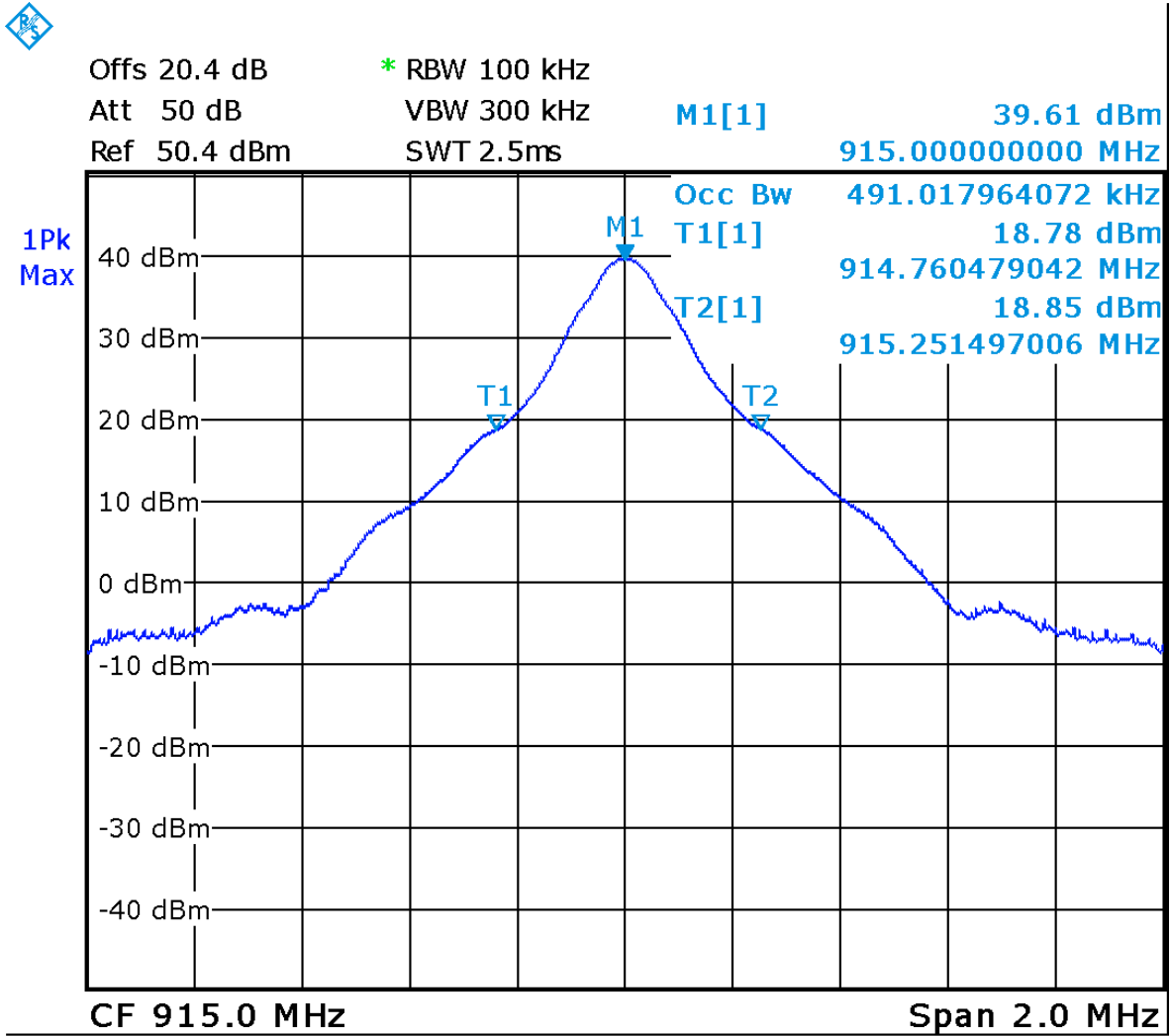
Protocol: 6B
Low Channel



Date: 2.APR.2015 09:48:06

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

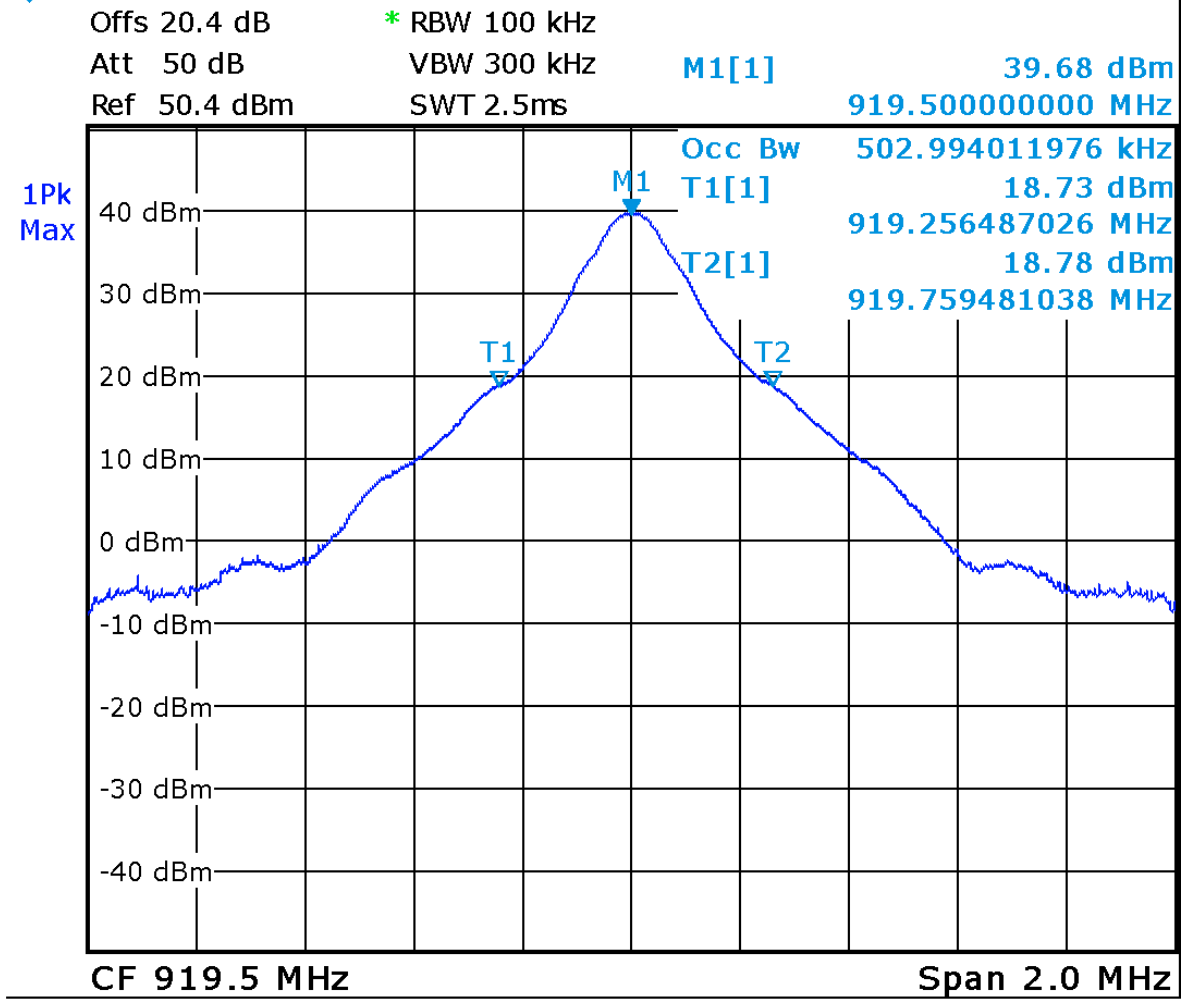
Protocol: 6B
Mid Channel



Date: 2.APR.2015 09:52:16

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

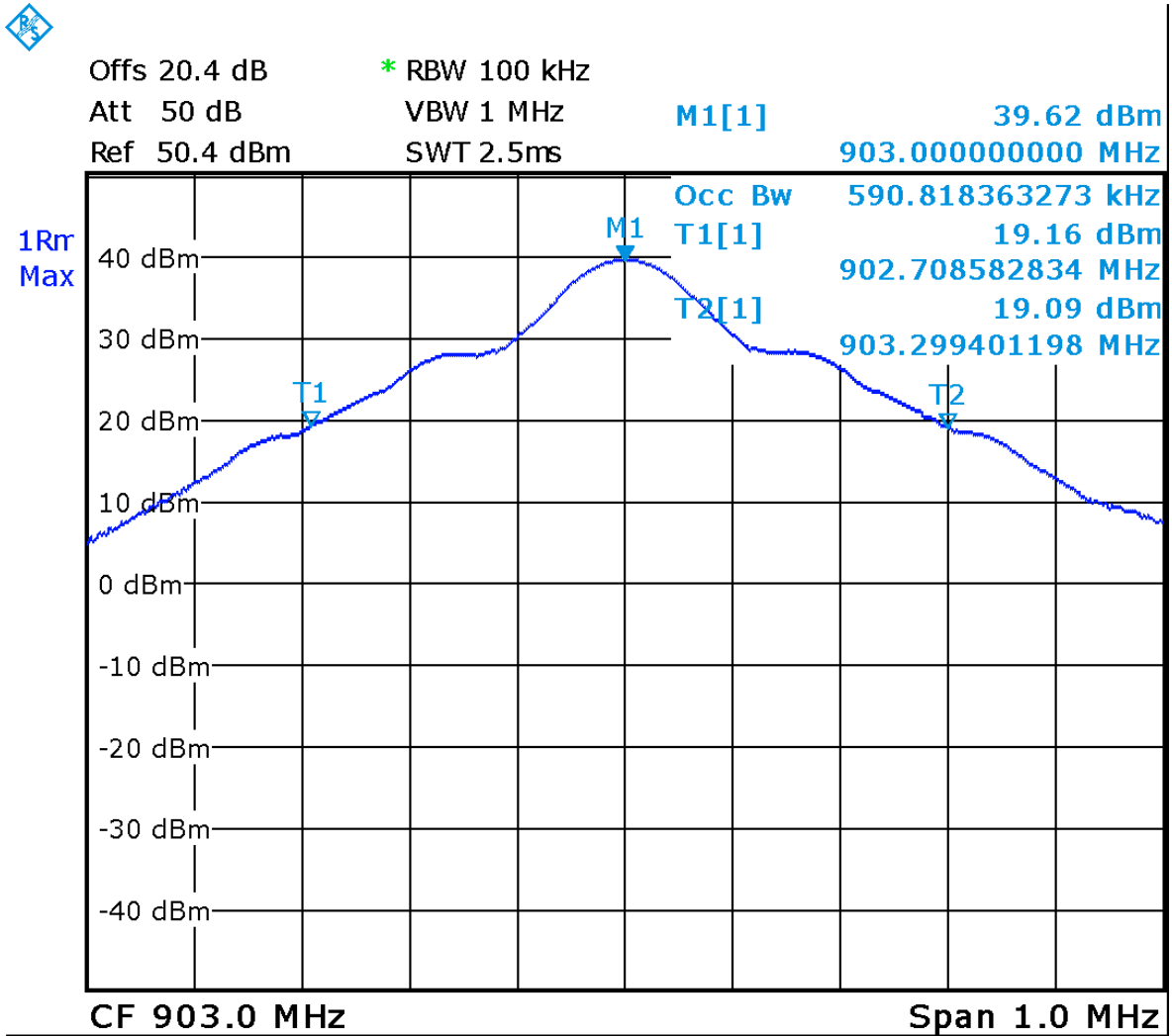
Protocol: 6B
High Channel



Date: 2.APR.2015 10:00:35

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

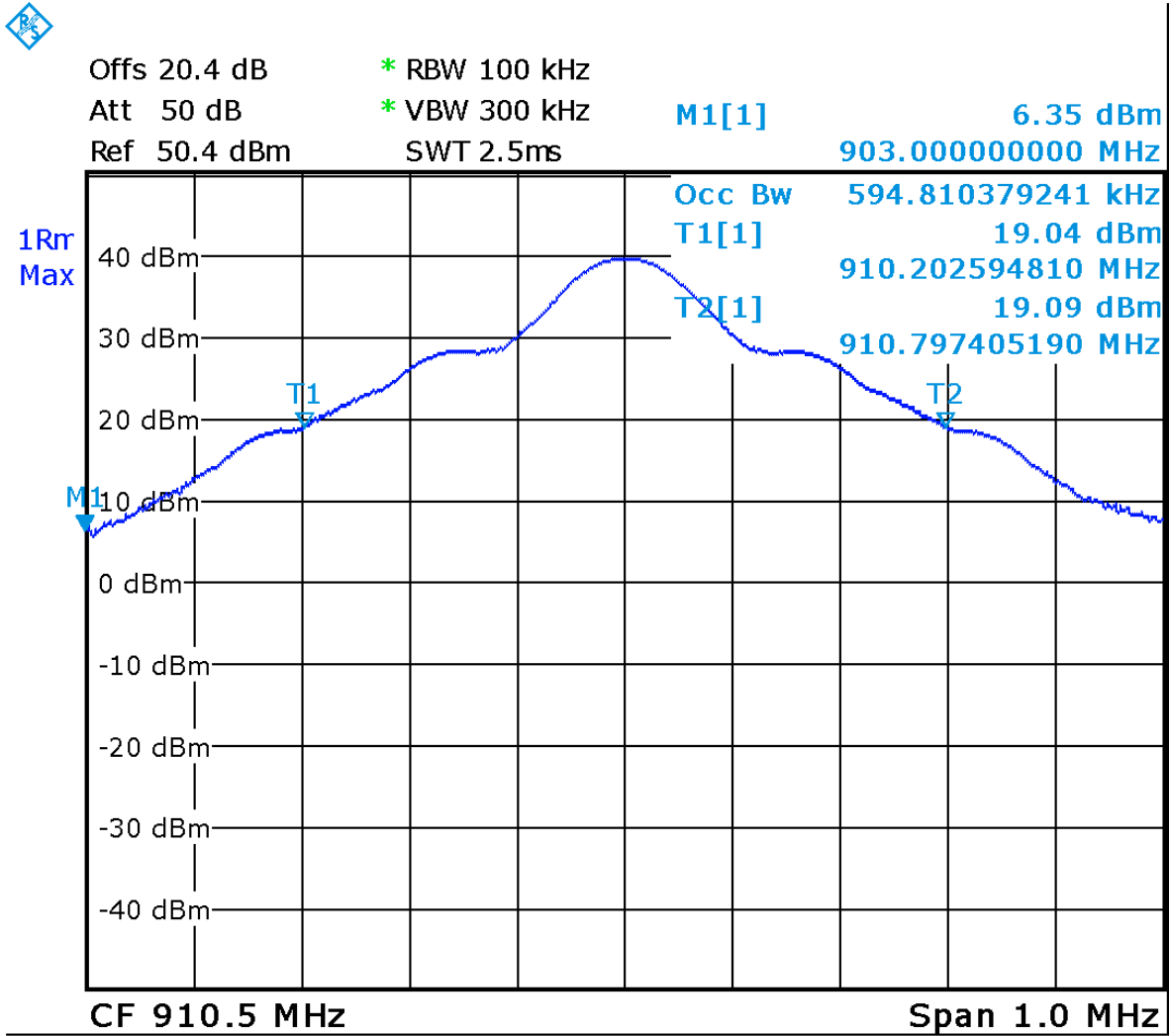
Protocol: 6C: 902 – 904 MHz Sub-Band



Date: 5.MAR.2015 11:54:30

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

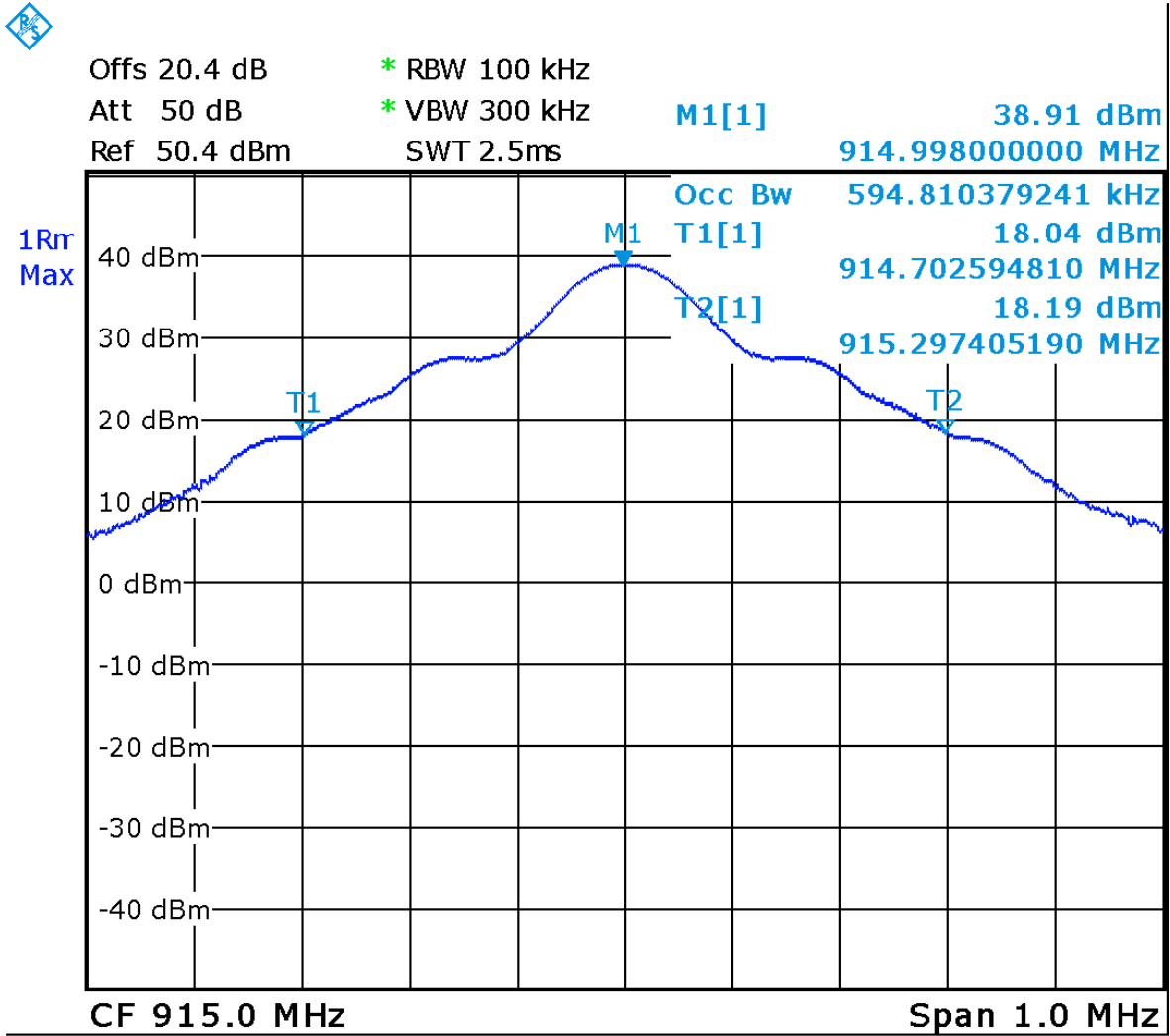
**Protocol: 6C: 909.75 – 921.75 MHz Sub-Band
Low Channel**



Date: 5.MAR.2015 12:01:54

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

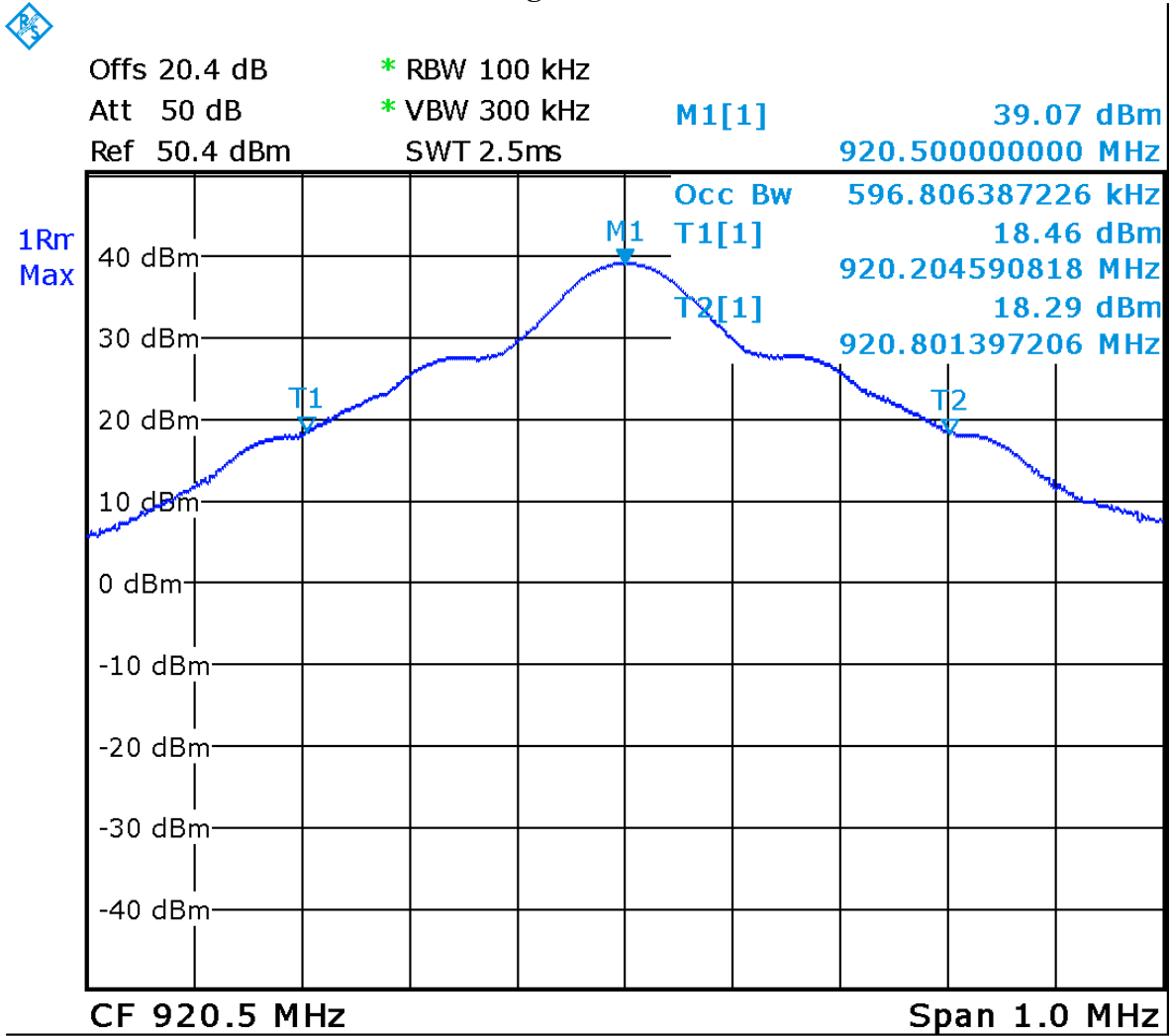
**Protocol: 6C: 909.75 – 921.75 MHz Sub-Band
Mid Channel**



Date: 5.MAR.2015 12:21:28

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

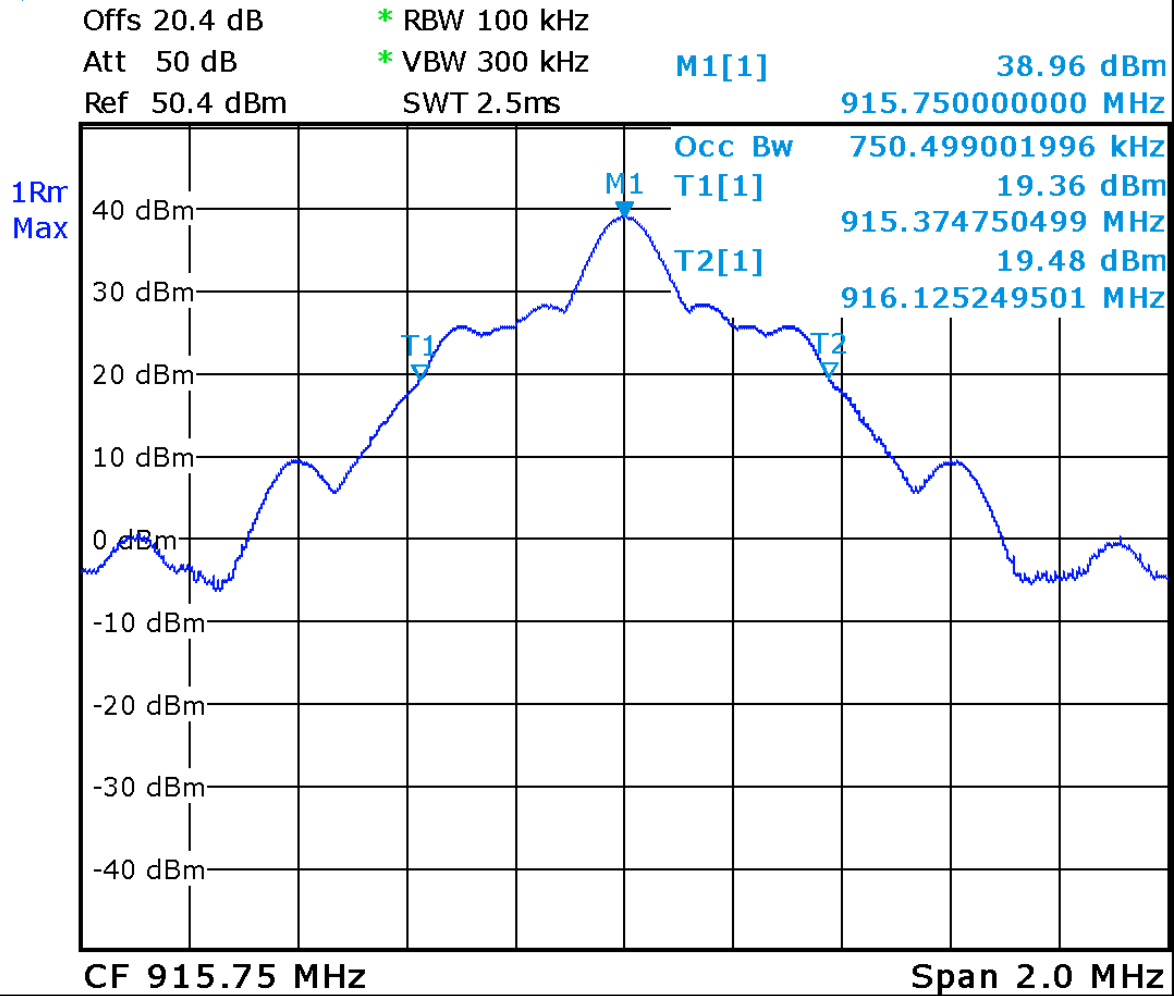
**Protocol: 6C: 909.75 – 921.75 MHz Sub-Band
High Channel**



Date: 5.MAR.2015 12:26:18

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

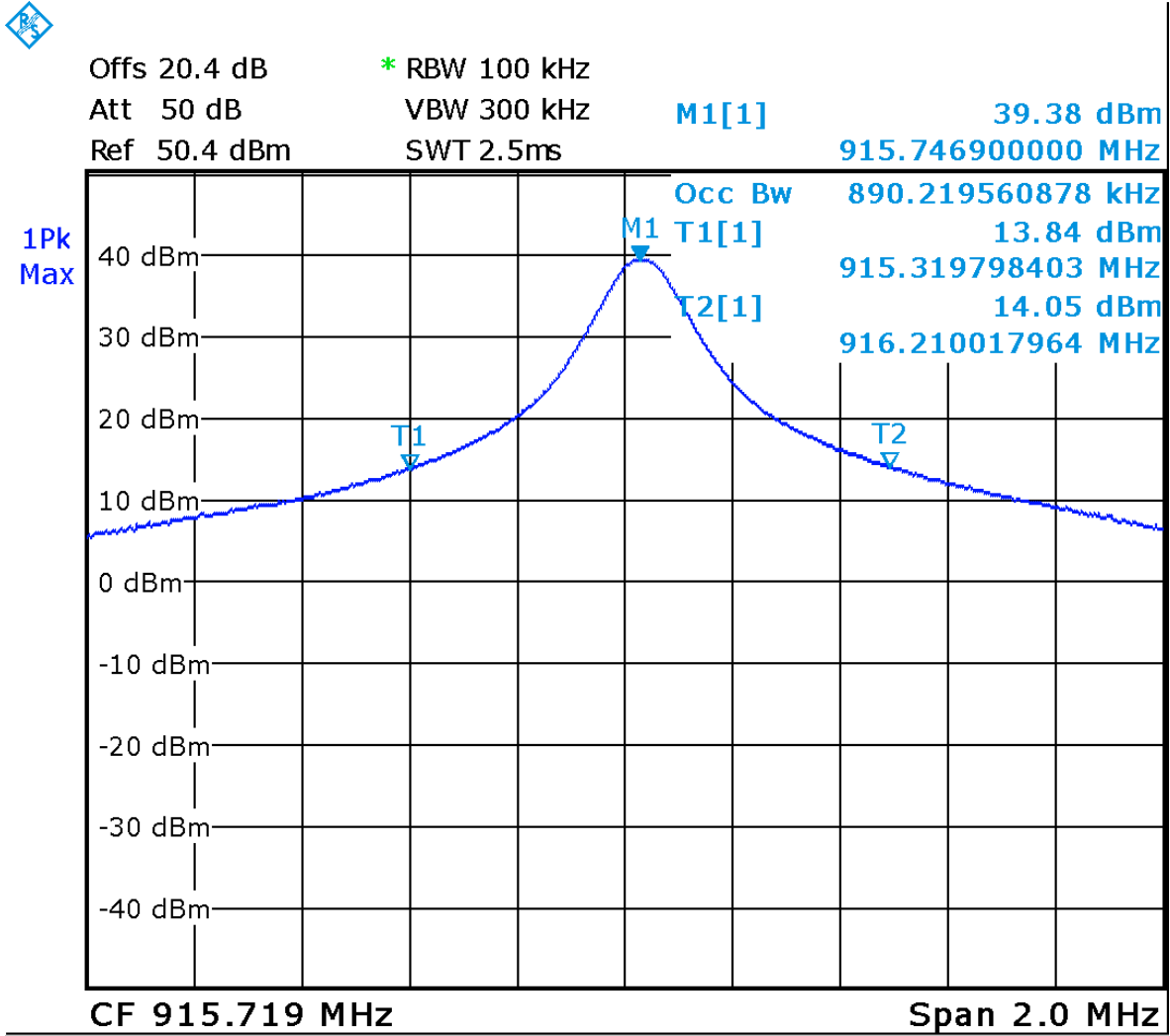
Protocol: Allegro



Date: 2.APR.2015 10:28:14

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

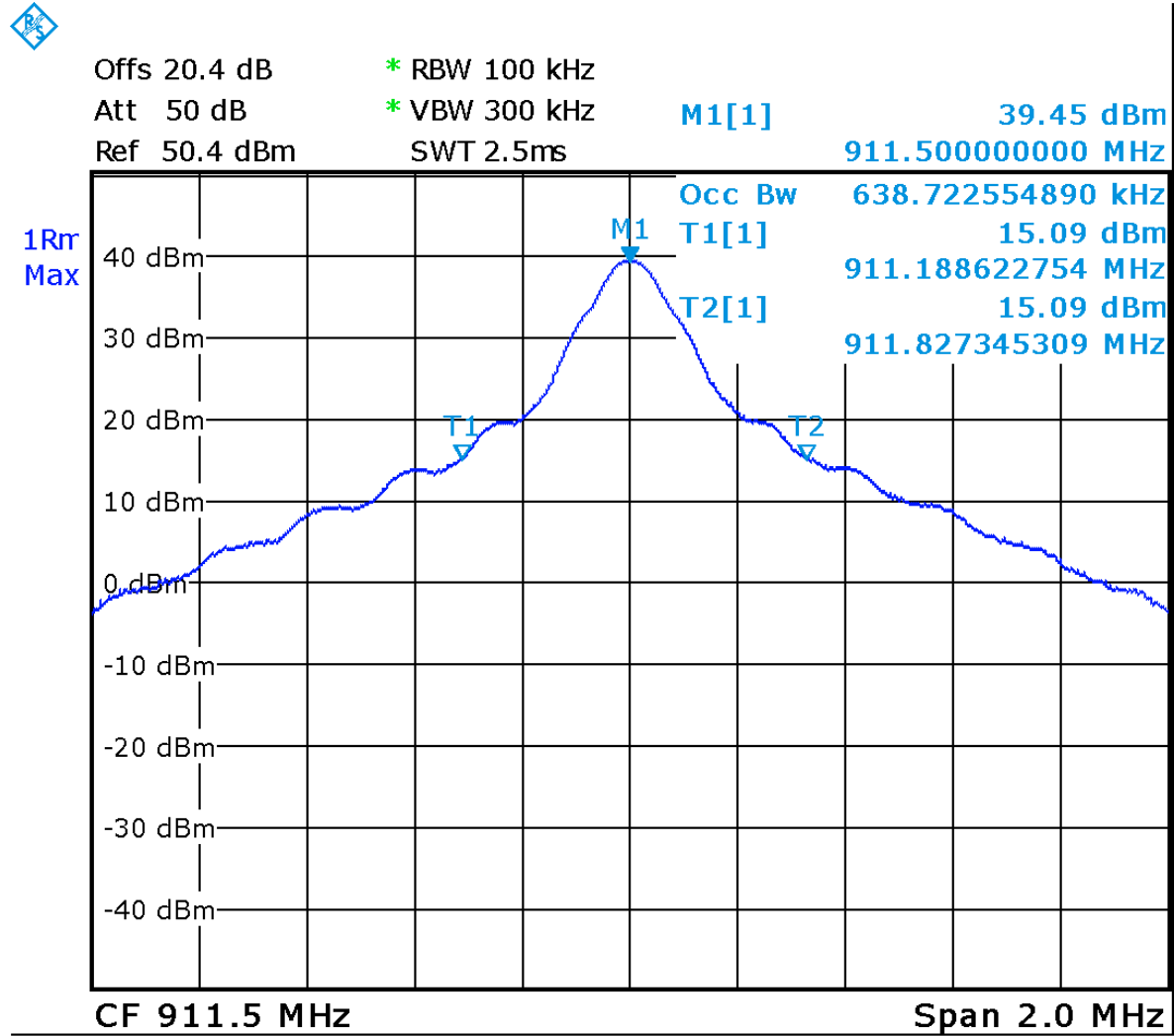
Protocol: IAG



Date: 5.MAR.2015 11:28:06

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

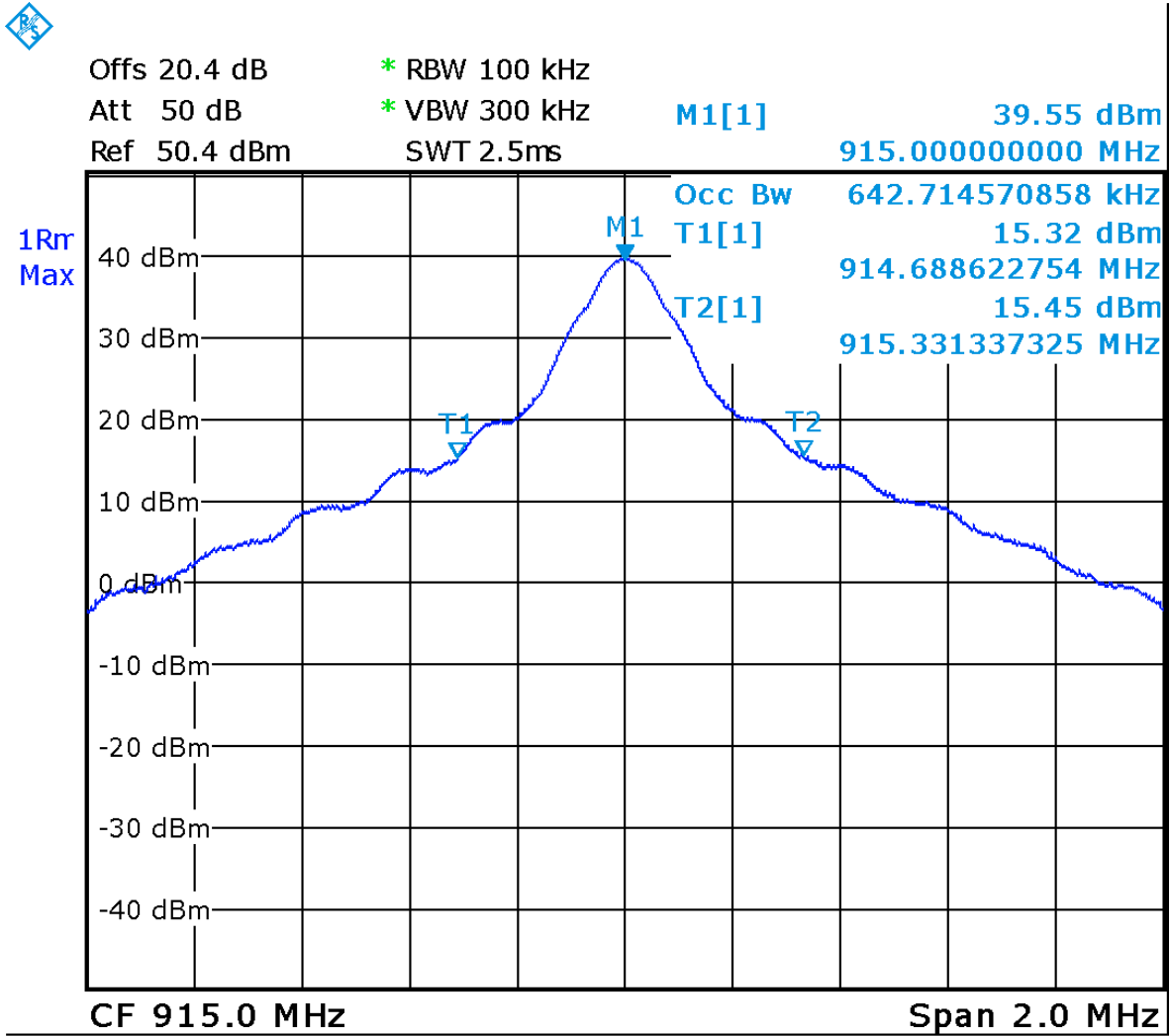
Protocol: SeGO
Low Channel



Date: 2.APR.2015 11:01:38

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

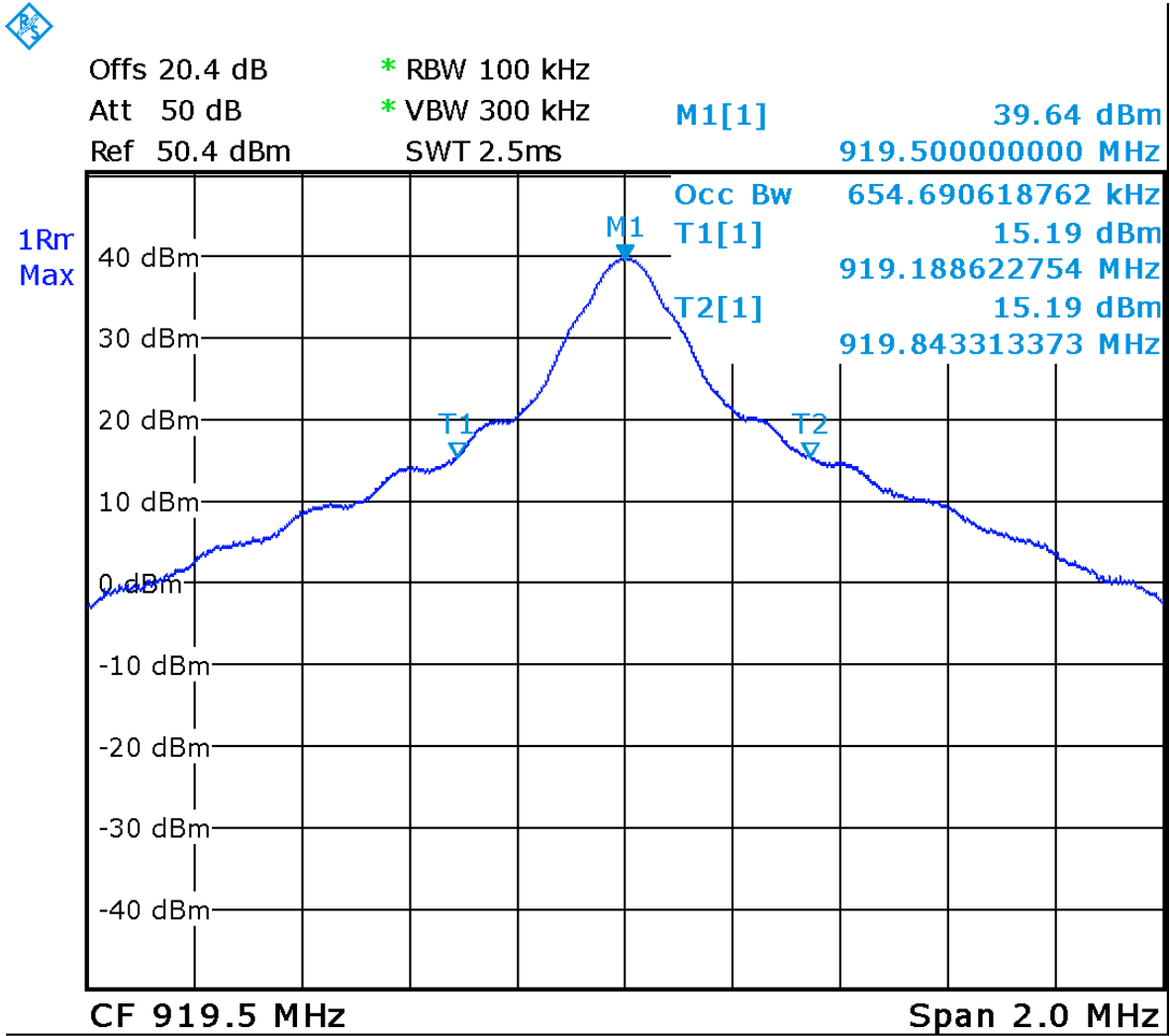
Protocol: SeGO
Mid Channel



Date: 2.APR.2015 11:12:16

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

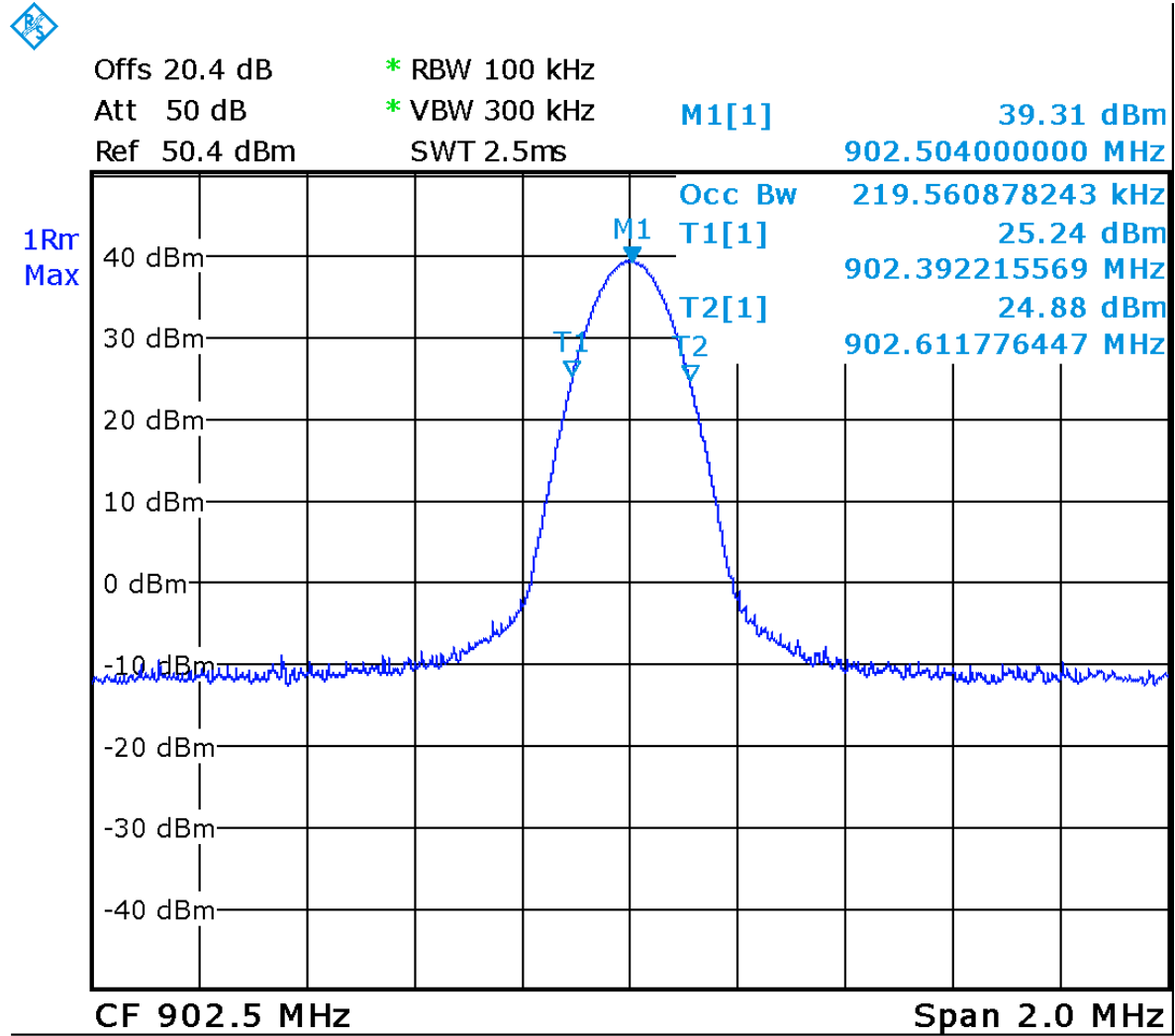
Protocol: SeGO
Hi Channel



Date: 2.APR.2015 11:19:30

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

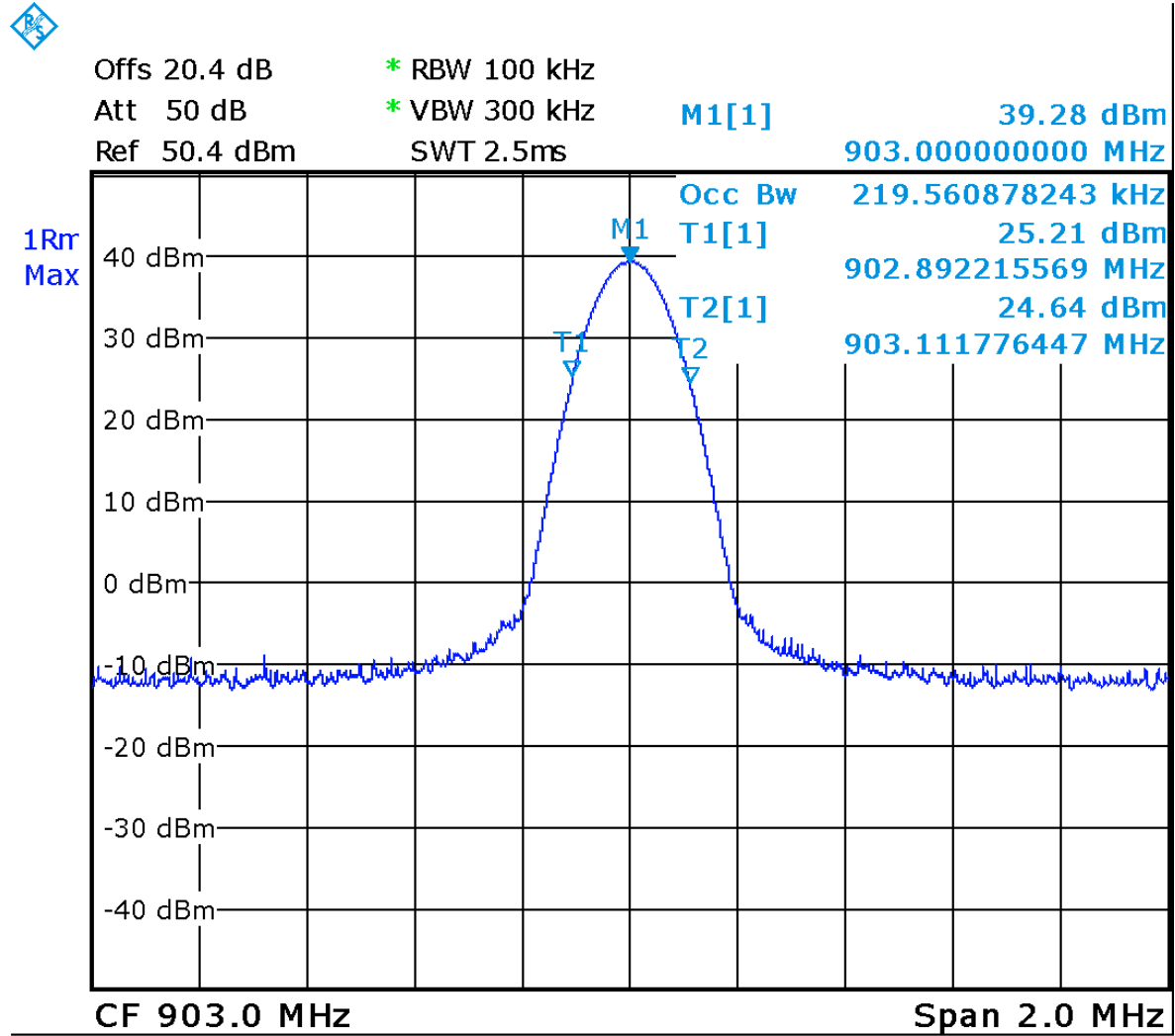
**Protocol: ATA – 902 – 904 MHz Sub-Band
Low Channel**



Date: 2.APR.2015 12:30:13

Client	Kapsch TrafficCom Canada Inc	
Product	MRFM-S with External Amplifier (MRFM-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

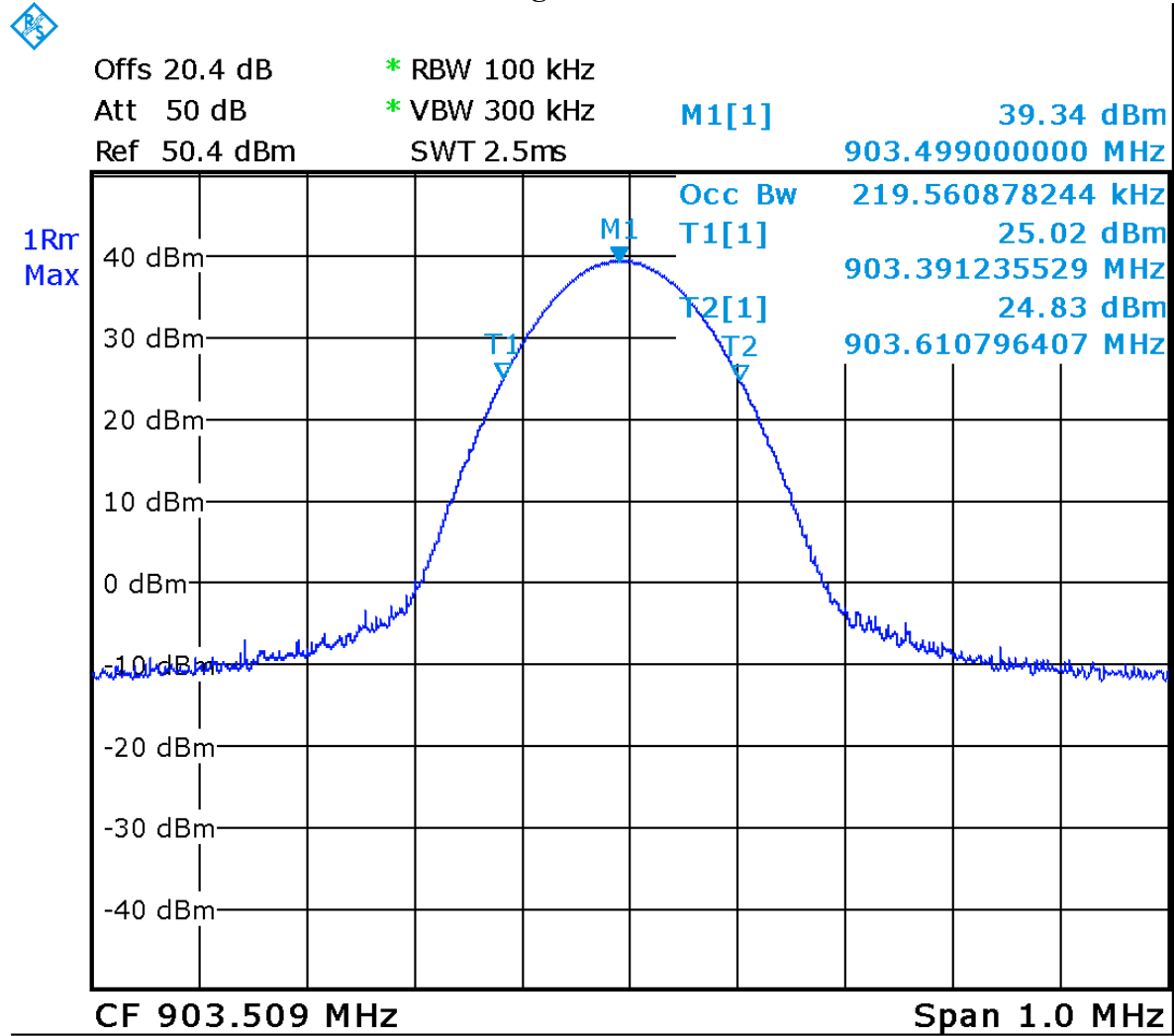
**Protocol: ATA – 902 – 904 MHz Sub-Band
Mid Channel**



Date: 2.APR.2015 12:33:02

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

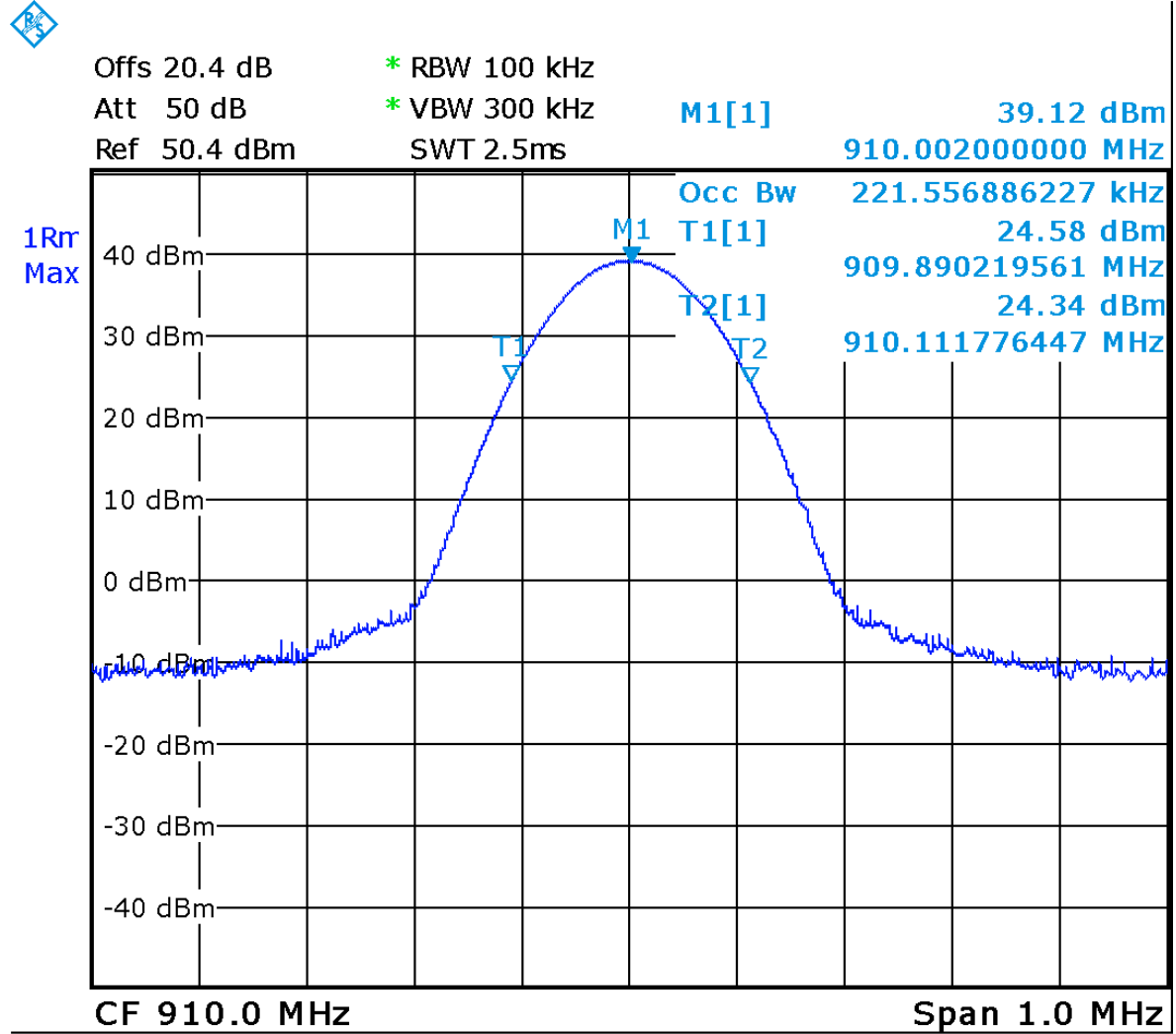
**Protocol: ATA – 902 – 904 MHz Sub-Band
High Channel**



Date: 2.APR.2015 12:48:14

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

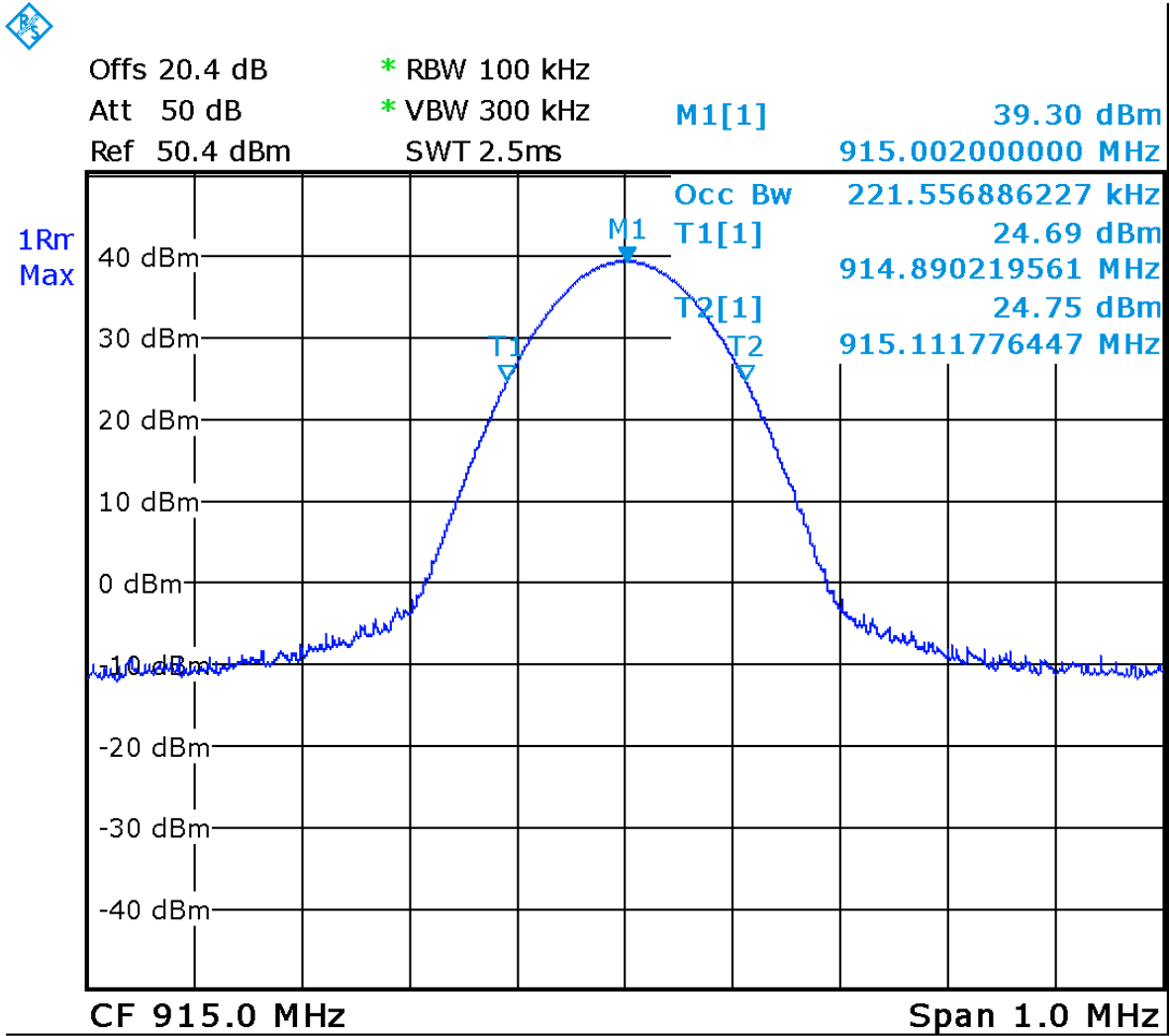
**Protocol: ATA – 909.75 – 921.75 MHz Sub-Band
Low Channel**



Date: 2.APR.2015 13:03:37

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

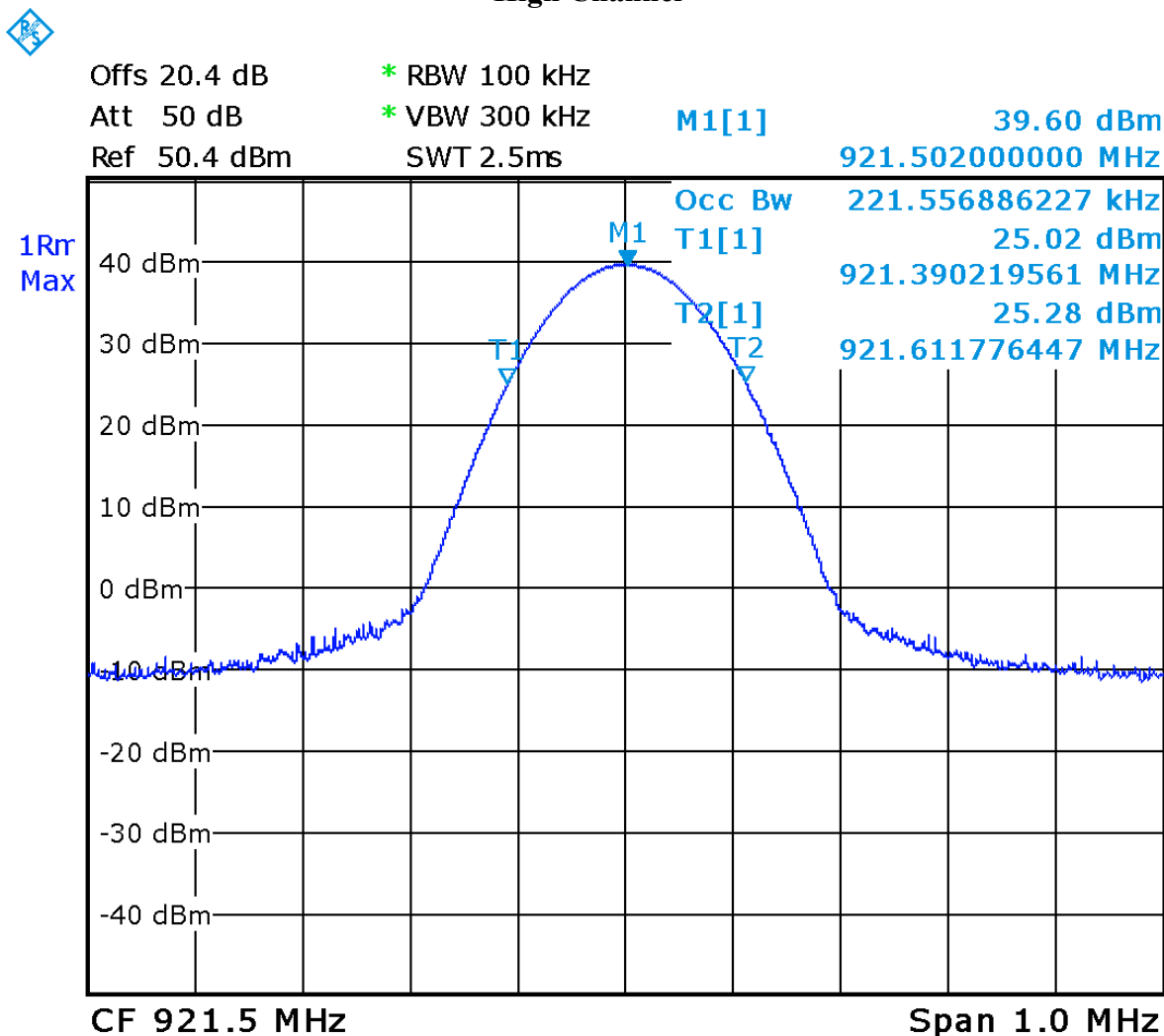
**Protocol: ATA -909.75 – 921.75 MHz Sub-Band
Mid Channel**



Date: 2.APR.2015 13:06:35

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

**Protocol: ATA -909.75 – 921.75 MHz Sub-Band
High Channel**



Date: 2.APR.2015 13:17:18

Note: See 'Appendix B – EUT & Test Setup Photographs' for photos showing the test set-up.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration date	Next calibration due date	Asset #
Spectrum Analyzer	ESL 6	Rohde & Schwarz	15-Nov-2013	15-Nov-2015	GEMC 160
Power Attenuator 20 dB	25-A-FFN-20	Bird / Hutton	NCR	NCR	GEMC 49
RF Cable 1m	LMR-400-1M-50OHM-MN-MN	LexTec	NCR	NCR	GEMC 29

This report module is based on GEMC template "FCC – Power Line Conducted Emissions Class B_Rev1"

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Emission Mask

Purpose

The purpose of this test is to ensure that the maximum power conducted to the radiating element at frequencies outside of the authorized spectrum does not exceed the limits specified. This ensures that the only the intended signal is delivered to the radiating element.

Limits

The Limit is as specified in FCC Part 90.210 (K) and RSS-137 Clause 6.5.3

Emission Mask K—(1) Wideband multilateration transmitters. For transmitters authorized under subpart M to provide forward or reverse links in a multilateration system in the subbands 904-909.75 MHz, 921.75-927.25 MHz and 919.75-921.75 MHz, and which transmit an emission occupying more than 50 kHz bandwidth: in any 100 kHz band, the center frequency of which is removed from the center of authorized sub-band(s) by more than 50 percent of the authorized bandwidth, the power of emissions shall be attenuated below the transmitter output power, as specified by the following equation, but in no case less than 31 dB:

$$A = 16 + 0.4(D - 50) + 10 \log B \text{ (attenuation greater than 66 dB is not required)}$$

Where:

- A = attenuation (in decibels) below the maximum permitted output power level
- D = displacement of the center frequency of the measurement bandwidth from the center frequency of the authorized sub-band, expressed as a percentage of the authorized bandwidth B
- B = authorized bandwidth in megahertz.

(2) Narrowband forward link transmitters. For LMS multilateration narrowband forward link transmitters operating in the 927.25-928 MHz frequency band the power of any emission shall be attenuated below the transmitter output power (P) in accordance with following schedule:

On any frequency outside the authorized sub-band and removed from the edge of the authorized sub-band by a displacement frequency (f_d in kHz): at least $116 \log ((f_d + 10)/6.1)$ dB or $50 + 10 \log (P)$ dB or 70 dB, whichever is the lesser attenuation.

(3) Other transmitters. For all other transmitters authorized under subpart M that operate in the 902-928 MHz band, the peak power of any emission shall be attenuated below the

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

power of the highest emission contained within the licensee's sub-band in accordance with the following schedule:

- (i) On any frequency within the authorized bandwidth: Zero dB.
 - (ii) On any frequency outside the licensee's sub-band edges: $55 + 10 \log(P)$ dB, where (P) is the highest emission (watts) of the transmitter inside the licensee's sub-band.
- (4) In the 902-928 MHz band, the resolution bandwidth of the instrumentation used to measure the emission power shall be 100 kHz, except that, in regard to paragraph (2) of this section, a minimum spectrum analyzer resolution bandwidth of 300 Hz shall be used for measurement center frequencies with 1 MHz of the edge of the authorized subband. The video filter bandwidth shall not be less than the resolution bandwidth.
- (5) Emission power shall be measured in peak values.
- (6) The LMS sub-band edges for non-multilateration systems for which emissions must be attenuated are 902.00, 904.00, 909.5 and 921.75 MHz.

Note: The EUT is a non- multilateration LMS transmitter. Emission limit (3) applies to the EUT. A $55 + 10 \log(P)$ dB attenuation (or -25 dBm absolute emission level) was applied all frequency from the outside authorized band.

Test procedure is as per eCFR 47 Part 2 Clause 2.1051.

Results

Harmonics of the EUT meet attenuation requirement at the antenna port.

Each of the 6 supported protocol was tested. Where a protocol have more than one channel, the low and high channels were measured. The worst case is presented as a graph for the spectrum.

The ATA and 6C protocols operate in both non- multilateration LMS sub-bands and the other 4 protocols operate in the 909.75 – 921.75 MHz sub-band.

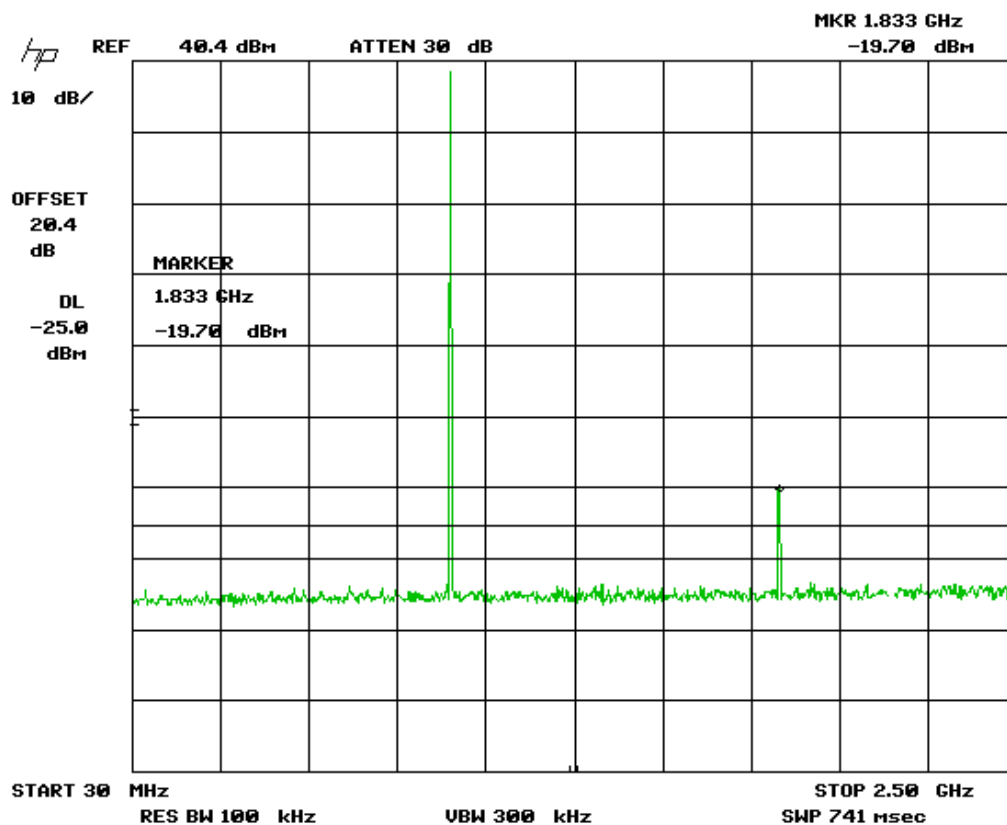
Band edge requirements were shown for the lower band edge at 902.0 and 909.5 MHz in the low band where applicable. Band edge requirements were also shown for the higher band edge at 904.0 and 921.75 MHz in the high band where applicable.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Graph(s)

The graphs shown below shows the peak power output of the device during the antenna conducted measurement during transmit operation of the EUT.

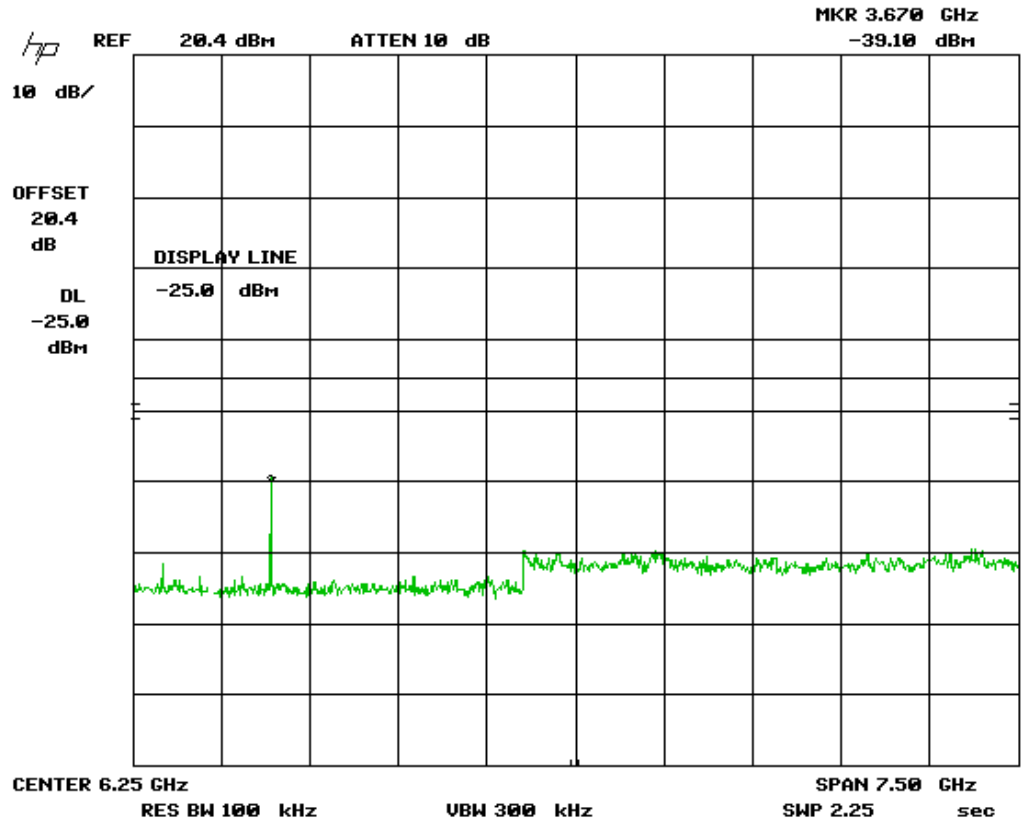
Protocol: 6B High Channel 30 MHz – 2.5 GHz



Note: Applying the minimum 2nd harmonic attenuation, 9.23 dB, the emission at 1.833 GHz is -28.93 dBm. Thus the EUT meets the Emission Mask requirements.

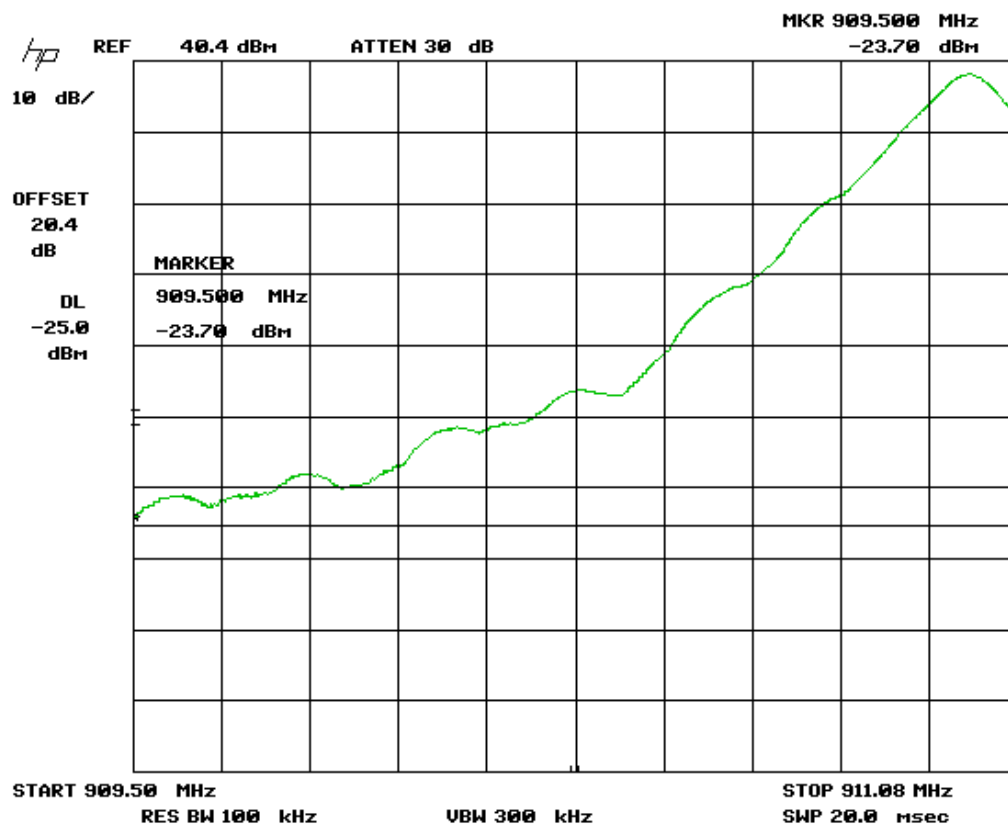
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Protocol: 6B
High Channel 2.5 GHz – 10 GHz



Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

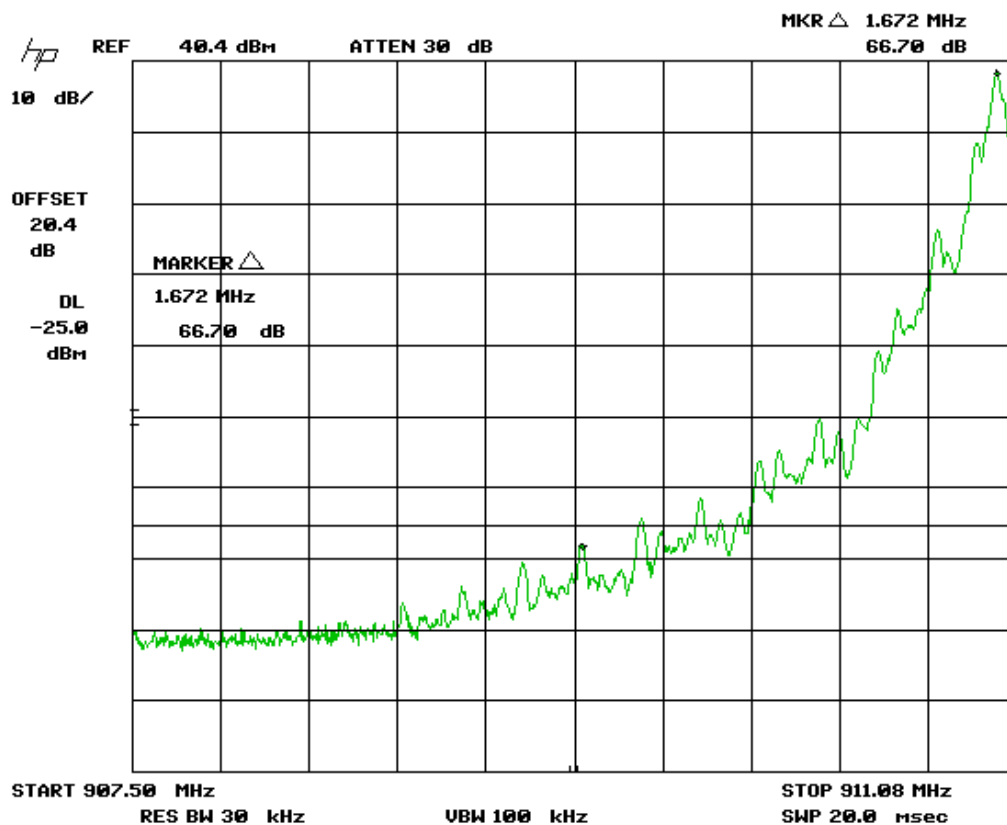
Protocol: 6B
Low Channel – 909.5 MHz Band Edge



Note: Marker Delta was applied to the 909.5 MHz Band edge. See tables for details.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

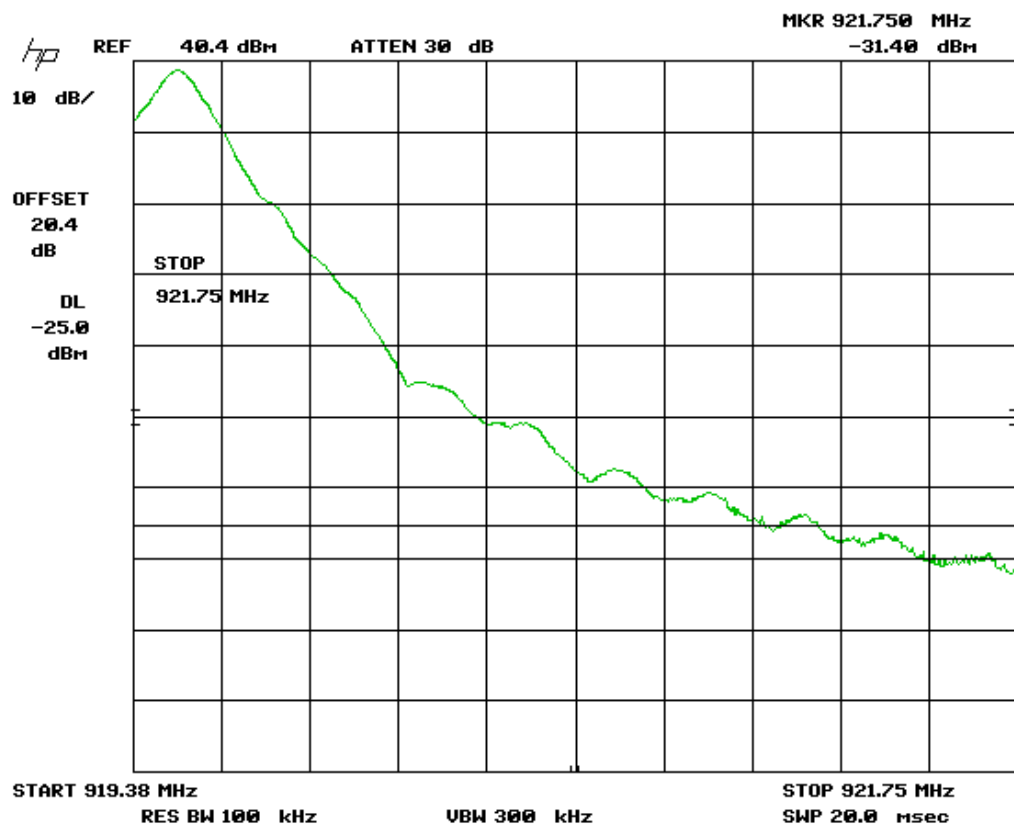
Protocol: 6B
Low Channel – 909.5 MHz Marker Delta



Note: Marker Delta was applied to the 909.5 MHz Band edge. See tables for details.

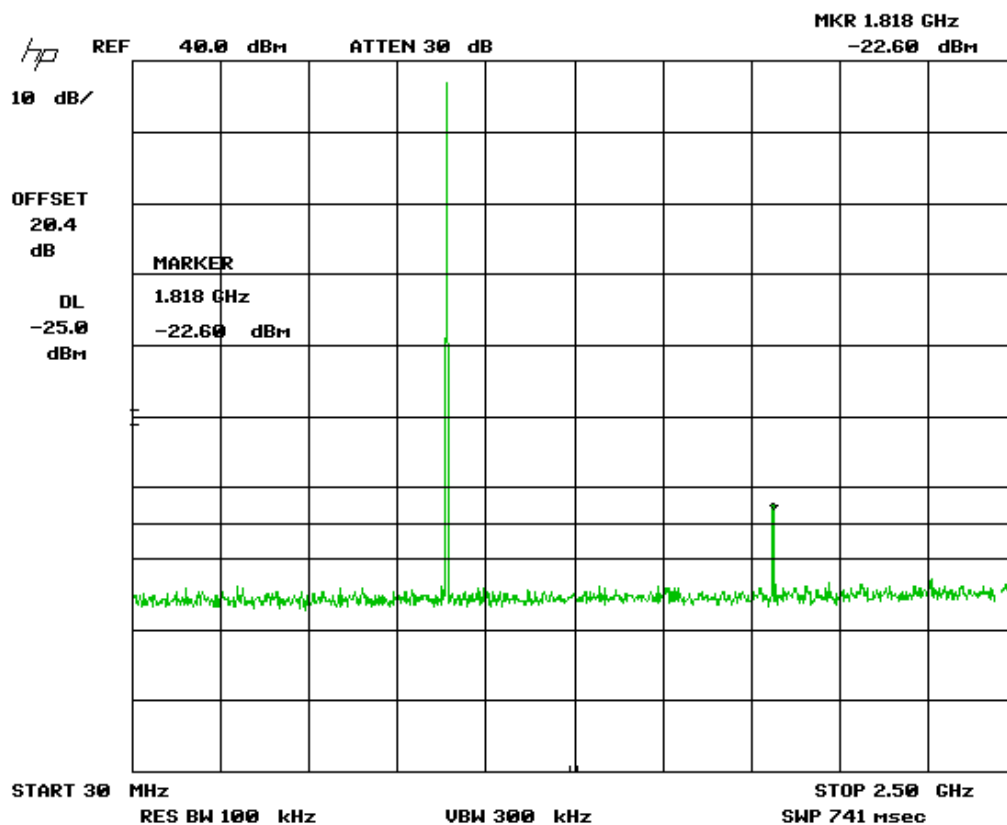
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Protocol: 6B
High Channel – Band Edge 921.75



Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

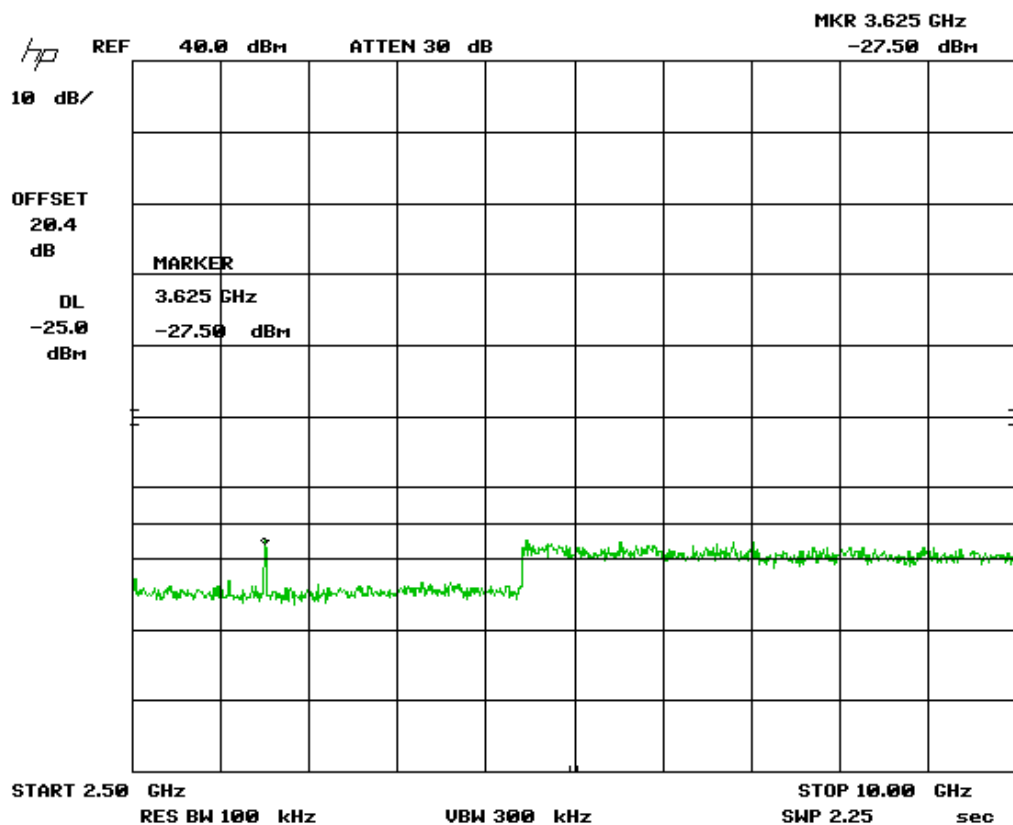
Protocol: 6C
High Channel 30 MHz – 2.5 GHz



Note: Applying the minimum 2nd harmonic attenuation, 9.23 dB, the emission at 1.818 GHz is -31.83 dBm. Thus the EUT meets the Emission Mask requirements.

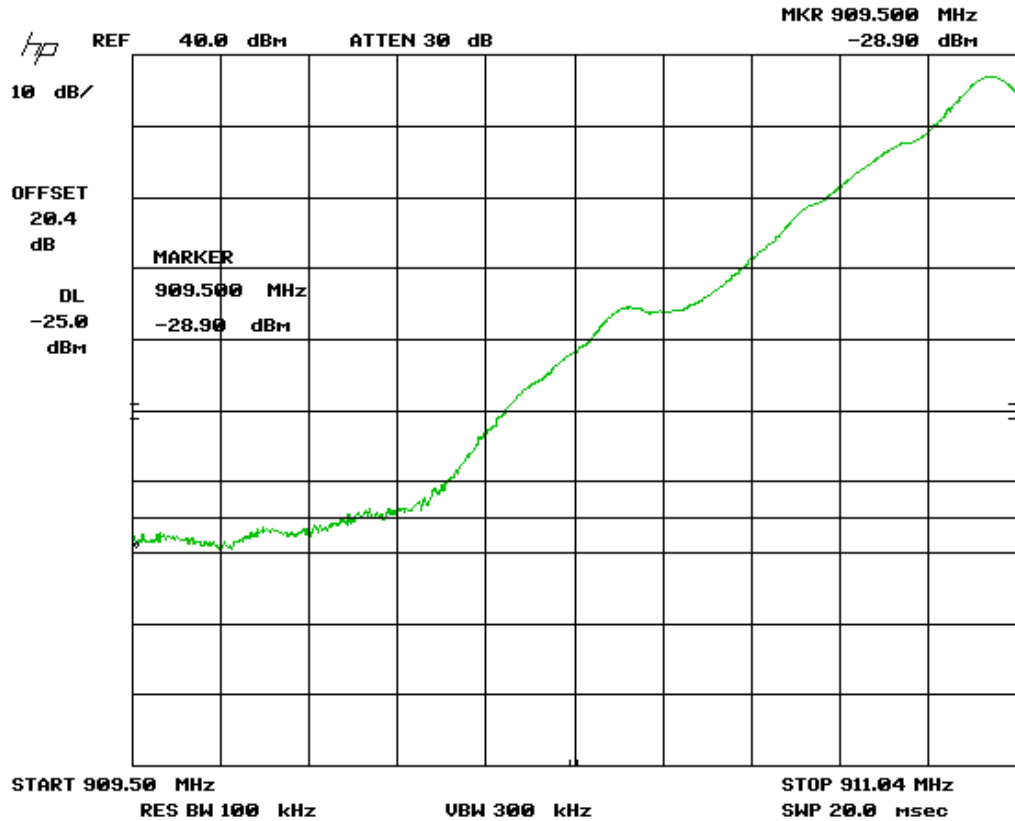
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Protocol: 6C
High Channel 2.5 GHz – 10 GHz



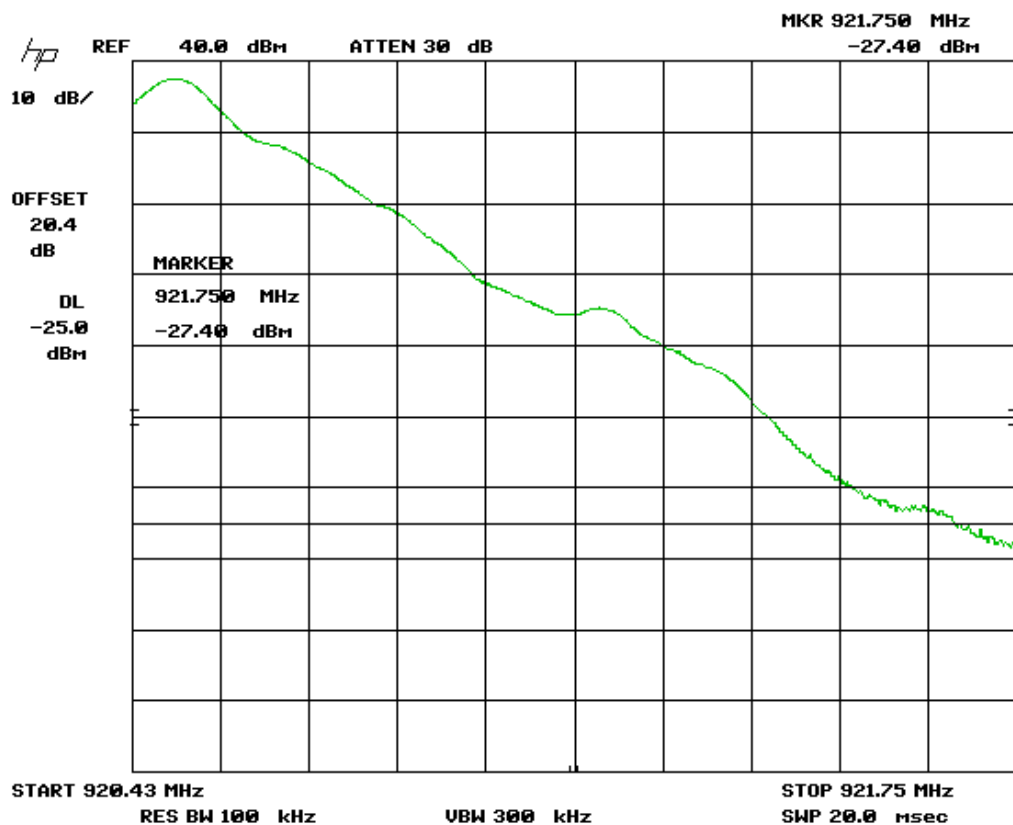
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

**Protocol: 6C: 909.75 – 921.75 MHz Sub-Band
Low Channel – 909.5 MHz Band Edge**



Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

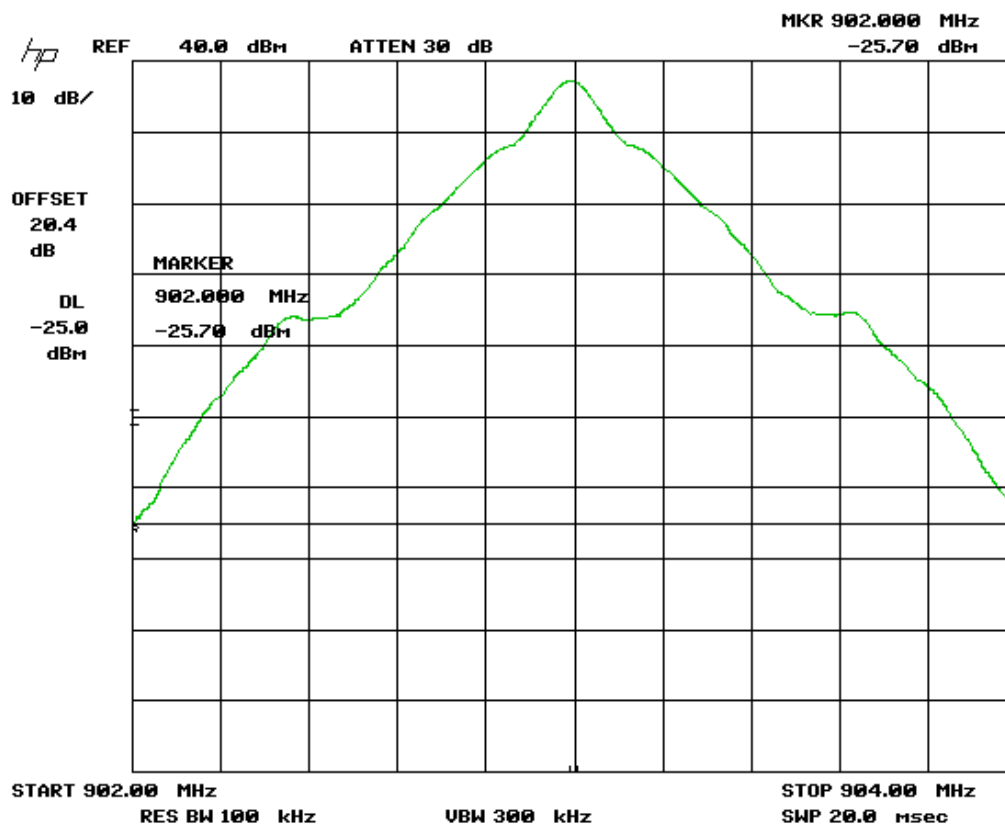
**Protocol: 6C: 909.75 – 921.75 MHz Sub-Band
High Channel –921.75 MHz Band Edge**



Note: Marker Delta was applied to the 902 MHz and 904 MHz Band edge. See tables for details.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

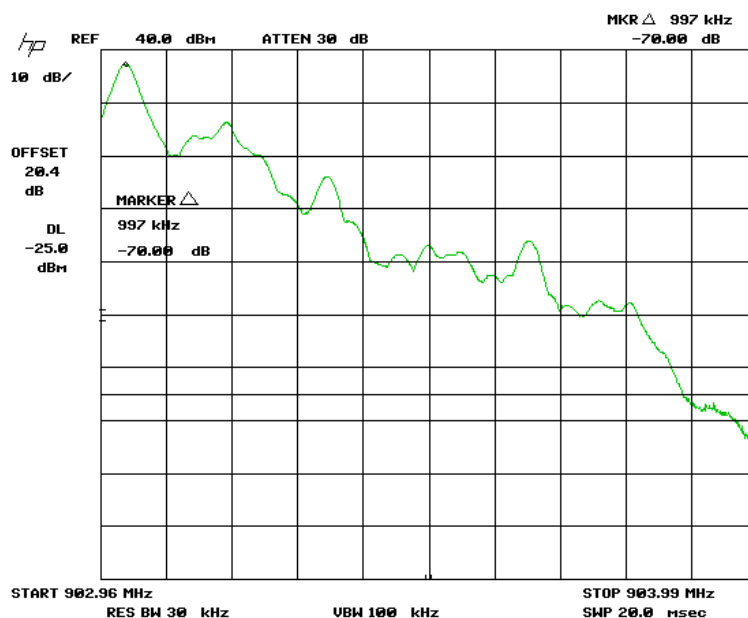
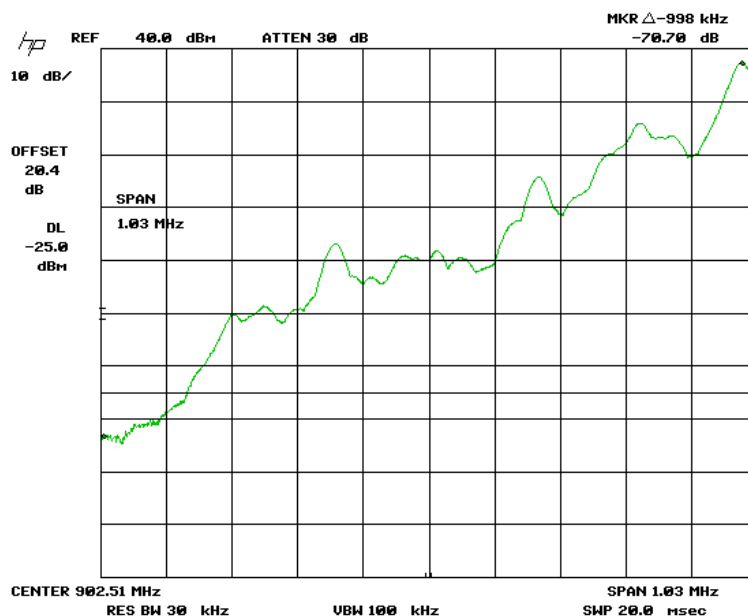
**Protocol: 6C: 902 – 904 MHz Sub-Band
902 and 904 MHz Band Edges**



Note: Marker Delta was applied to the 902 MHz and 904 MHz Band edge. See tables for details.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

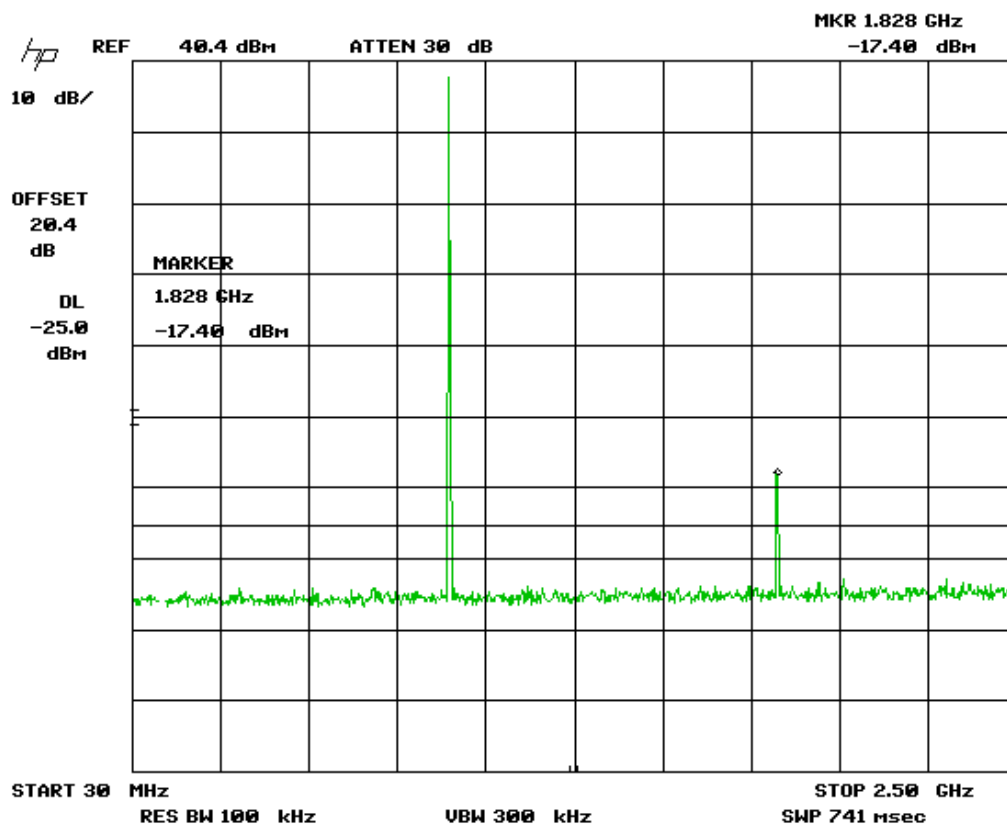
**Protocol: 6C: 902 – 904 MHz Sub-Band
902 and 904 MHz Marker Delta**



Note: Marker Delta was applied to the 902 MHz and 904 MHz Band edge. See tables for details.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

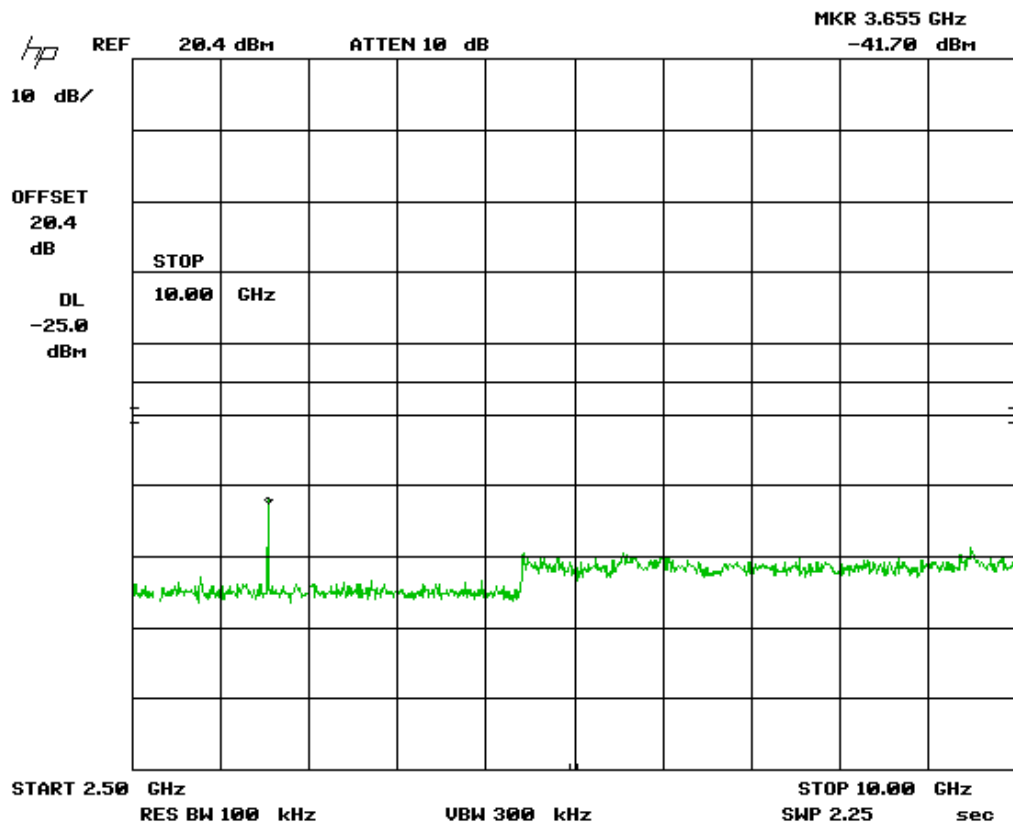
**Protocol: Allegro
30 MHz – 2.5 GHz**



Note: Applying the minimum 2nd harmonic attenuation, 9.23 dB, the emission at 1.828 GHz is -26.63 dBm. Thus the EUT meets the Emission Mask requirements.

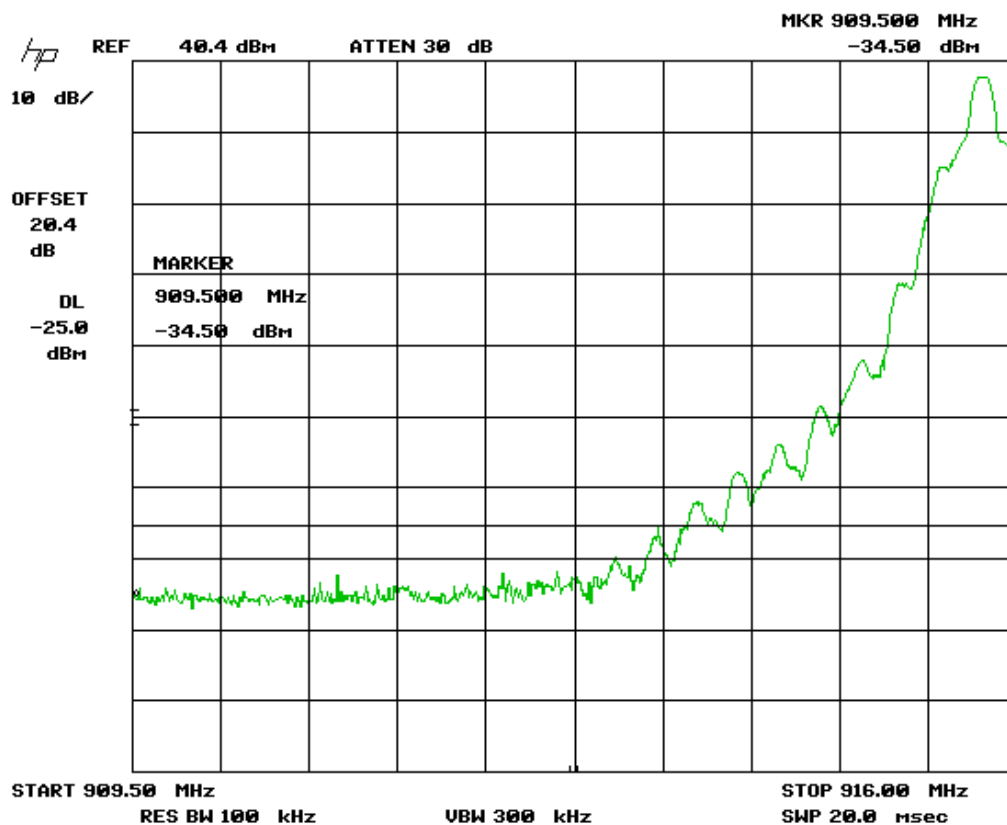
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Protocol: Allegro
2.5 GHz – 10 GHz



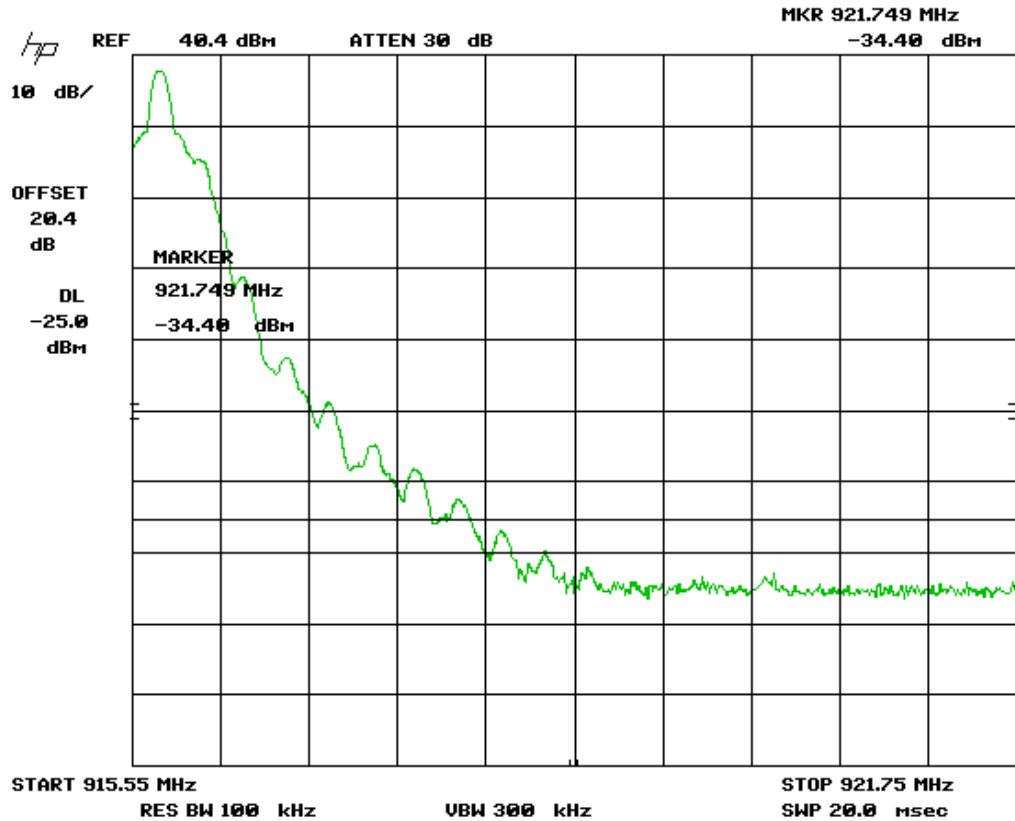
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

**Protocol: Allegro
909.5 MHz Band Edge**



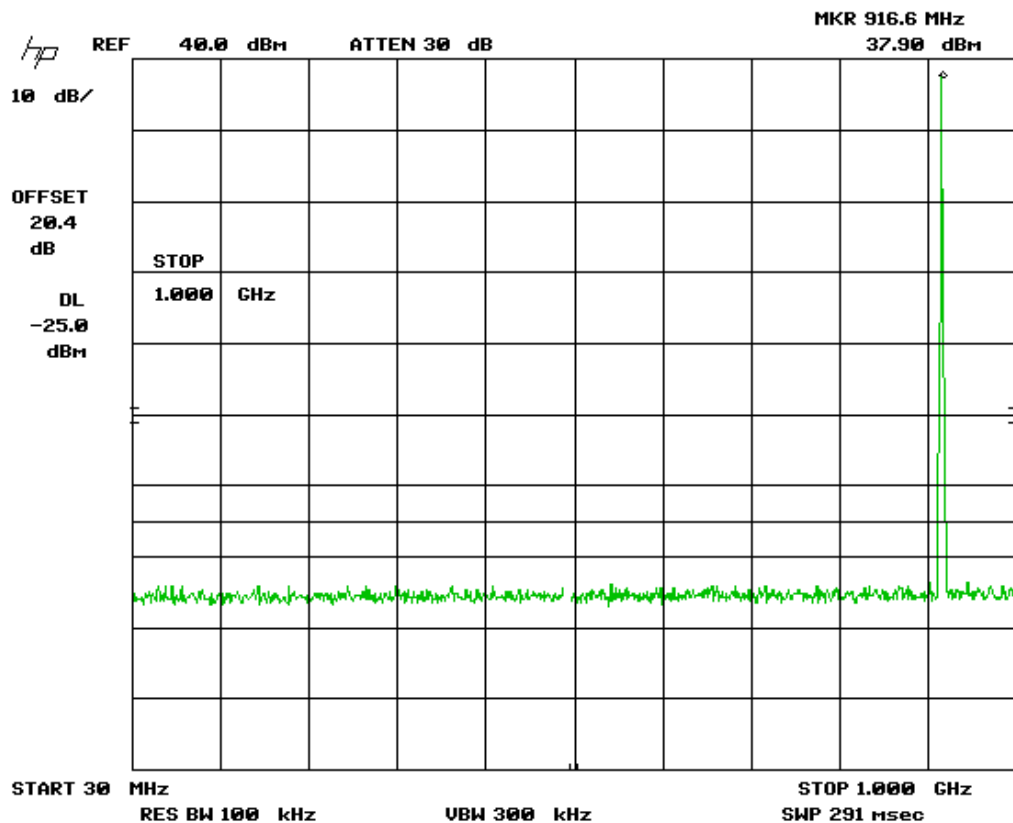
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

**Protocol: Allegro
921.75 MHz Band Edge**



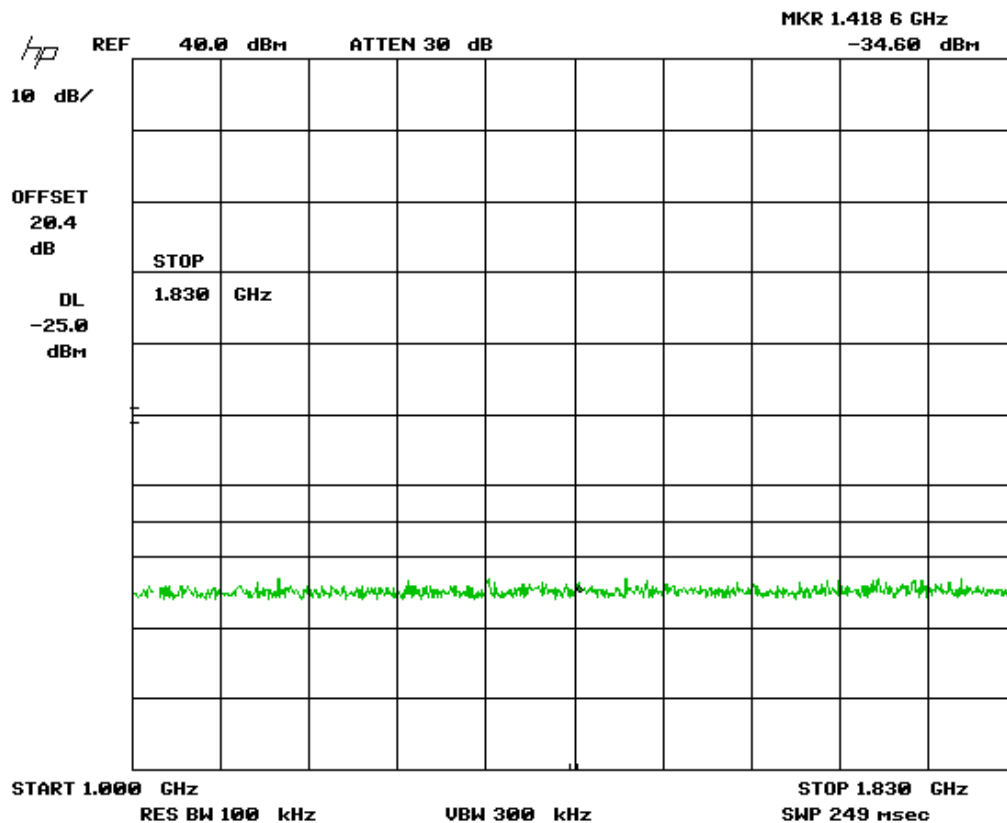
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

**Protocol: IAG
30 MHz – 1GHz**



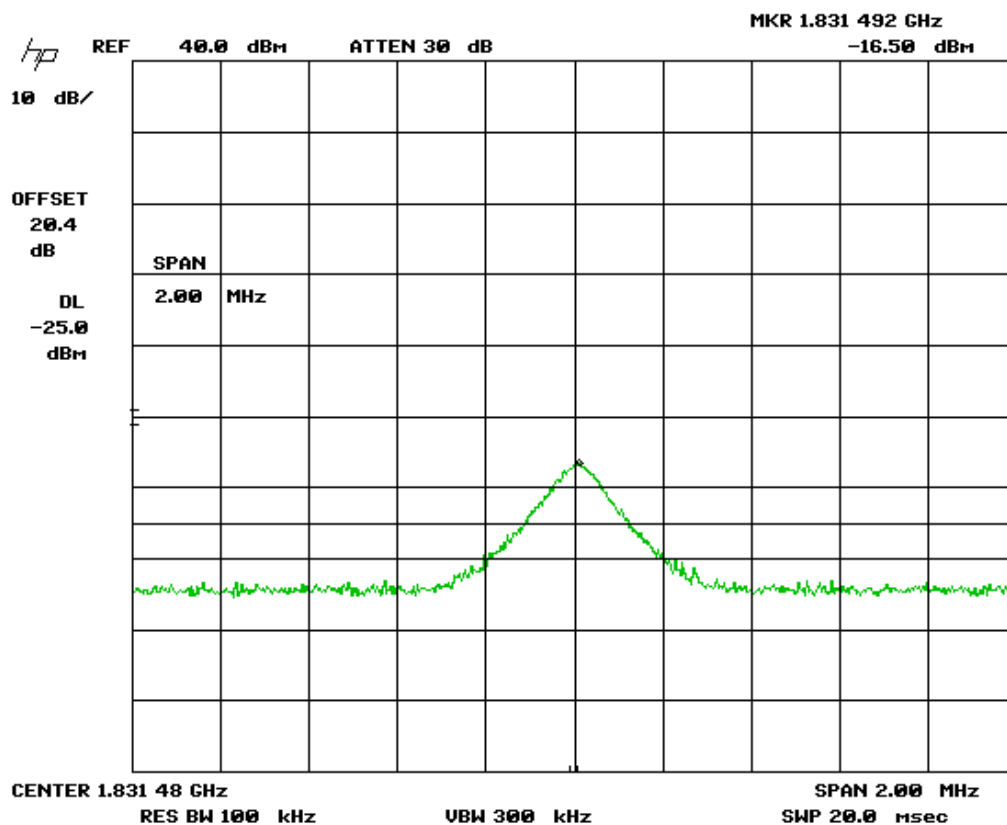
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

**Protocol: IAG
1 GHz – 1.83 GHz**



Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

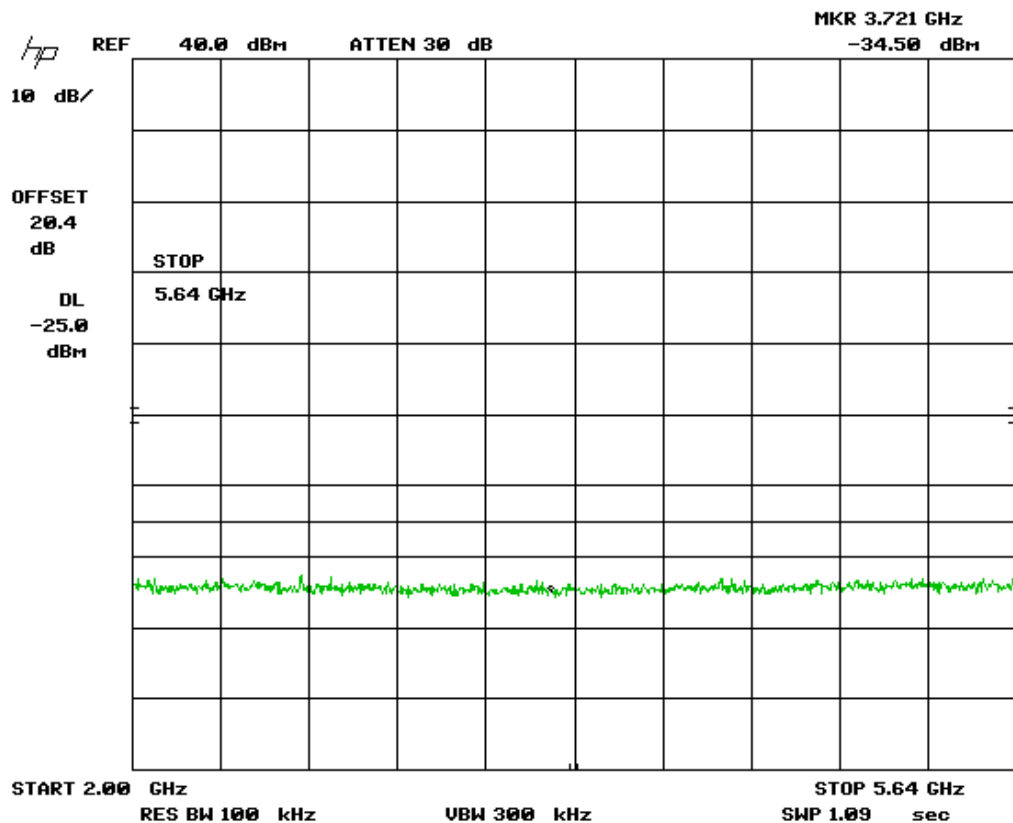
Protocol: IAG
1.83 GHz – 2 GHz / 2nd Harmonic



Note: Applying the minimum 2nd harmonic attenuation, 9.23 dB, the emission at 1.831 GHz is -25.73 dBm. Thus the EUT meets the Emission Mask requirements.

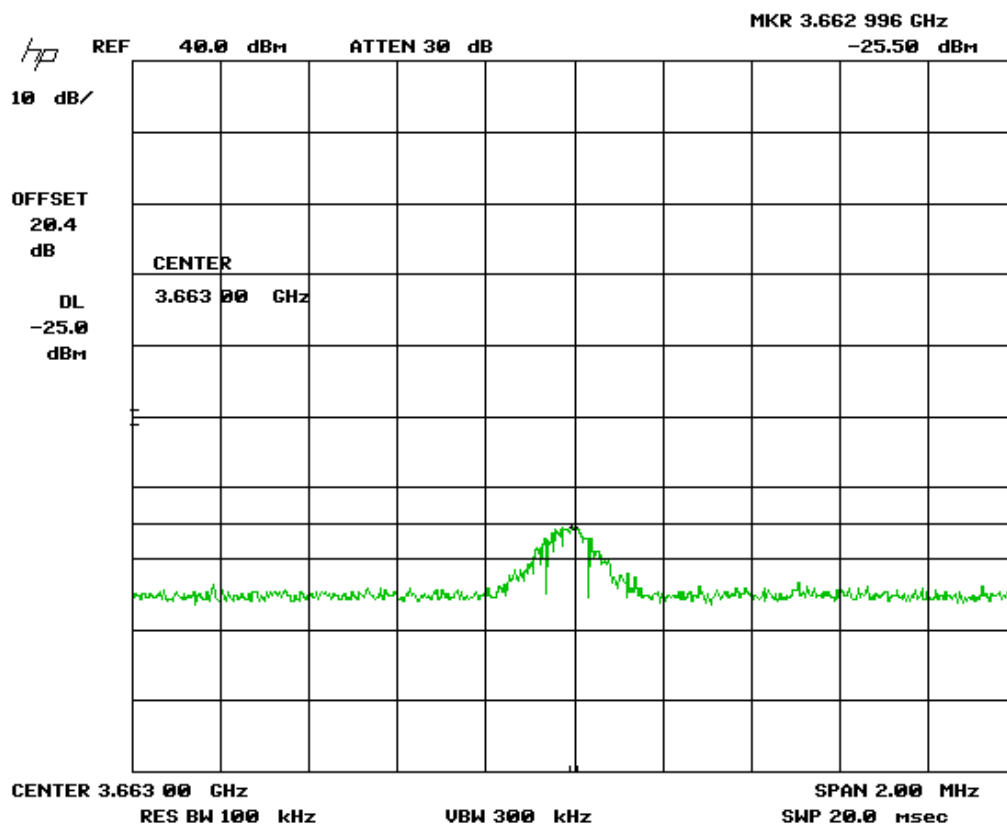
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Protocol: IAG
2 GHz – 5.6 GHz



Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

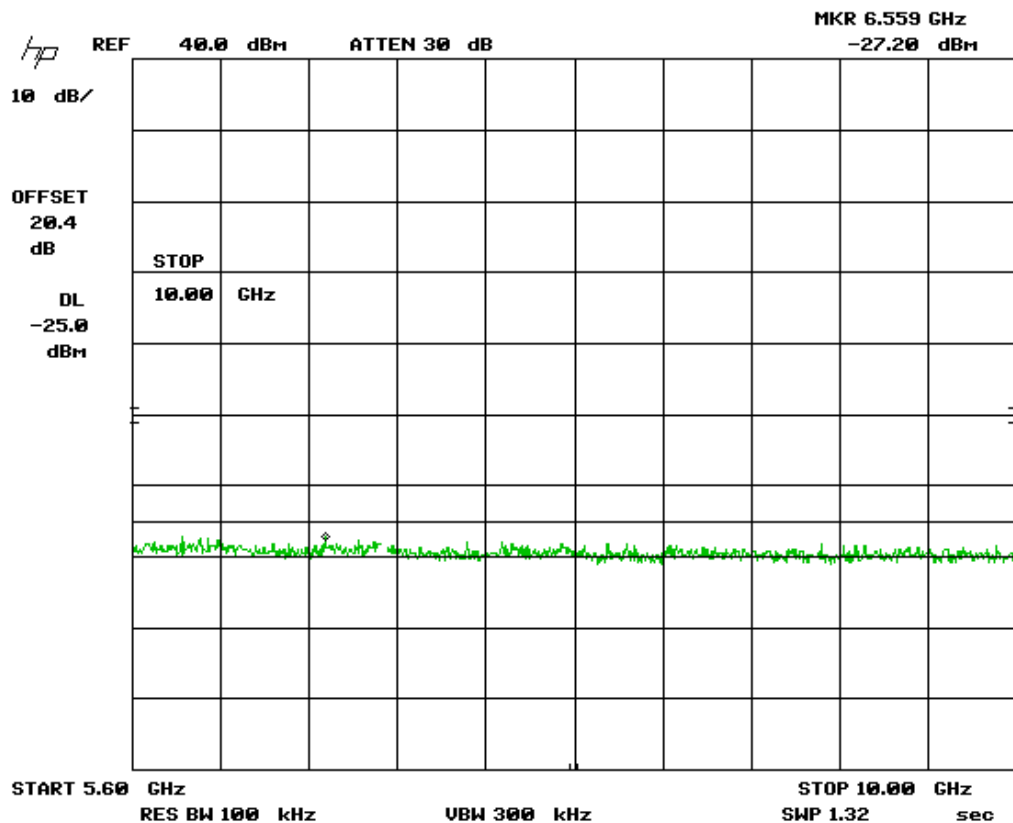
**Protocol: IAG
4th Harmonic**



Note: Due the switching characteristic of the IAG protocol, each harmonic emission were analyzed individually. The 3rd, 5th, and 6th harmonics have no emissions.

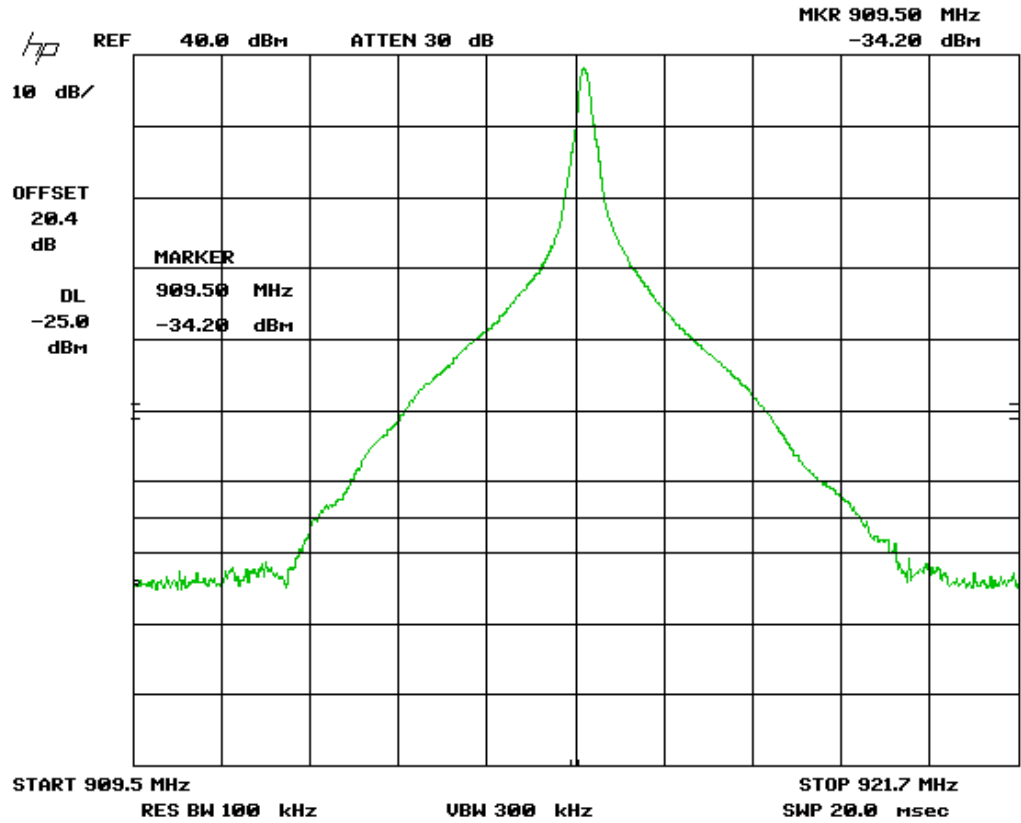
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Protocol: IAG
5.6 GHz – 10 GHz



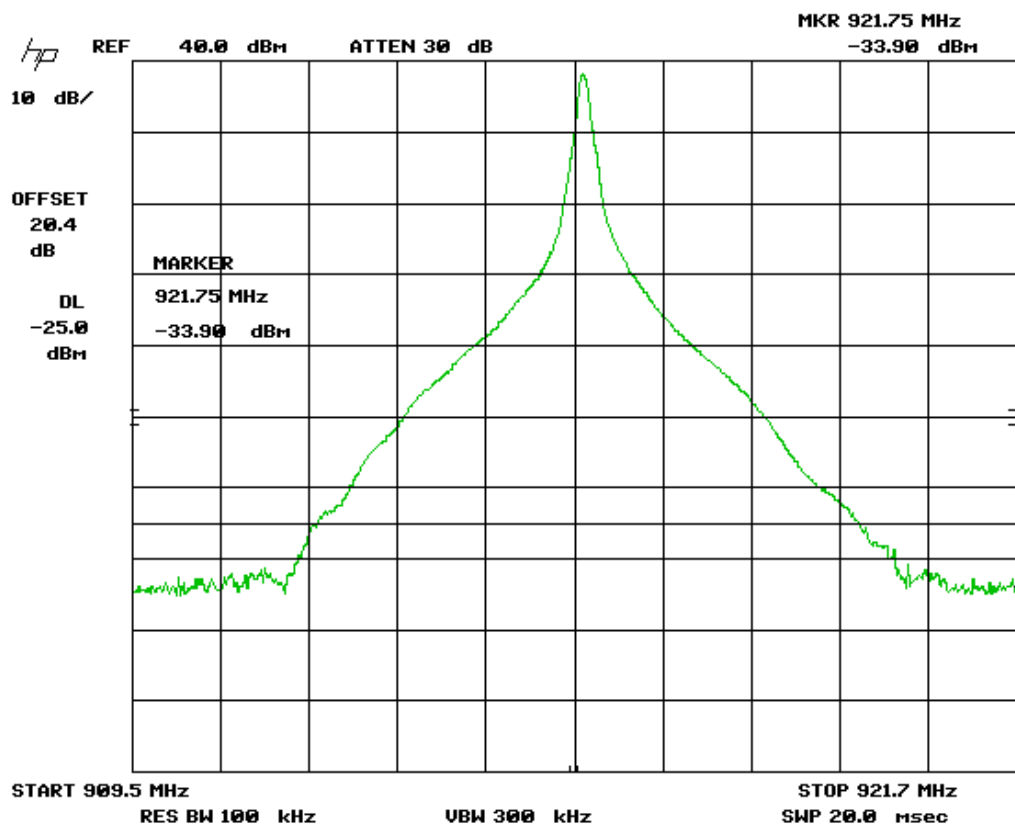
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

**Protocol: IAG
909.5 MHz Band Edge**



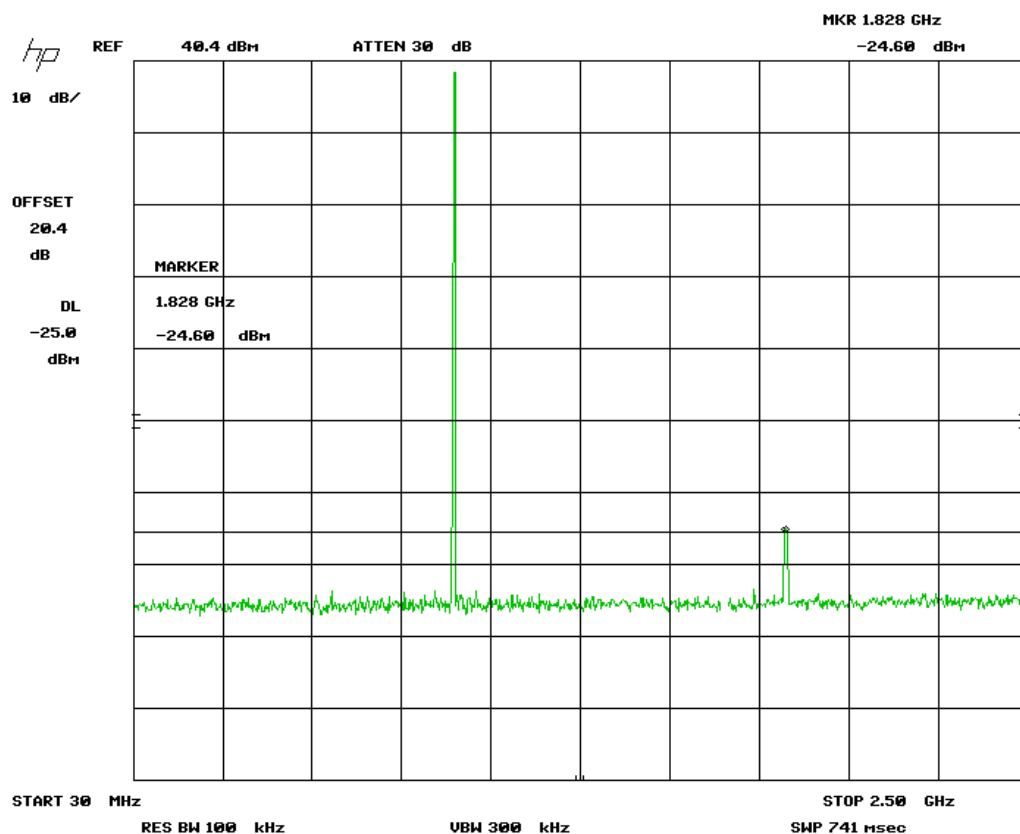
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

**Protocol: IAG
921.75 MHz Band Edge**



Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

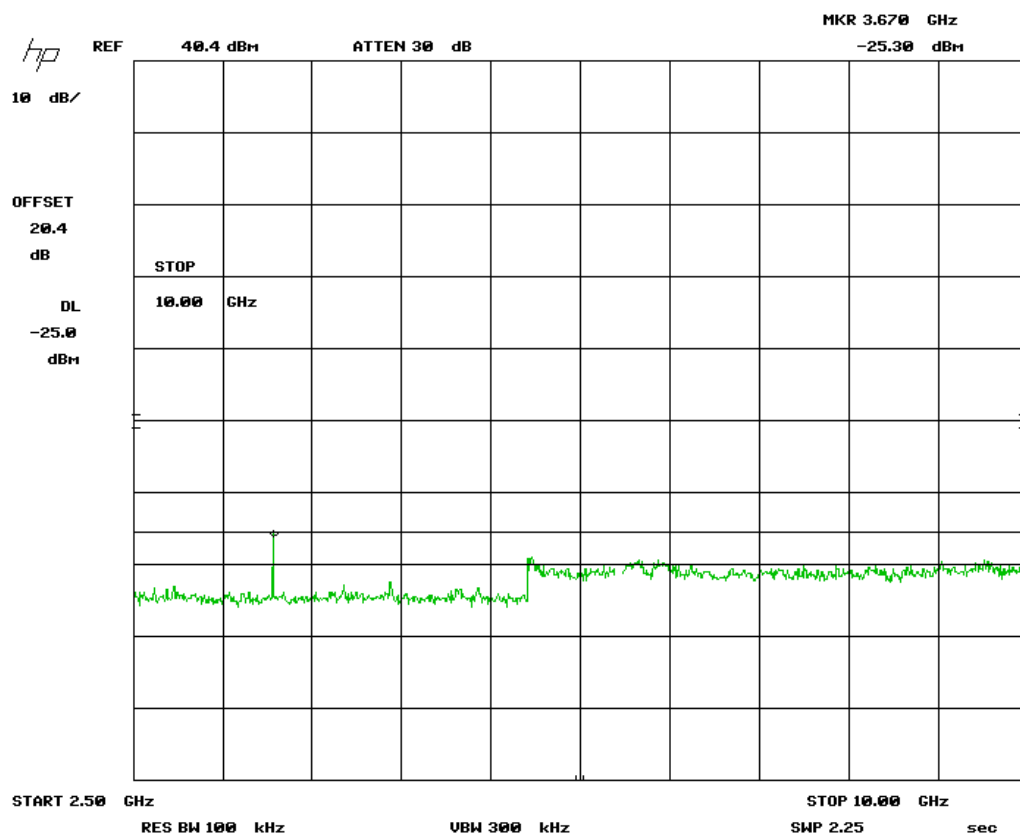
Protocol: SeGO
High Channel 30 MHz – 2.5 GHz



Note: Applying the minimum 2nd harmonic attenuation, 9.23 dB, the emission at 1.818 GHz is -33.83 dBm. Thus the EUT meets the Emission Mask requirements.

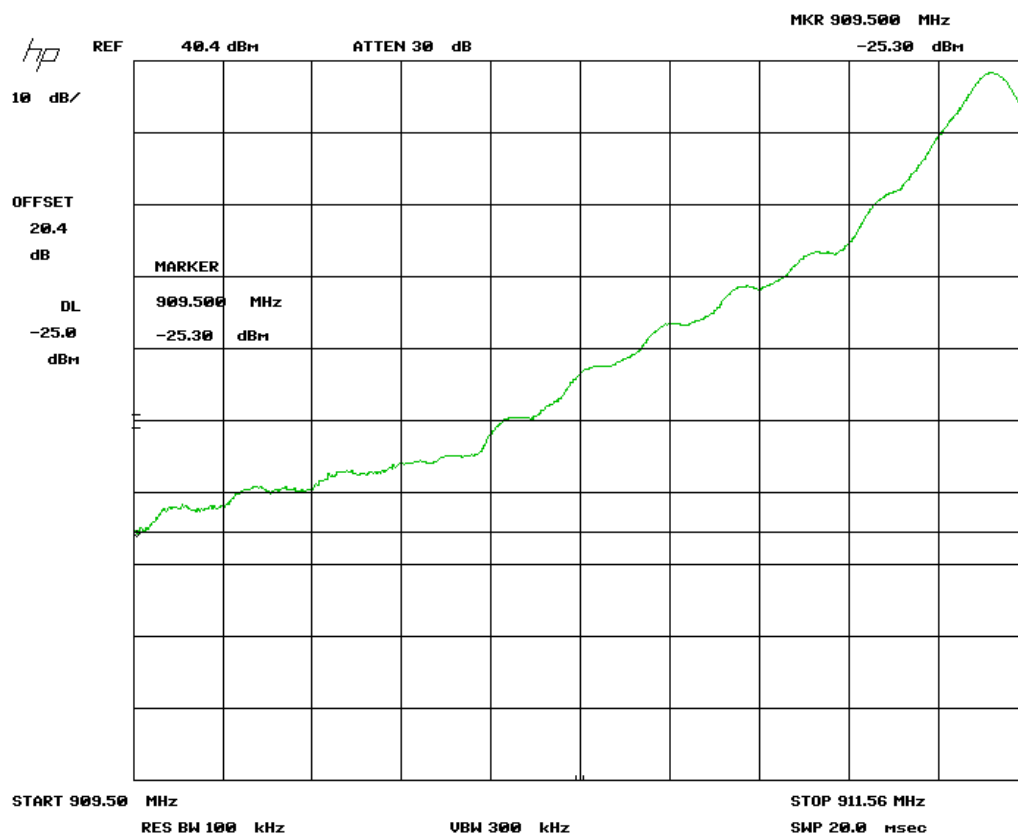
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Protocol: SeGO
High Channel 2.5 GHz – 10 GHz



Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

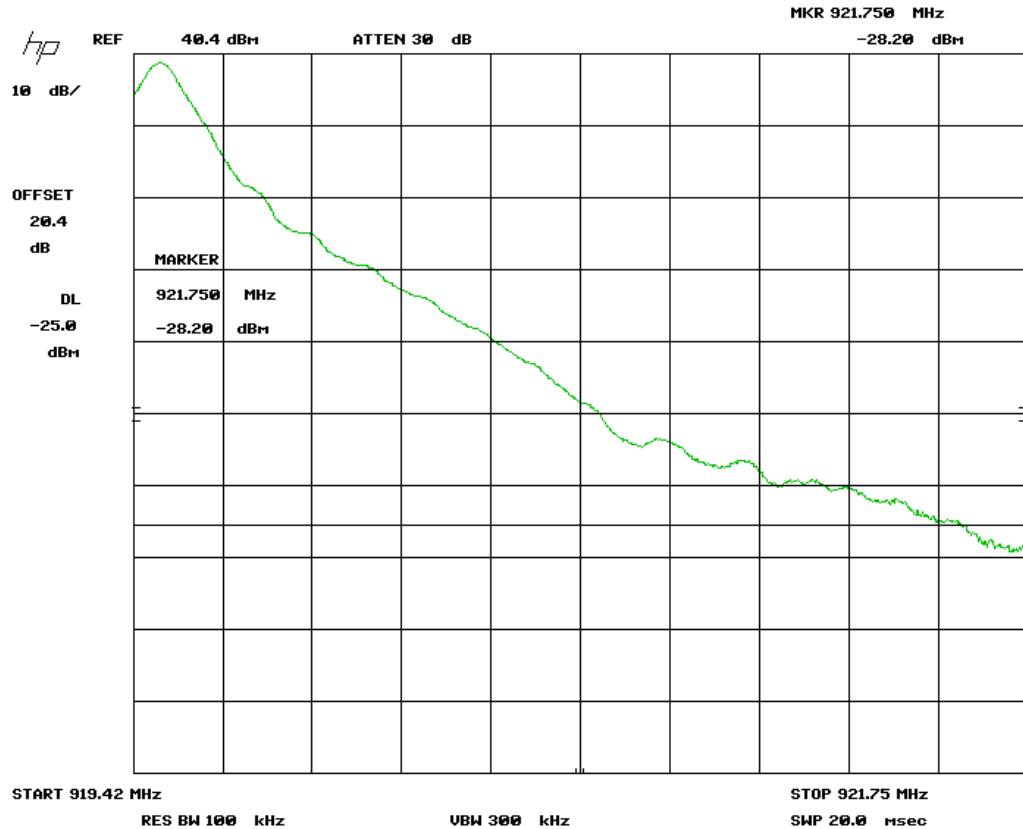
Protocol: SeGO
Low Channel – 909.5 MHz Band Edge



Note: Marker Delta was applied to the 909.5 MHz Band edge. See tables for details.

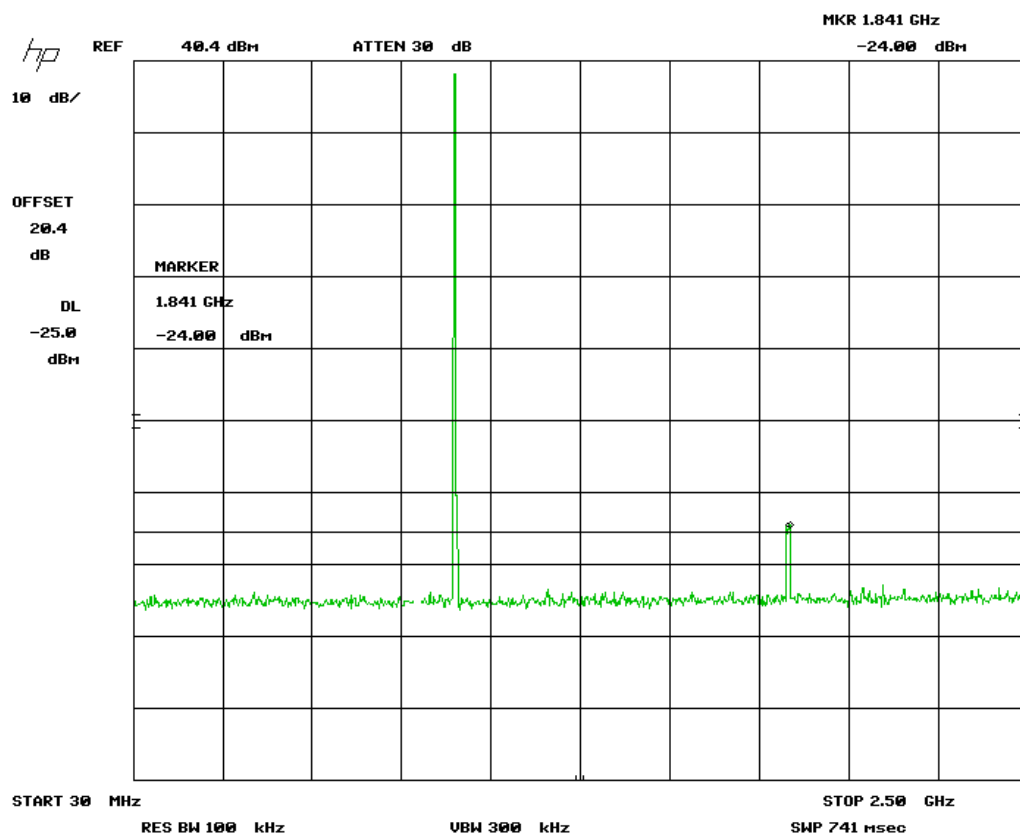
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Protocol: SeGO
High Channel – 921.75 MHz Band Edge



Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

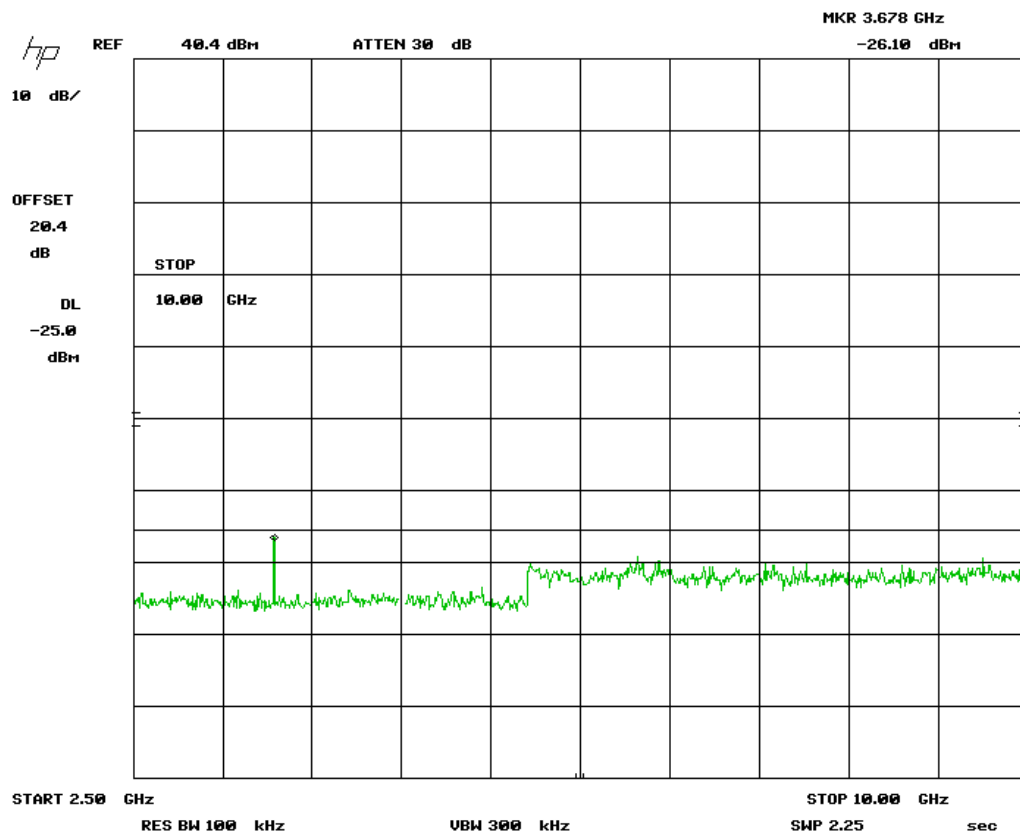
Protocol: ATA
High Channel 30 MHz – 2.5 GHz



Note: Applying the minimum 2nd harmonic attenuation, 9.23 dB, the emission at 1.818 GHz is -33.23 dBm. Thus the EUT meets the Emission Mask requirements.

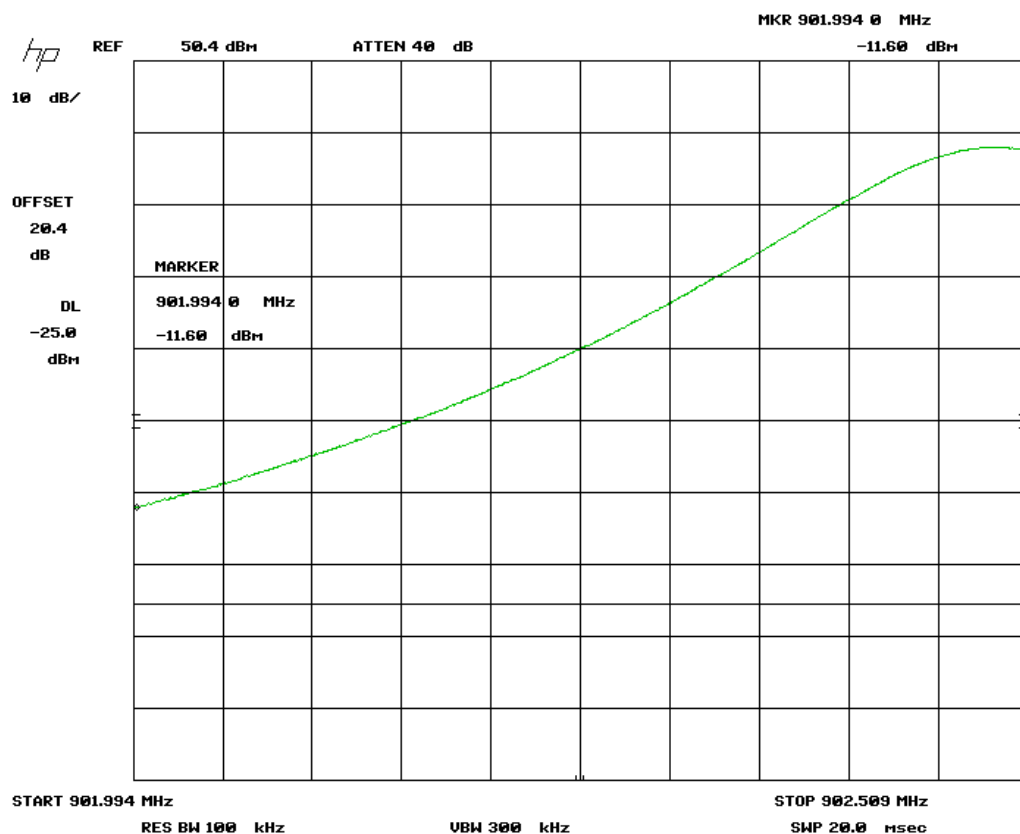
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Protocol: ATA
High Channel 2.5 MHz – 10 GHz



Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

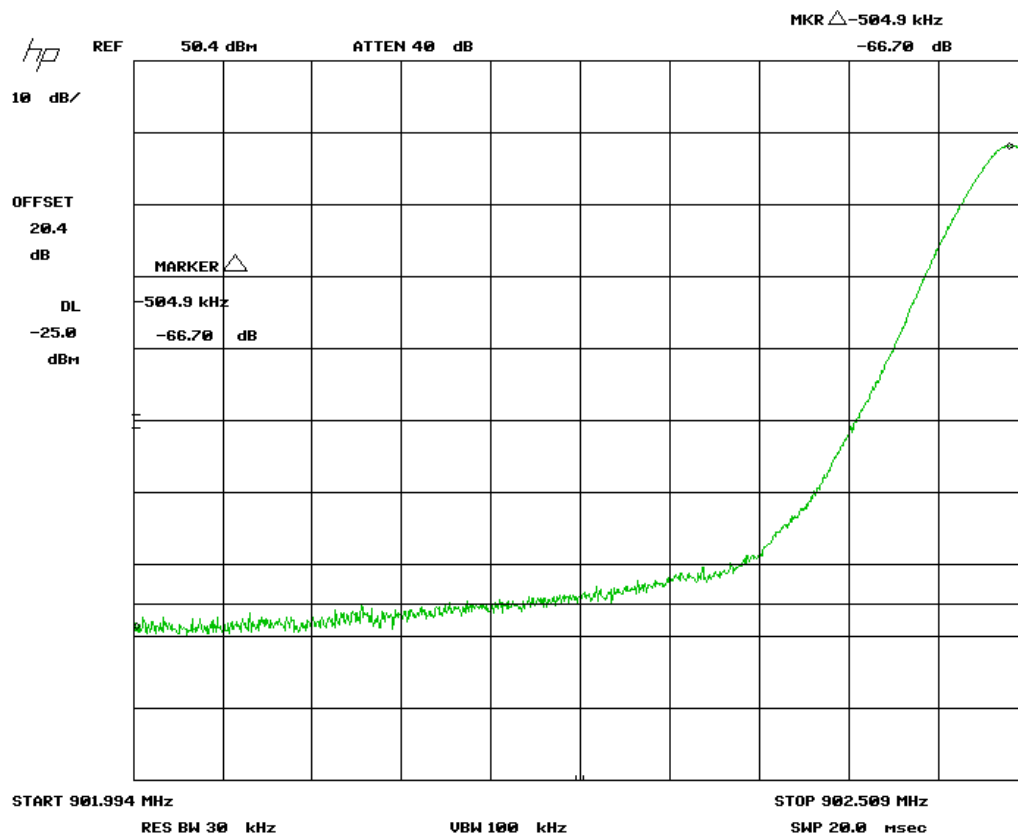
**Protocol: ATA – 902 – 904 MHz Sub-Band
Low Channel – 902 MHz Band Edge**



Note: Marker Delta was applied to the 902 MHz Band edge. See tables for details.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

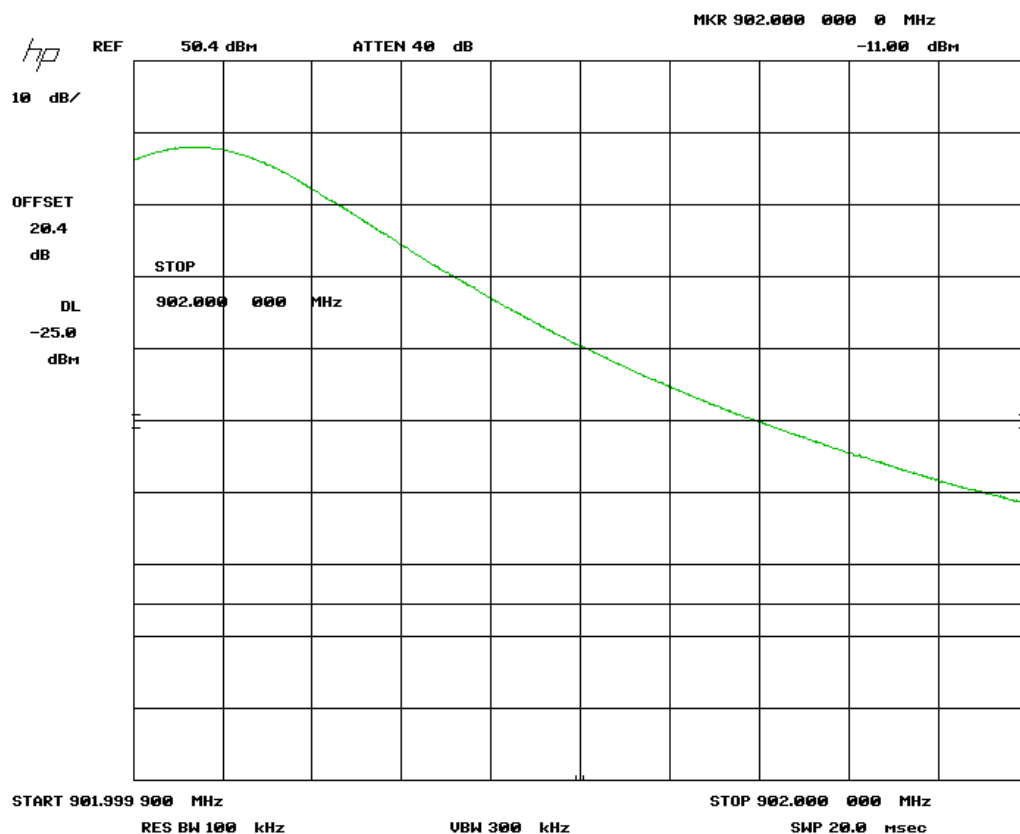
**Protocol: ATA – 902 – 904 MHz Sub-Band
Low Channel – 902 MHz Marker Delta**



Note: Marker Delta was applied to the 902 MHz Band edge. See tables for details.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

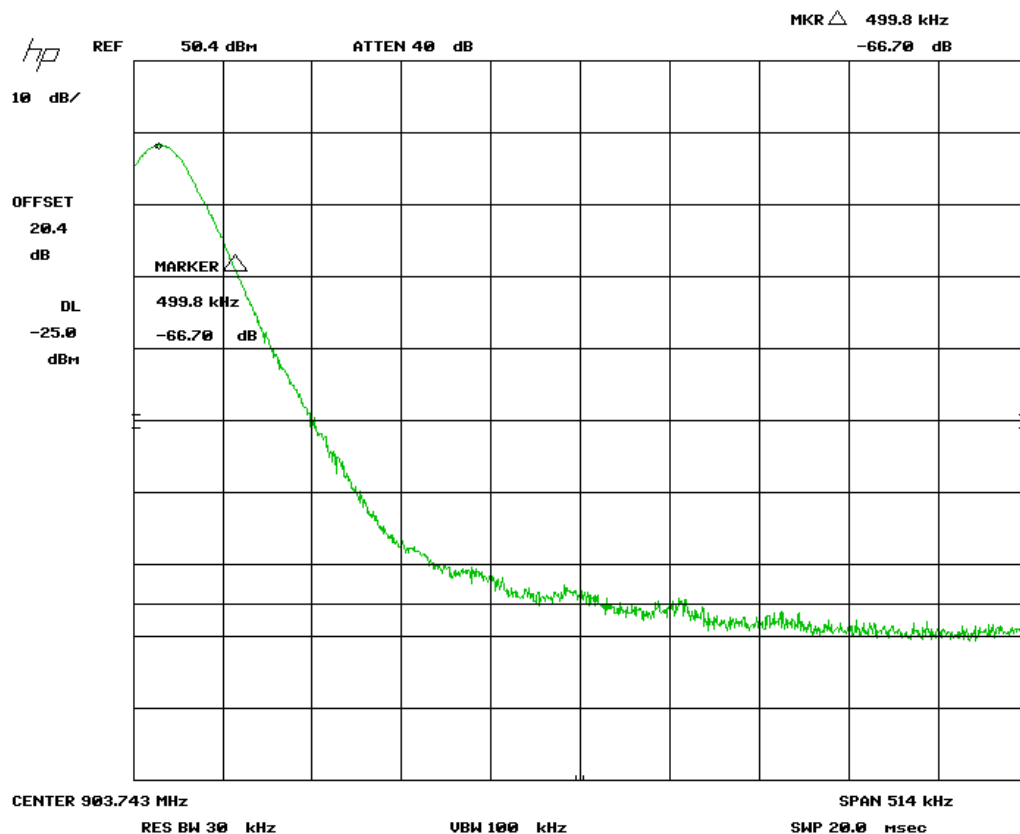
**Protocol: ATA – 902 – 904 MHz Sub-Band
High Channel – 904 MHz Band Edge**



Note: Marker Delta was applied to the 904 MHz Band edge. See tables for details.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

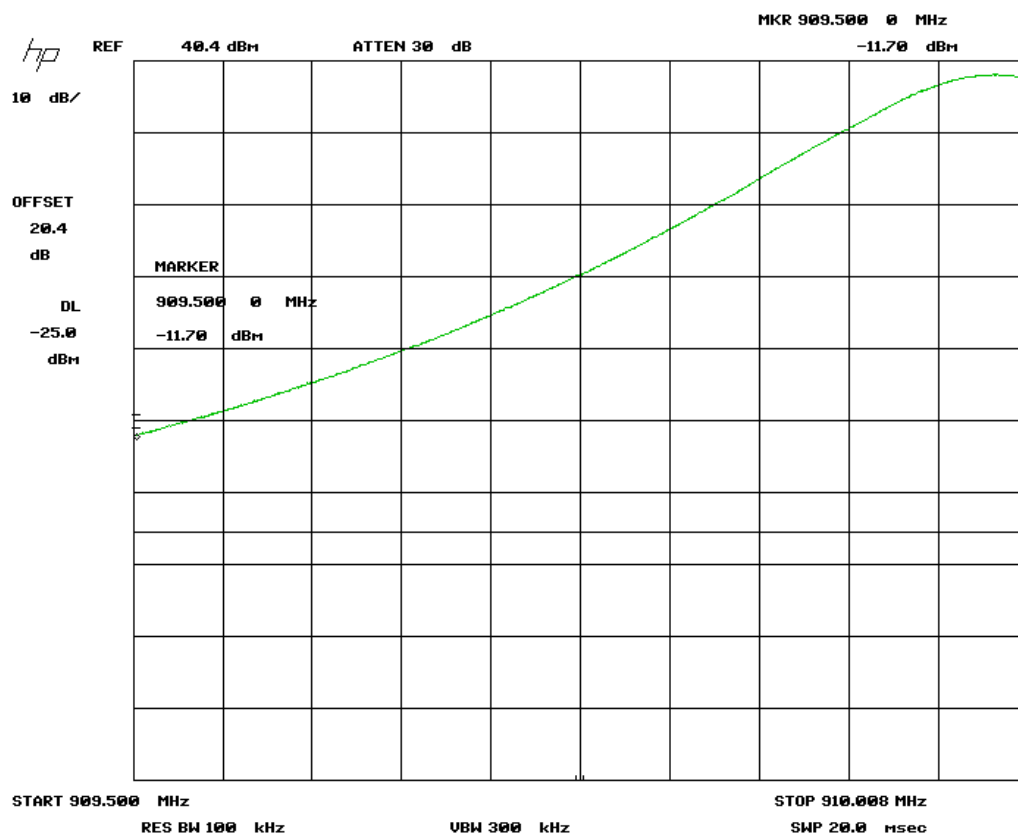
**Protocol: ATA – 902 – 904 MHz Sub-Band
High Channel – 904 MHz Marker Delta**



Note: Marker Delta was applied to the 904 MHz Band edge. See tables for details.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

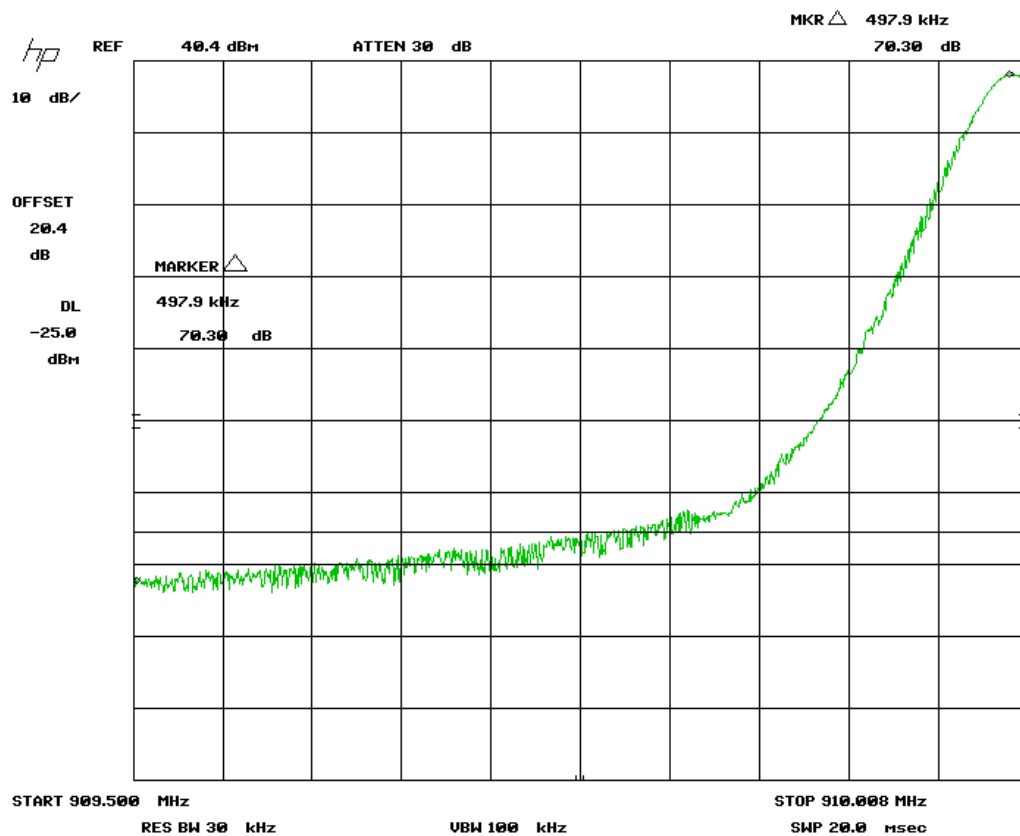
**Protocol: ATA – 909.75 – 921.75 MHz Sub-Band
Low Channel – 909.5 MHz Band Edge**



Note: Marker Delta was applied to the 909.5 MHz Band edge. See tables for details.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

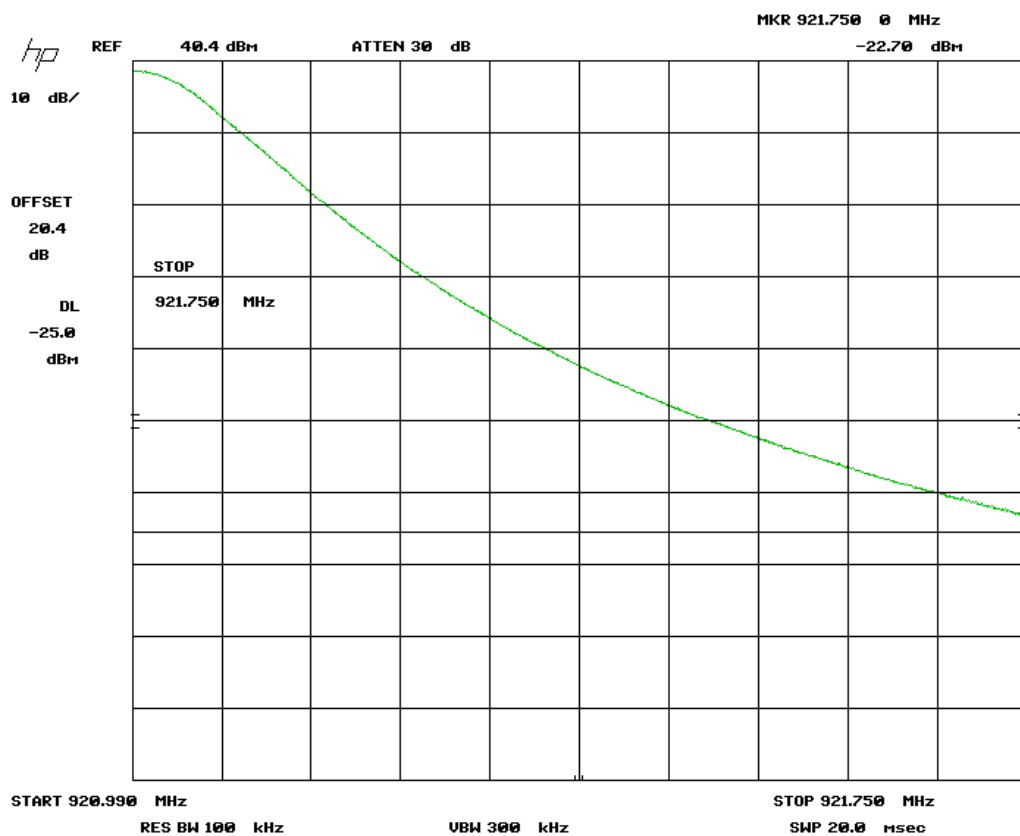
**Protocol: ATA – 909.75 – 921.75 MHz Sub-Band
Low Channel – 909.5 MHz Marker Delta**



Note: Marker Delta was applied to the 909.5 MHz Band edge. See tables for details.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

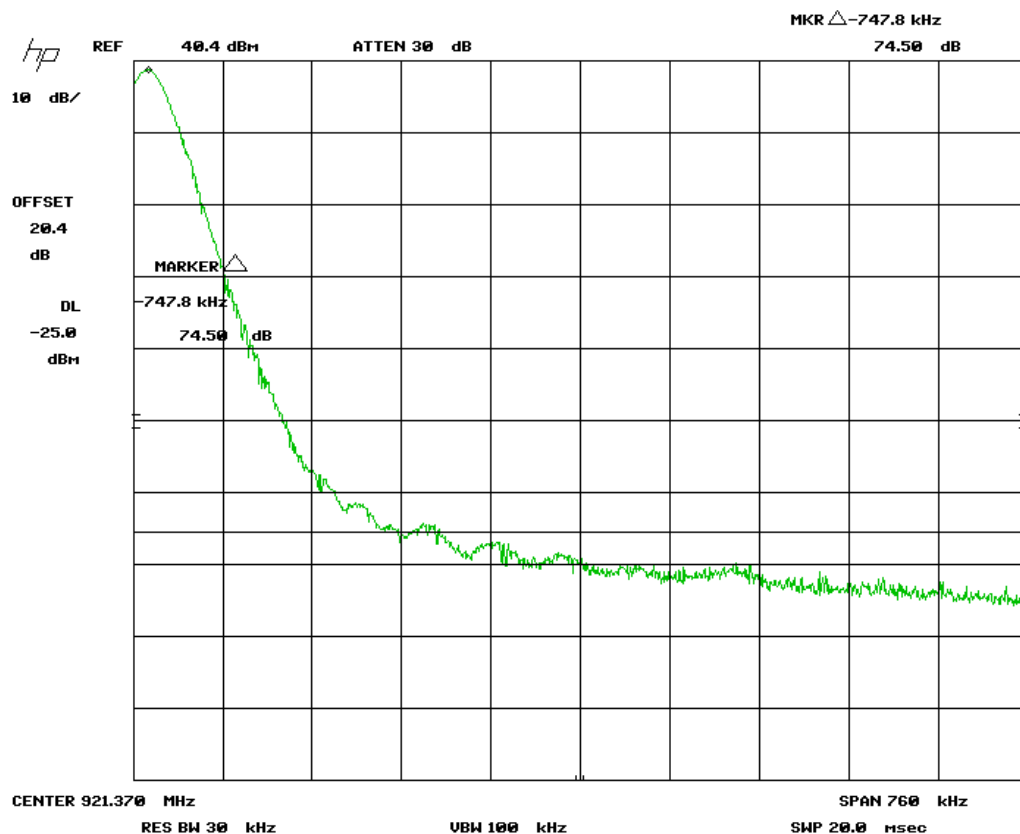
**Protocol: ATA – 909.75 – 921.75 MHz Sub-Band
High Channel – 921.75 MHz Band Edge**



Note: Marker Delta was applied to the 921.75 MHz Band edge. See tables for details.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

**Protocol: ATA – 909.75 – 921.75 MHz Sub-Band
High Channel – 921.75 MHz Marker Delta**



Note: Marker Delta was applied to the 921.75 MHz Band edge. See tables for details.

See 'Appendix B – EUT & Test Setup Photographs' for photos showing the test set-up.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Final Measurements

Note: All measurements were made with an external 20 dB attenuator. The attenuator and cable insertion loss were adjusted with Reference Level Offset function in the spectrum analyzer.

Protocol	Frequency (MHz)	Level (dBm)	Minimum 2 nd Harmonic Factor (dB)	Adjusted 2 nd Harmonic Level (dBm)	Limit (dBm)	Margin (dB)
ATA	902	-27.1	--	--	-25	2.1 [*]
ATA	904	-27.2	--	--	-25	2.2 [*]
ATA	909.5	-30.9	--	--	-25	5.9 [*]
ATA	921.5	-34.8	--	--	-25	9.8
ATA	1841	-24.0	-9.23	-33.2	-25	8.2 ^a
ATA	3678	-26.1	--	--	-25	1.1
Allegro	909.5	-34.5	--	--	-25	9.5
Allegro	921.75	-34.4	--	--	-25	9.4
Allegro	1828	-17.4	-9.23	-26.6	-25	1.6 ^a
Allegro	3655	-41.7	--	--	-25	16.7
IAG	909.5	-34.2	--	--	-25	9.2
IAG	921.75	-33.9	--	--	-25	8.9
IAG	1831.5	-16.5	-9.23	-25.7	-25	0.7 ^a
IAG	3663	-25.5	--	--	-25	0.5
SeGO	909.5	-27.8	--	--	-25	2.8 [*]
SeGO	921.75	-32.8	--	--	-25	7.8 [*]
SeGO	1828	-24.6	-9.23	-33.8	-25	8.8 ^a
SeGO	3670	-25.3	--	--	-25	0.3
6B	909.5	-27.1	--	--	-25	2.1 [*]
6B	921.75	-28.2	--	--	-25	3.2 [*]
6B	1833	-19.7	-9.23	-28.9	-25	3.9 ^a
6B	3670	-39.1	--	--	-25	13.9
6C	902	-31.0	--	--	-25	6.0 [*]
6C	904	-30.3	--	--	-25	5.3 [*]
6C	909.5	-29.0	--	--	-25	4.0 [*]
6C	921.75	-27.4	--	--	-25	2.4
6C	1823	-22.6	-9.23	-31.8	-25	6.8 ^a
6C	3625	-27.5	--	--	-25	2.5

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

*Marker Delta were used obtain these margins.

^a See Justification section for further details.

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration date	Next calibration due date	Asset #
Power Attenuator 20 dB	25-A-FFN-20	Bird / Hutton	NCR	NCR	GEMC 49
1.2 GHz High pass filter	5IH30-1078	K & L Microwave	NCR	NCR	GEMC118
Spectrum Analyzer	8566B	HP	2013-10-02	2015-10-02	GEMC190
Quasi Peak Adapter	85650A	HP	2013-10-01	2015-10-01	GEMC191
RF Cable 1m	LMR-400-1M-50OHM-MN-MN	LexTec	NCR	NCR	GEMC 29

This report module is based on GEMC template "FCC – Power Line Conducted Emissions Class B_Rev1"

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Transmitter Spurious Radiated Emissions

Purpose

The purpose of this test is to ensure that the RF energy unintentionally emitted from the EUT does not exceed the limits listed below as defined in the applicable test standard, as measured from a receiving antenna. This helps protect broadcast radio services such as television, FM radio, pagers, cellular telephones, emergency services, and so on, from unwanted interference.

Limit(s) and Method

The method is as defined in FCC 2.1053 and the limits are as defined in FCC Part 90.210(K).

(3) *Other transmitters.* For all other transmitters authorized under subpart M that operate in the 902-928 MHz band, the peak power of any emission shall be attenuated below the power of the highest emission contained within the licensee's sub-band in accordance with the following schedule:

(i) On any frequency within the authorized bandwidth: Zero dB.

(ii) On any frequency outside the licensee's sub-band edges: $55 + 10 \log(P)$ dB, where (P) is the highest emission (watts) of the transmitter inside the licensee's sub-band.

Spurious radiated emissions of the EUT was performed at 3 meters. The limit specified in FCC 90.210 (K) is $55 + 10 \log(P)$ dBc. For all intensive purpose, the limit is -25 dBm. The field strength limit for the EUT is give in the below:

$$E(\text{dB}\mu\text{V/m}) = \text{ERIP}(\text{dBm}) + 95.2$$

$$\text{Where EIRP} = \text{ERP} + 2.15$$

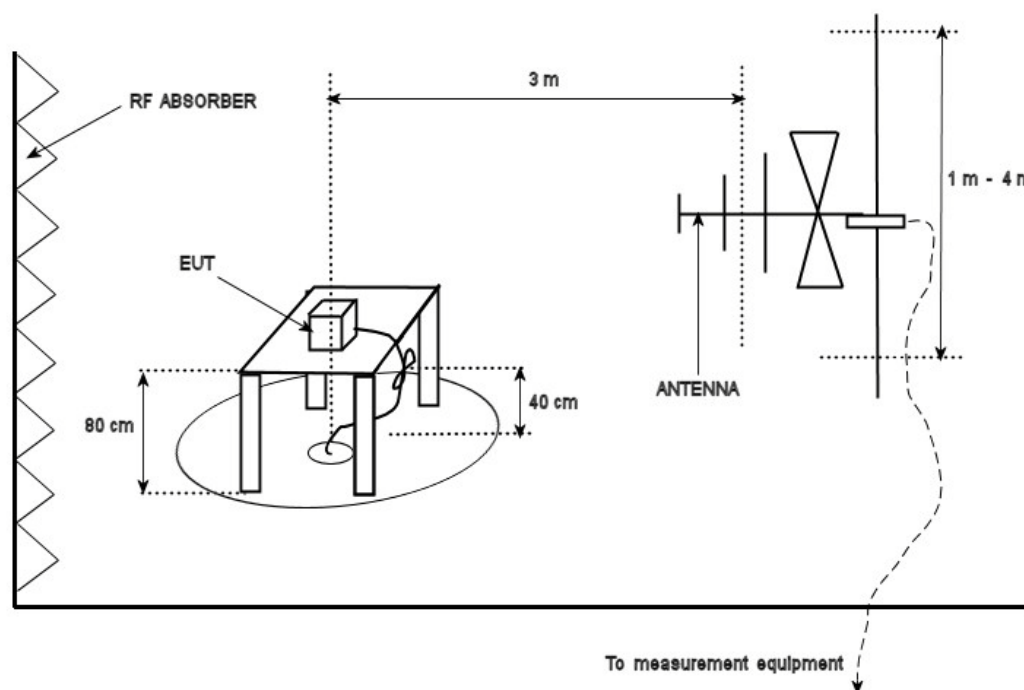
$$E(\text{dB}\mu\text{V/m}) = \text{ERP}(\text{dBm}) + 97.35$$

$$E(\text{dB}\mu\text{V/m}) = -25 \text{ dBm} + 97.35 = 72.35 \text{ dBuV}$$

This limit is applicable all emission at 3 meter measurement distance.
The Limit is with 100 kHz measurement bandwidth and using a Peak detector.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Typical Radiated Emissions Setup



Measurement Uncertainty

The expanded measurement uncertainty is calculated in accordance with CISPR 16-4-2 and is ± 4.4 dB with a 'k=2' coverage factor and a 95% confidence level.

Preliminary Graphs

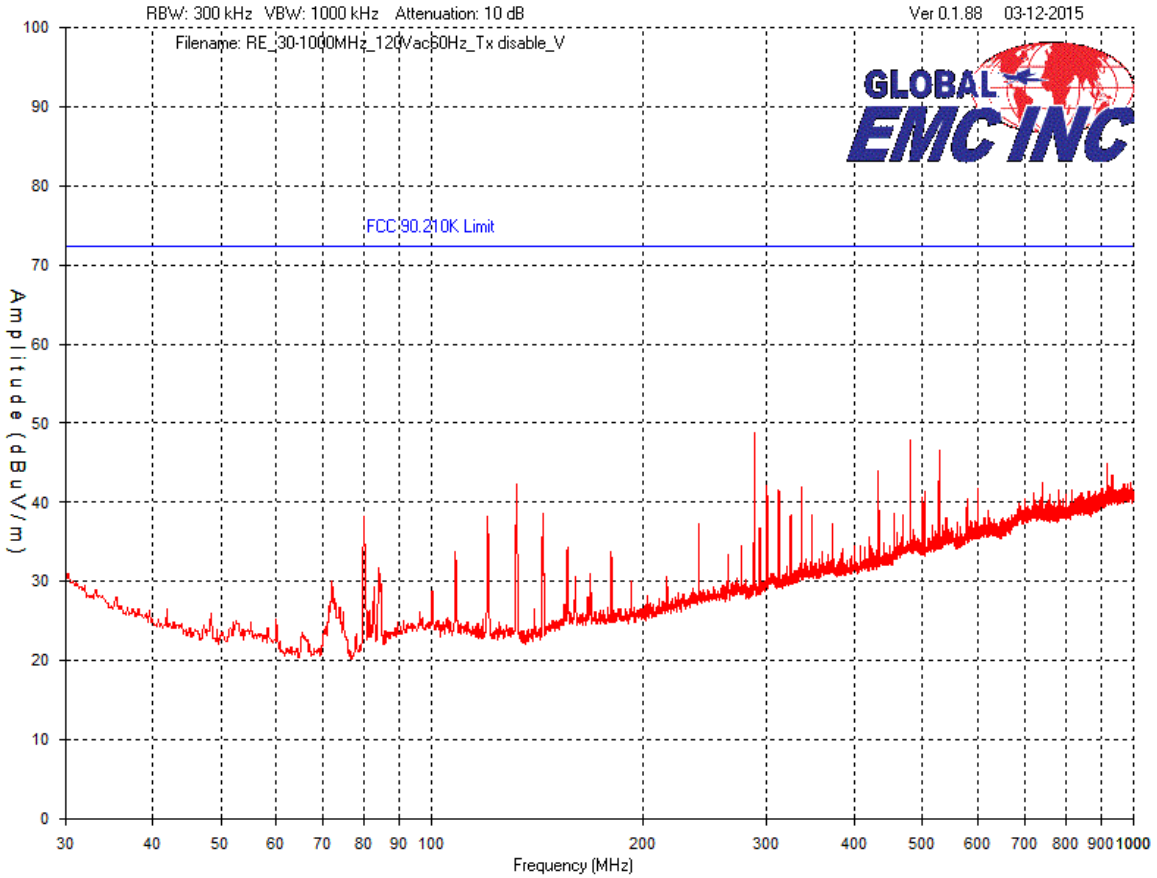
Note the graphs shown below are for graphical illustration only. For final measurements with the appropriate detector, please refer to the final measurement table where applicable. The graph shown below is a maximized peak measurement graph, measured with a resolution bandwidth greater than the final required detector and over a full 0-360 rotation. This peaking process is done as a worst case measurement. This process enables the detection of frequencies of concern for final measurement, and provides considerable time savings.

The device was scanned to the 10th harmonic (a minimum of a 10 GHz).

The measured radiation includes the emissions from the reader being used to control the EUT.

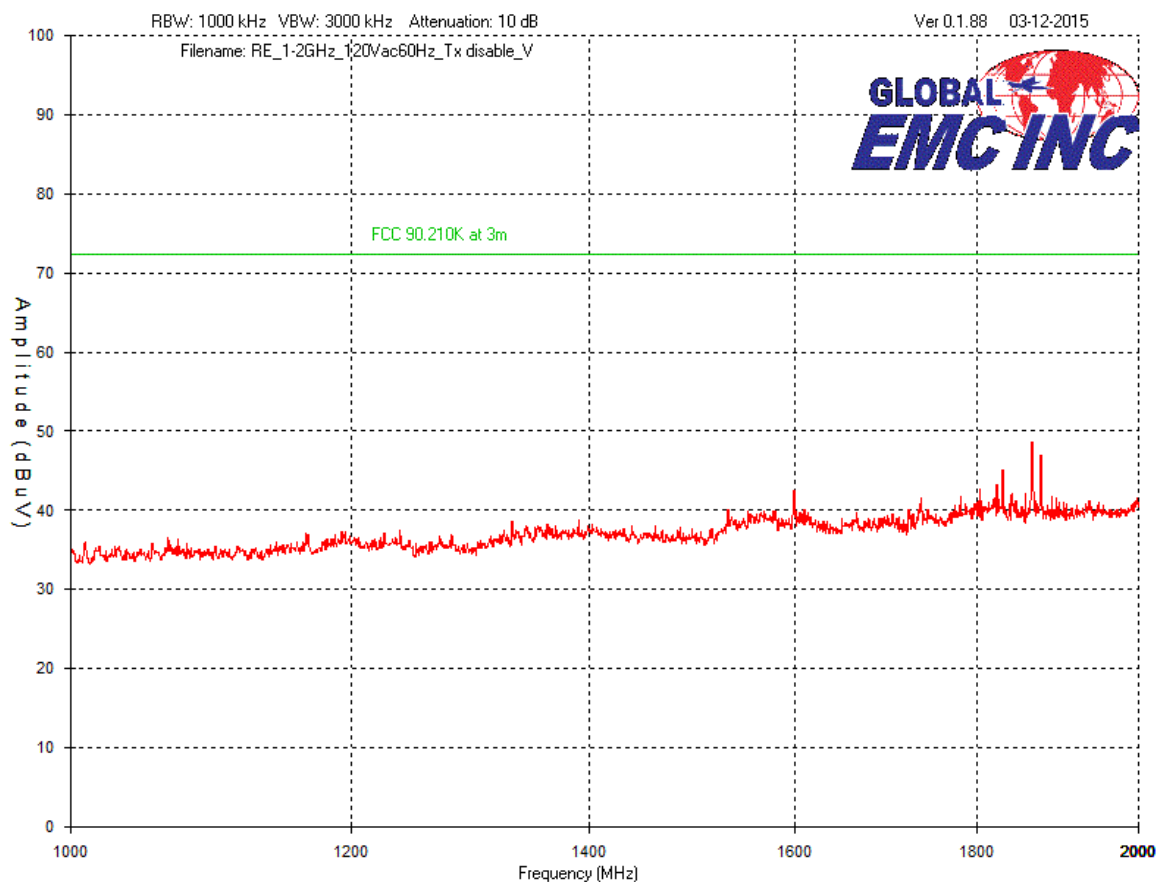
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Vertical – Peak Emission Graph 30 MHz – 1 GHz



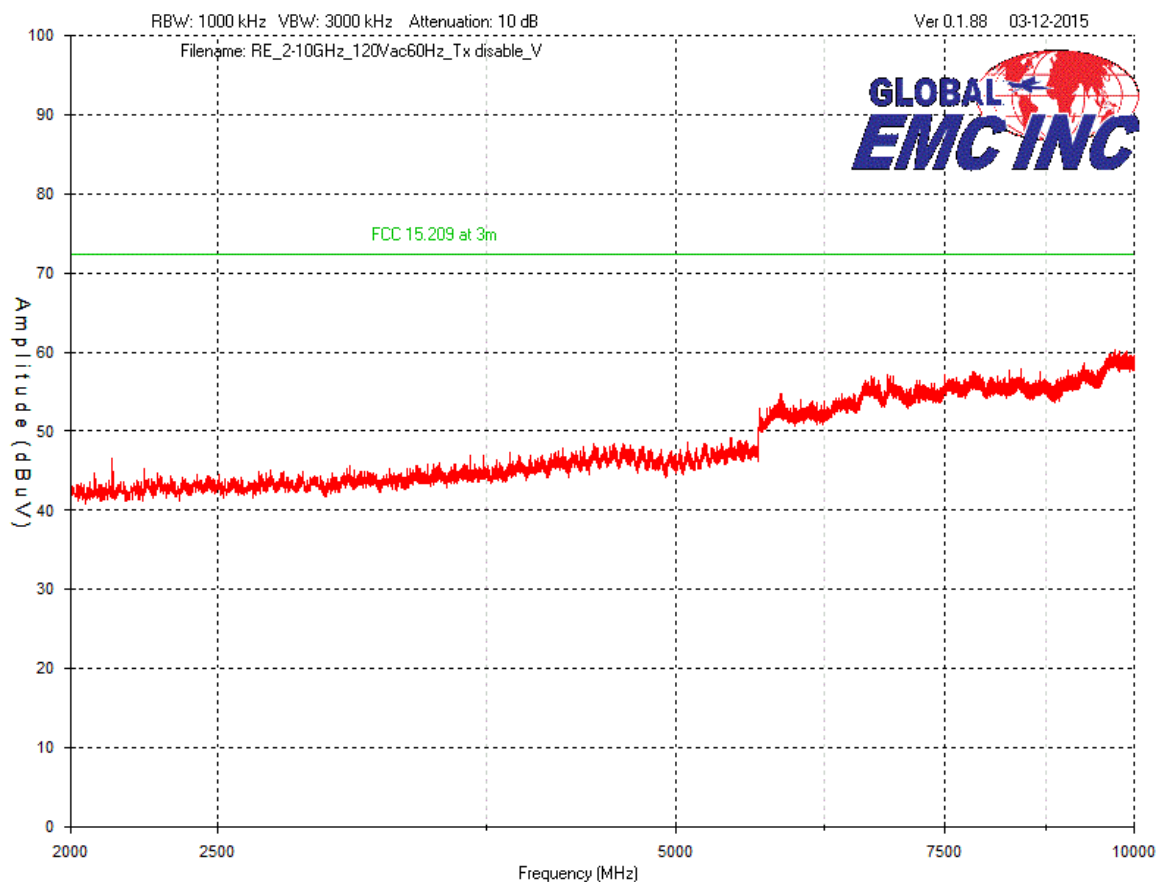
Client	Kapsch TrafficCom Canada Inc	
Product	MRFM-S with External Amplifier (MRFM-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Vertical – Peak Emission Graph 1 GHz – 2 GHz



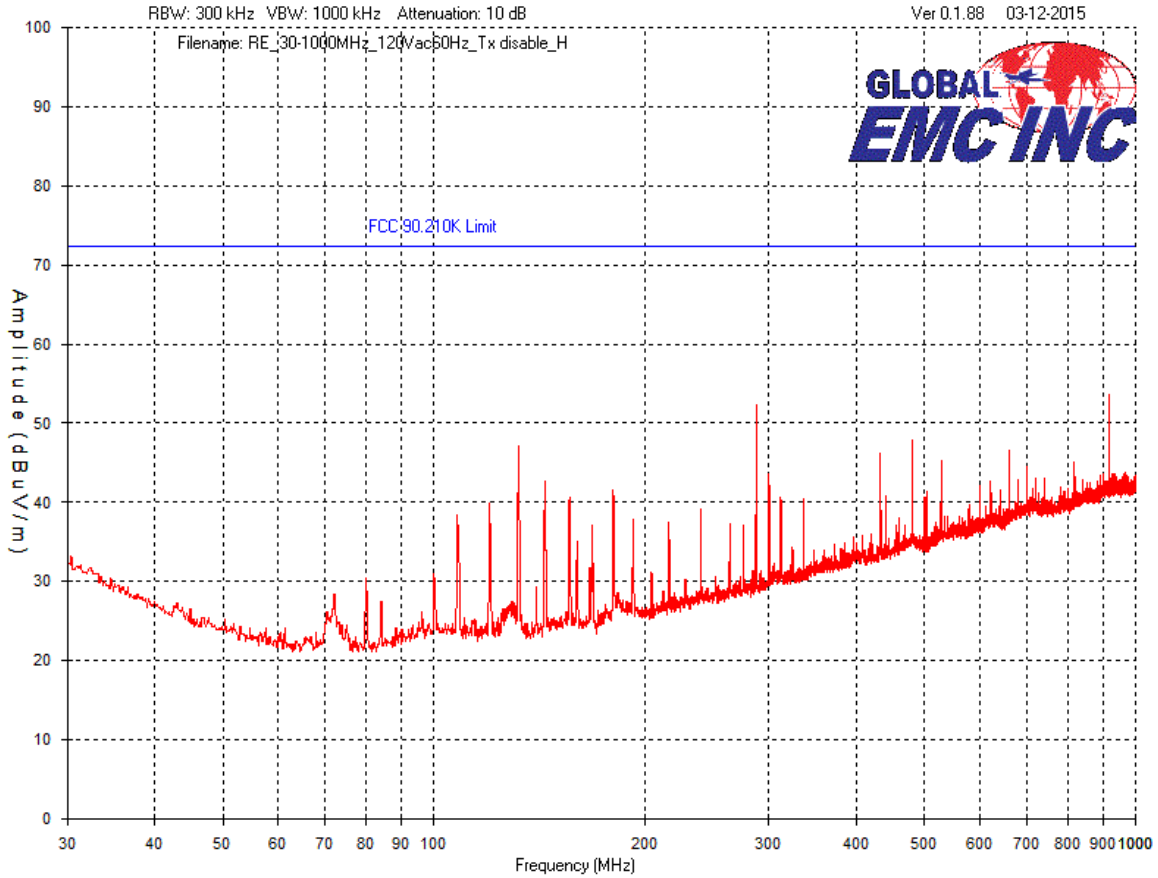
Client	Kapsch TrafficCom Canada Inc	
Product	MRFM-S with External Amplifier (MRFM-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Vertical – Peak Emission Graph 2 GHz – 10 GHz



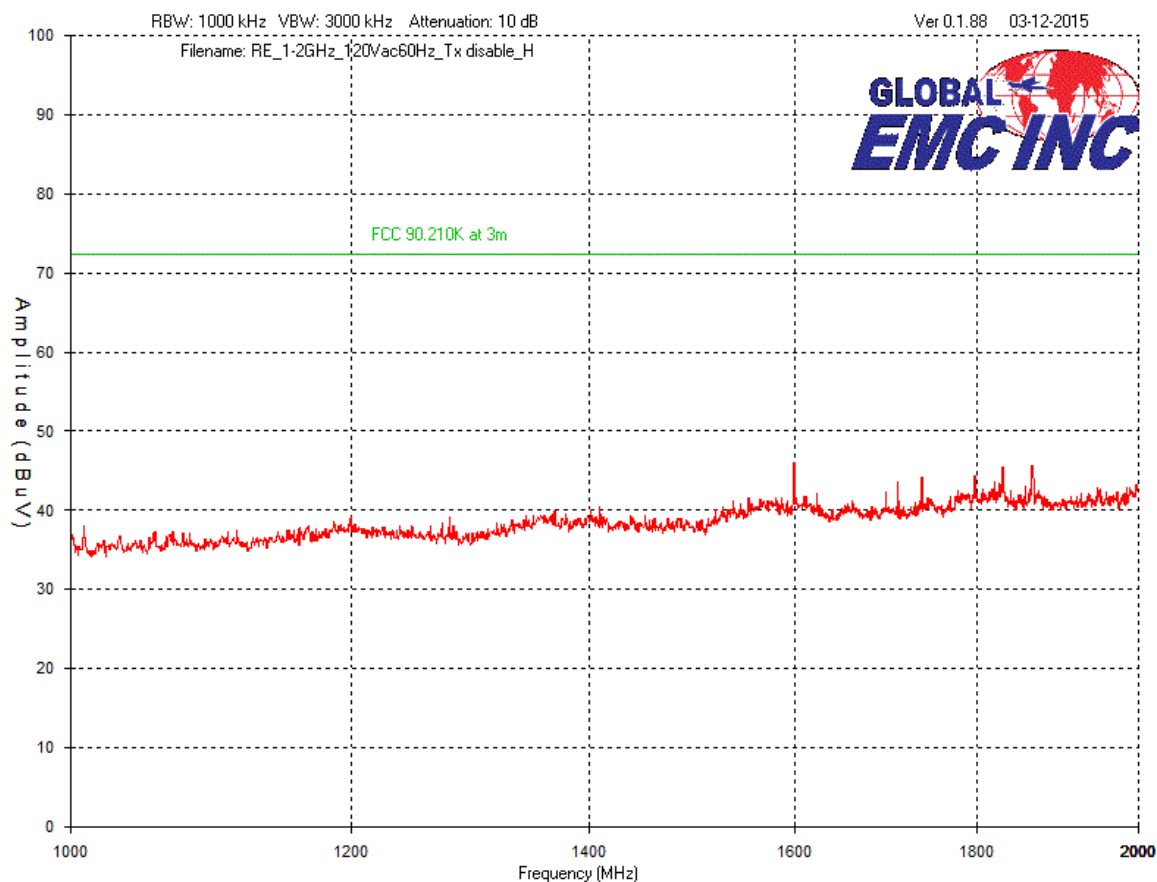
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Horizontal – Peak Emission Graph 30 MHz – 1 GHz



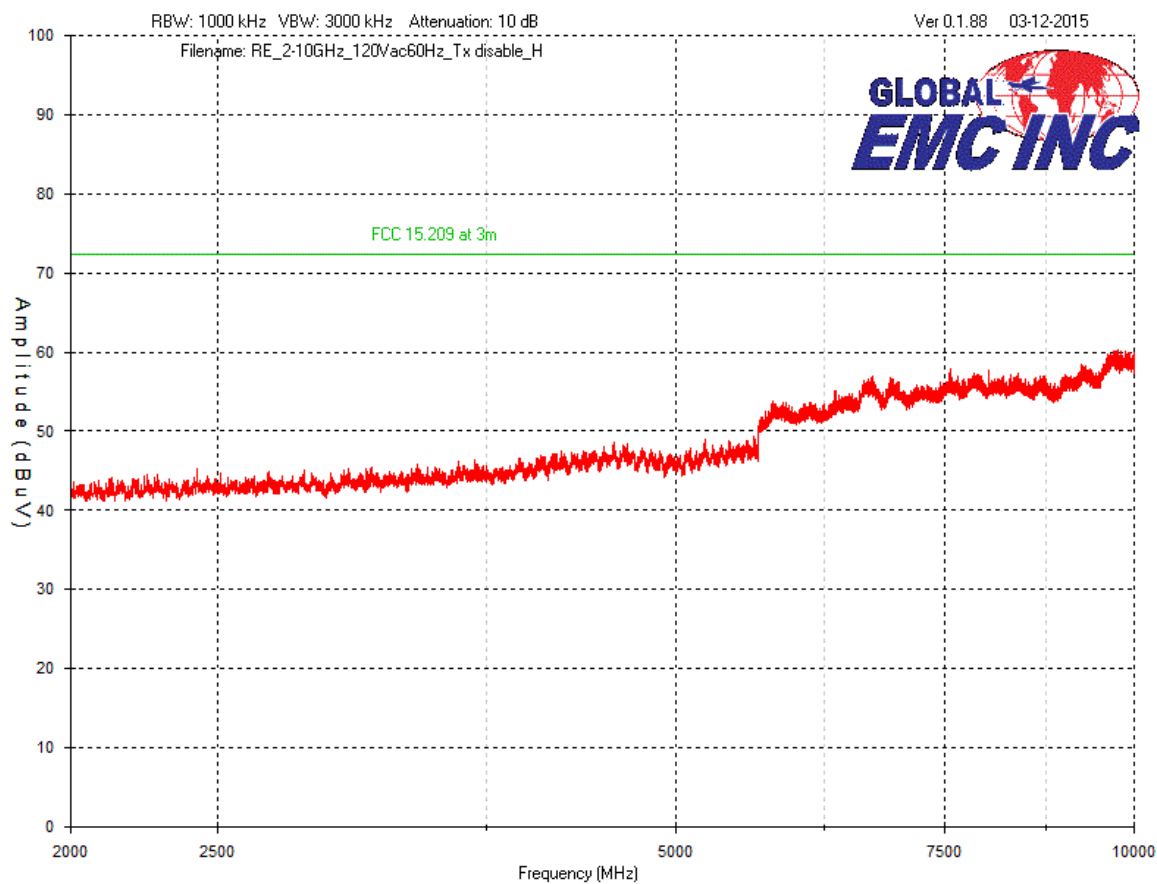
Client	Kapsch TrafficCom Canada Inc	
Product	MRFM-S with External Amplifier (MRFM-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Horizontal – Peak Emission Graph 1 GHz – 2 GHz



Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Horizontal – Peak Emission Graph 2 GHz – 10 GHz



Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Results

Pass.

The EUT meets the Transmitter Spurious Radiated Emissions requirements.

All scan were perform with a measurement bandwidth greater than the required bandwidth.
No peak emissions were above the limit.

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration date	Next calibration due date	Asset #
Spectrum Analyzer	8566B	HP	Oct 2, 2013	Oct 2, 2015	GEMC190
Quasi Peak Adapter	85650A	HP	Oct 2, 2013	Oct 2, 2015	GEMC191
BiLog Antenna	3142-C	ETS	Feb 10, 2015	Feb 10, 2017	GEMC 137
Band Reject Filter	BRC50722	Micro-Tronics	NCR	NCR	GEMC186
Chase Preamp 9kHz - 2 GHz	CPA9231A	Chase	Sept 9, 2014	Sept 9, 2016	GEMC 6403
Q-Par 1.5-18 GHz Horn	6878/24	Q-par	Sept 10, 2014	Sept 10, 2016	GEMC 6365
1-26G pre-amp	HP 8449B	HP	Sept 9, 2014	Sept 9, 2016	GEMC 6351
RF Cable 7m	LMR-400-7M-50OHM-MN-MN	LexTec	NCR	NCR	GEMC 28
RF Cable 1m	LMR-400-1M-50OHM-MN-MN	LexTec	NCR	NCR	GEMC 29
RF Cable 0.5M	LMR-400-0.5M-50OHM-MN-MN	LexTec	NCR	NCR	GEMC 31

This report module is based on GEMC template "FCC - 15.209 - Radiated Emissions_Rev1.doc"

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Temperature Frequency Stability

Purpose

The purpose of this test is to ensure that the RF energy unintentionally emitted from the EUT does not exceed the permitted bandwidth during extreme temperature variations. This helps protect radio broadcasts and receivers with spectrum nearby to the equipment under test from unwanted interference. This also helps ensure proper reception of the intended signal by ensuring the transmit frequency is correct in any temperature.

Limit(s) and Method

The methods are given in FCC Part 2.1055. There limits given in FCC Part 90.213.

However, the device meets the following condition:

Fixed non-multilateration transmitters with an authorized bandwidth that is more than 40 kHz from the band edge, intermittently operated hand-held readers, and mobile transponders are not subject to frequency tolerance restrictions.

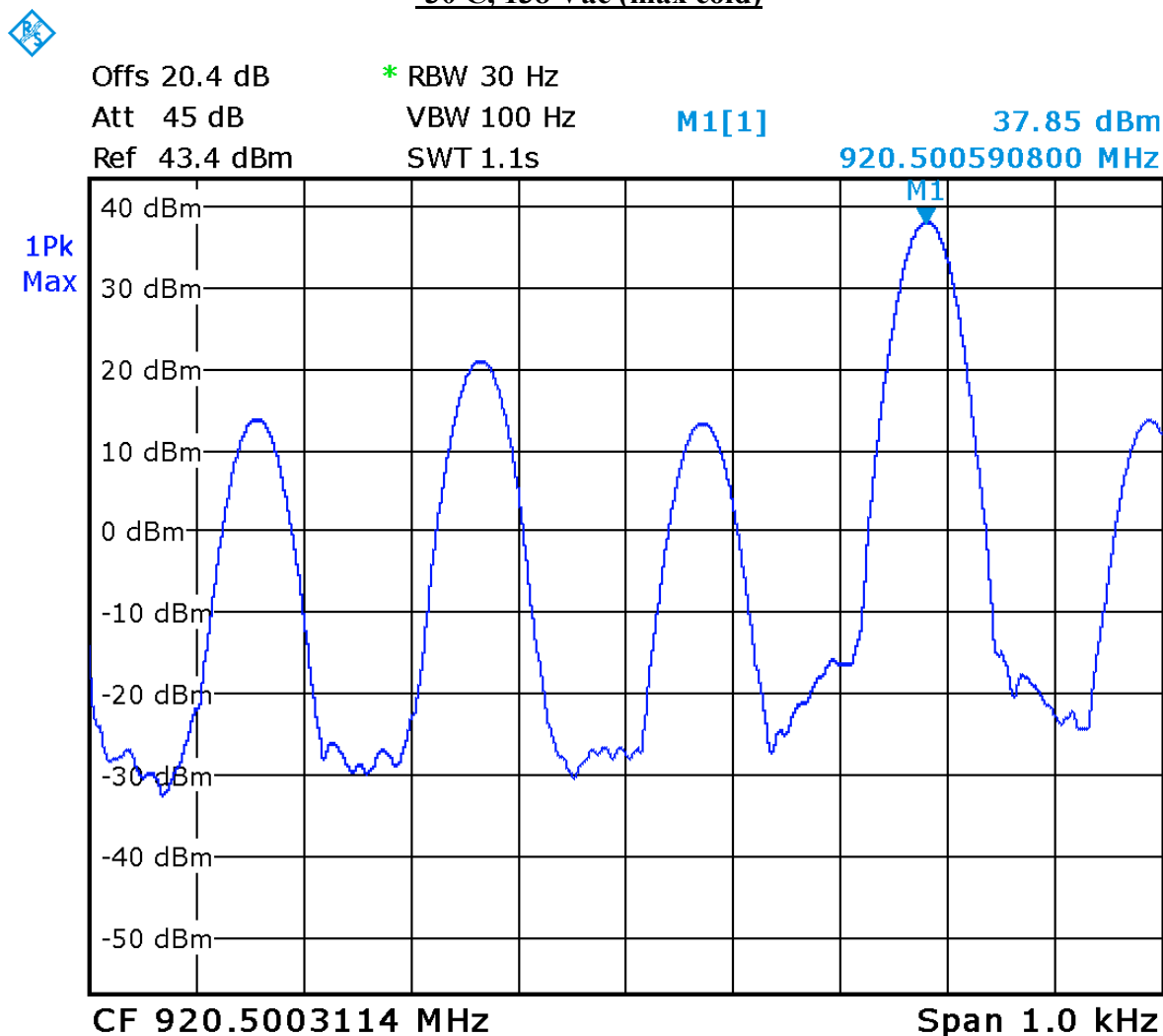
Frequency tolerances measurements are taken for information purpose. Frequency must be maintained from -30 C to +50 C. The EUT is monitored at each 10 degree increment. At each temperature, the device is checked after a stabilization period required for the device to reach the temperature.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Measurement Graphs

The worst case results are presented, with the frequency shown. The device was checked at each 10 degree increment of temperature

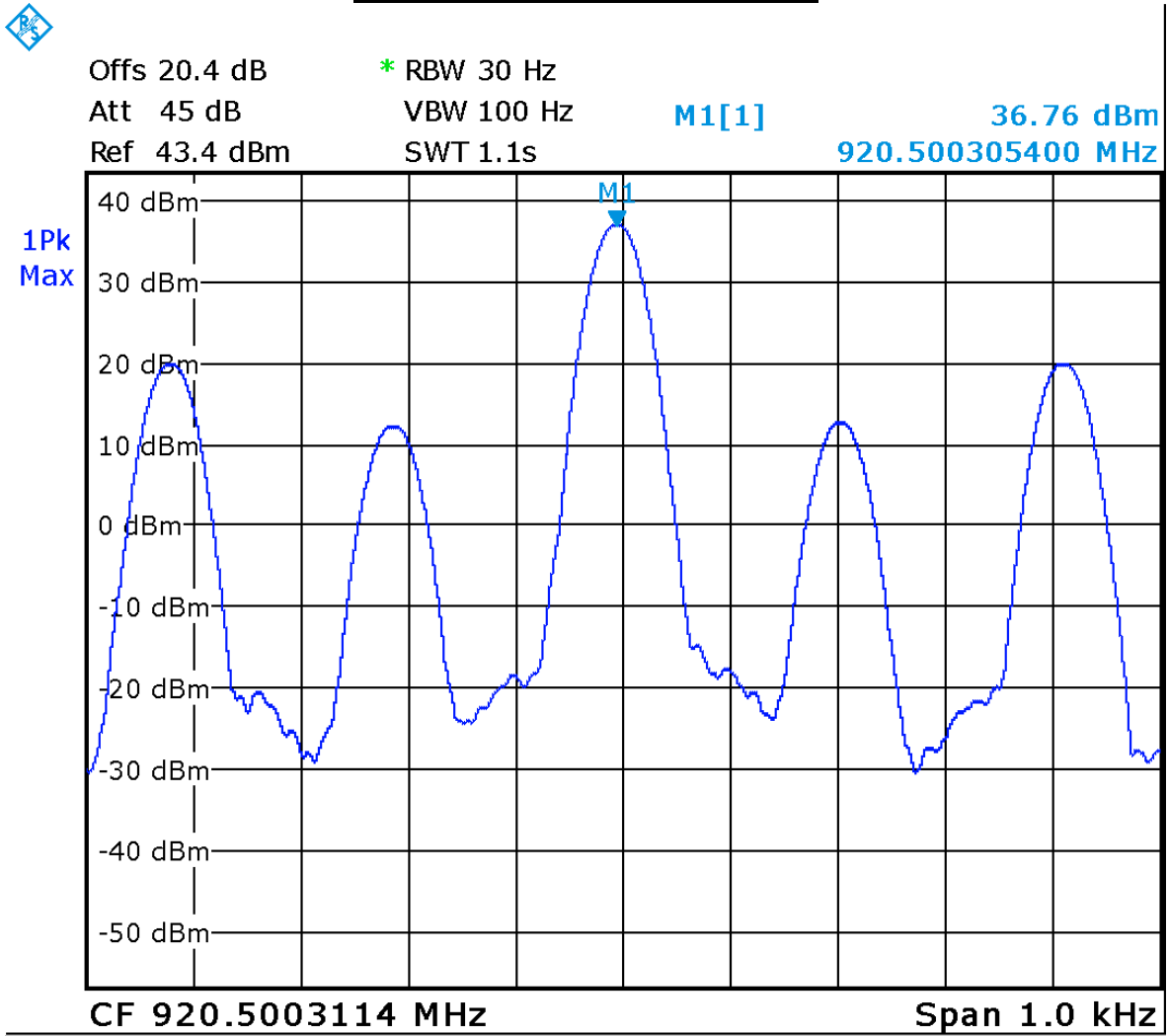
-30 C, 138 Vac (max cold)



Date: 5.MAR.2015 16:54:26

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

22C, 102 Vac (Room temperature)



Date: 5.MAR.2015 16:02:55

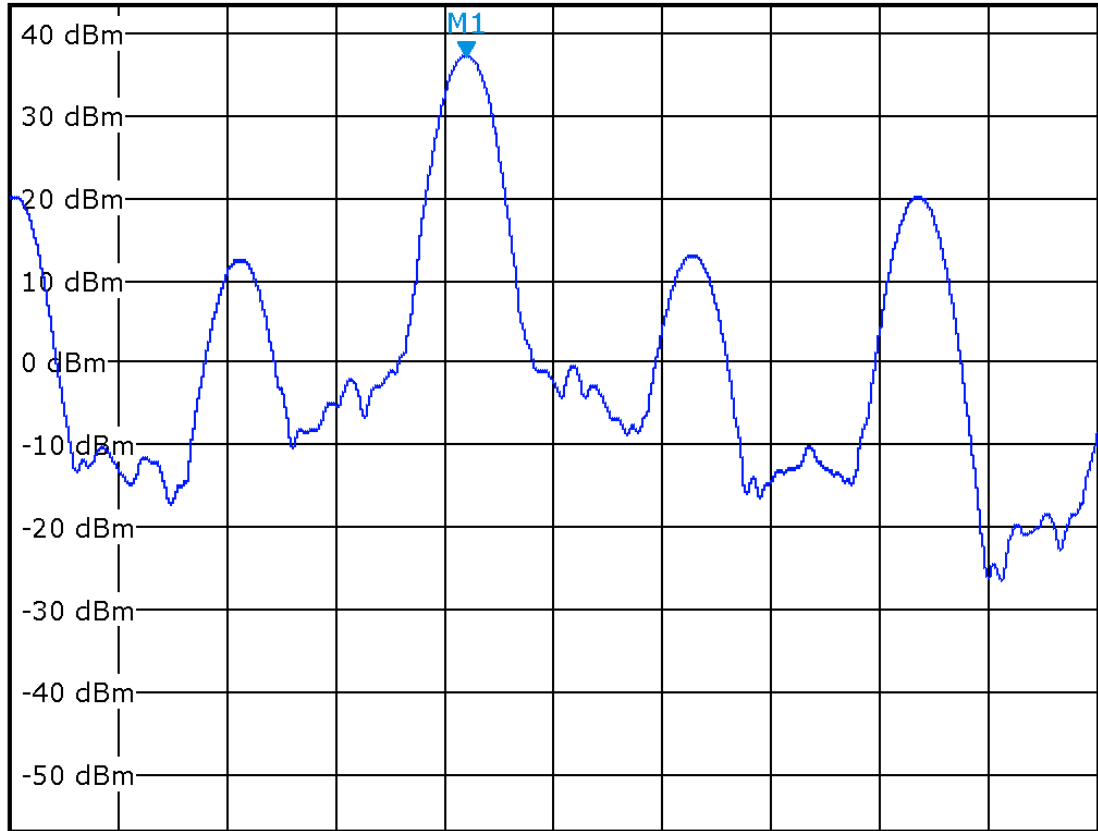
Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

+50C, 138Vac (max heat)



Offs 20.4 dB * RBW 30 Hz
 Att 45 dB VBW 100 Hz **M1[1]** **37.02 dBm**
 Ref 43.4 dBm SWT 1.1s **920.500231600 MHz**

**1Pk
Max**



CF 920.5003114 MHz

Span 1.0 kHz

Date: 5.MAR.2015 18:01:19

Client	Kapsch TrafficCom Canada Inc	
Product	MRF-S with External Amplifier (MRF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Table

Test Condition	Measured Frequency (MHz)	Frequency Drift (ppm)
+22°C, 120 Vac	920.5003114	--
+22°C, 102 Vac	920.5003054	-0.007
+22°C, 138Vac	920.5003134	0.002
-30°C, 120 Vac	920.5005689	0.280
-30°C, 102 Vac	920.5005829	0.295
-30°C, 138Vac	920.5005908	0.304
+50°C, 120 Vac	920.5002160	-0.104
+50°C, 102 Vac	920.5002296	-0.089
+50°C, 138Vac	920.5002316	-0.087

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration date	Next calibration due date	Asset #
Spectrum Analyzer	ESL 6	Rohde & Schwarz	15-Nov-2013	15-Nov-2015	GEMC 160
Power Attenuator 20 dB	25-A-FFN-20	Bird / Hutton	NCR	NCR	GEMC 49
RF Cable 7m	LMR-400-7M-50OHM-MN-MN	LexTec	NCR	NCR	GEMC 28
Environmental Chamber	SM-32-7800	Thermotron	NCR	NCR	GEMC 153

This report module is based on GEMC template "FCC - 15.225 - RFID Freq Stab_Rev1.doc"

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Appendix A – EUT Summary

For further details for filing purposes, refer to filing package.

General EUT Description

Client Details	
Organization / Address	Kapsch TrafficCom Canada Inc. 6020 Ambler Drive, Mississauga, Ont. Canada L4W 2P1
Contact	Richard Turnock, CTO
Phone	905-624-3020 x 7900
Email	richard.turnock@kapsch.net
Manufacturer Details (if not same as above)	
Organization / Address	
Contact	Alastair Malarky, Chief Engineer
Phone	905-624-3020 x 7900
Email	alastair.malarky@kapsch.net
EUT (Equipment Under Test) Details	
EUT Name (for report title)	MRMF-S with External Amplifier(MRMF-SEA)
EUT Model / SN (if known)	802295AA
EUT revision	Module revision 002 Rev. CC
Software version	N/A
Equipment category	
EUT is powered using	Module: DC, Amplifier Assembly; AC
Input voltage range(s) (V)	Module: 15VDC and 5VDC Amplifier: 115 Vac
Frequency range(s) (Hz)	60 Hz
Nominal power consumption (W)	Combined power: 50W
Number of power supplies in EUT	1
Transmits RF energy? (describe)	Yes
Testing is required for the following standards	FCC 90, RSS 137, as NM-LMS transmitter and verification as receiver required under FCC 15.

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Basic EUT functionality description	See separate document CONF FCCID_Operation Description
High level block diagram of EUT (attachment)	See separate document CONF FCCID_Operation Description
Modes of operation	See separate document CONF FCCID_Operation Description
Customer to setup EUT on site?	Yes
EUT response time (ms)	Click here...
EUT setup time (min)	
Frequency of all clocks present in EUT	48 MHz used for FPGA, 10 MHz reference for Synthesizer, 8 MHz for microcontroller, 500 kHz for power supplies
I/O cable description Specify length and type	N/A
Available connectors on EUT	See separate document CONF FCCID_Operation Description
Peripherals required to exercise EUT Ex. Signal generator	Kapsch Reader, test coupler and TDM test tag

Note the EUT is considered to have been received the date of the commencement of the first test, unless otherwise stated. For a close-up picture of the EUT, see 'Appendix B – EUT & Test Setup Photographs'.

Client	Kapsch TrafficCom Canada Inc	
Product	MRFM-S with External Amplifier (MRFM-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Technical Specifications

Operation Band: 902 – 928 MHz

Modulation: On-Off Keying

Emission Designator ATA Protocol: N0N
6B, 6C, SeGO, Allegro, IAG: K1D

Operation Frequency:

Protocol	ATA	Sego	6B	6C	Allegro	IAG
TX modulation symbol rate	CW only	Manchester 80 kbps	Manchester Bi Phase 40 kbps	Pulse Interval Encoded 160 kbps	Manchester 300 kbps	Manchester 500 kbps
TX frequency range permitted	902.5 MHz to 903.5 MHz 910 MHz to 921.5 MHz	911.5 MHz to 919.5 MHz	911 MHz to 920.5 MHz	903MHz and 910.5 MHz to 920.5 MHz	915.75 MHz	915.75 MHz

EUT Configurations

Please see Appendix B for a picture of the unit running in normal conditions.

- Module was installed in a Reader Electronics for all testing.
- During Transmitter spurious radiated emissions, RF output was dissipated in a 50 Ω load.
- Cables and earthing are connected as per manufacturer's specification.

Operational Setup

These devices are required to be attached to the EUT for its normal operation.

- The EUT transmits continuously

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Appendix B – EUT and Test Setup Photographs

Client	Kapsch TrafficCom Canada Inc	
Product	MRFM-S with External Amplifier (MRFM-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

Note: These photos are for information purposes only. Also refer to PDF files that are separate from this test report.



Illustration 1: 802295AA part 1 of 2 front view

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

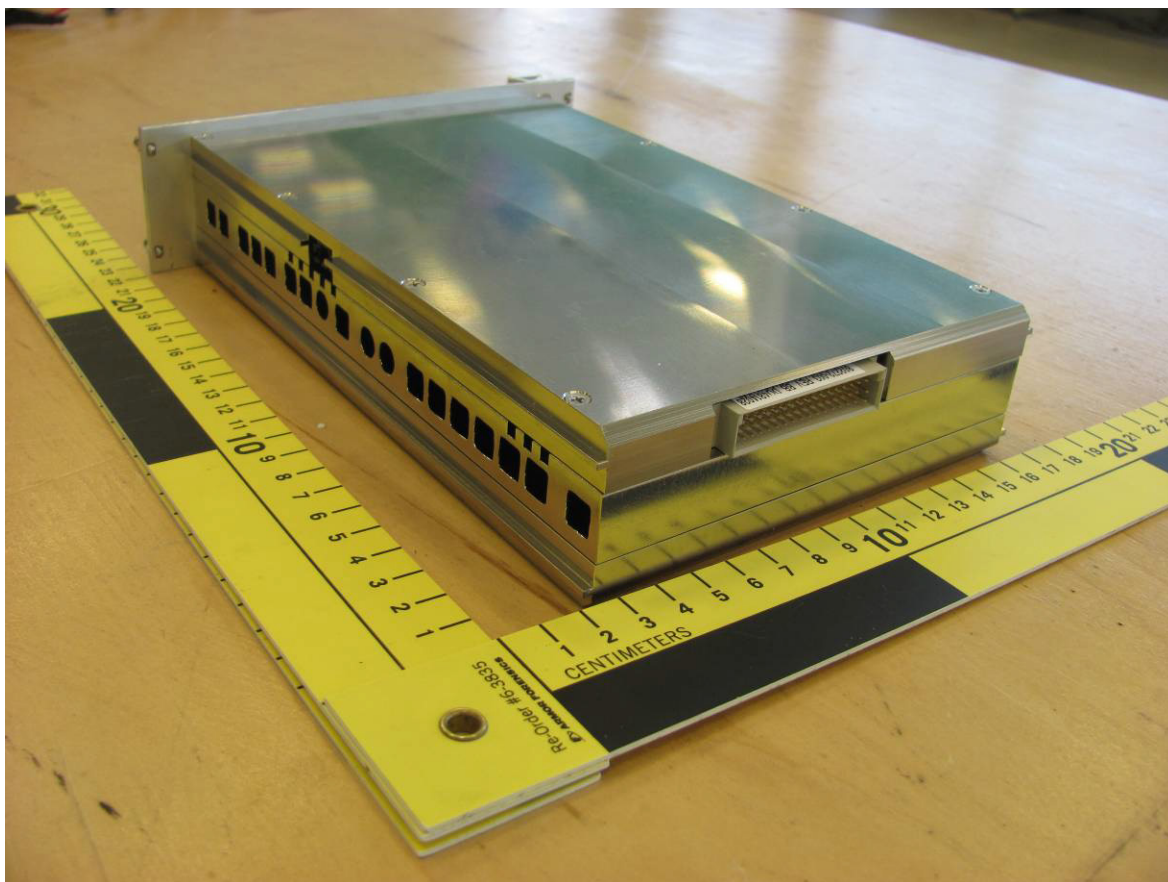


Illustration 2: 802295AA part 1 of 2 rear view

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

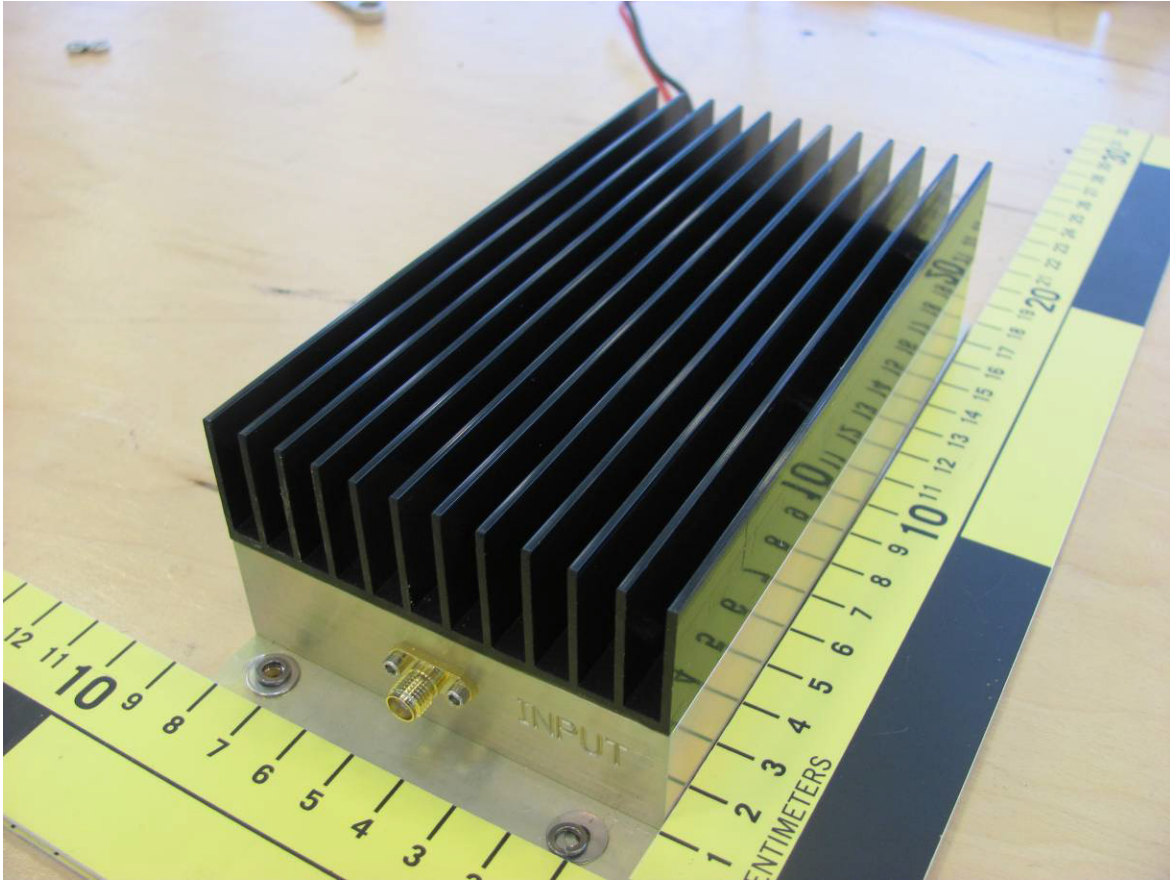


Illustration 3: Amplifier used in 802295AA part 2 of 2, input and side view

Client	Kapsch TrafficCom Canada Inc	
Product	MRFM-S with External Amplifier (MRFM-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

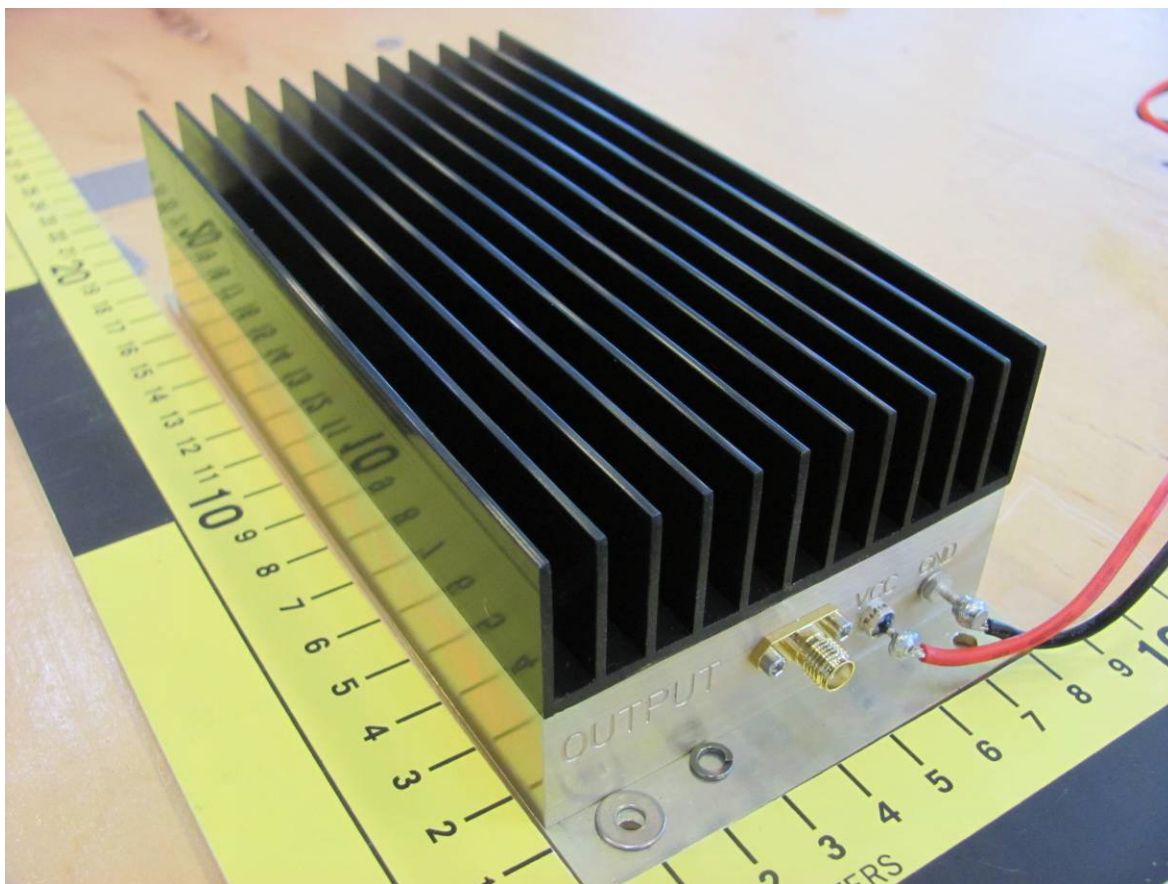


Illustration 4: Amplifier used in 802295AA part 2 of 2, output and side view

Client	Kapsch TrafficCom Canada Inc	
Product	MRFM-S with External Amplifier (MRFM-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	



Illustration 5: 802295AA part 2 of 2, Amplifier Assembly

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

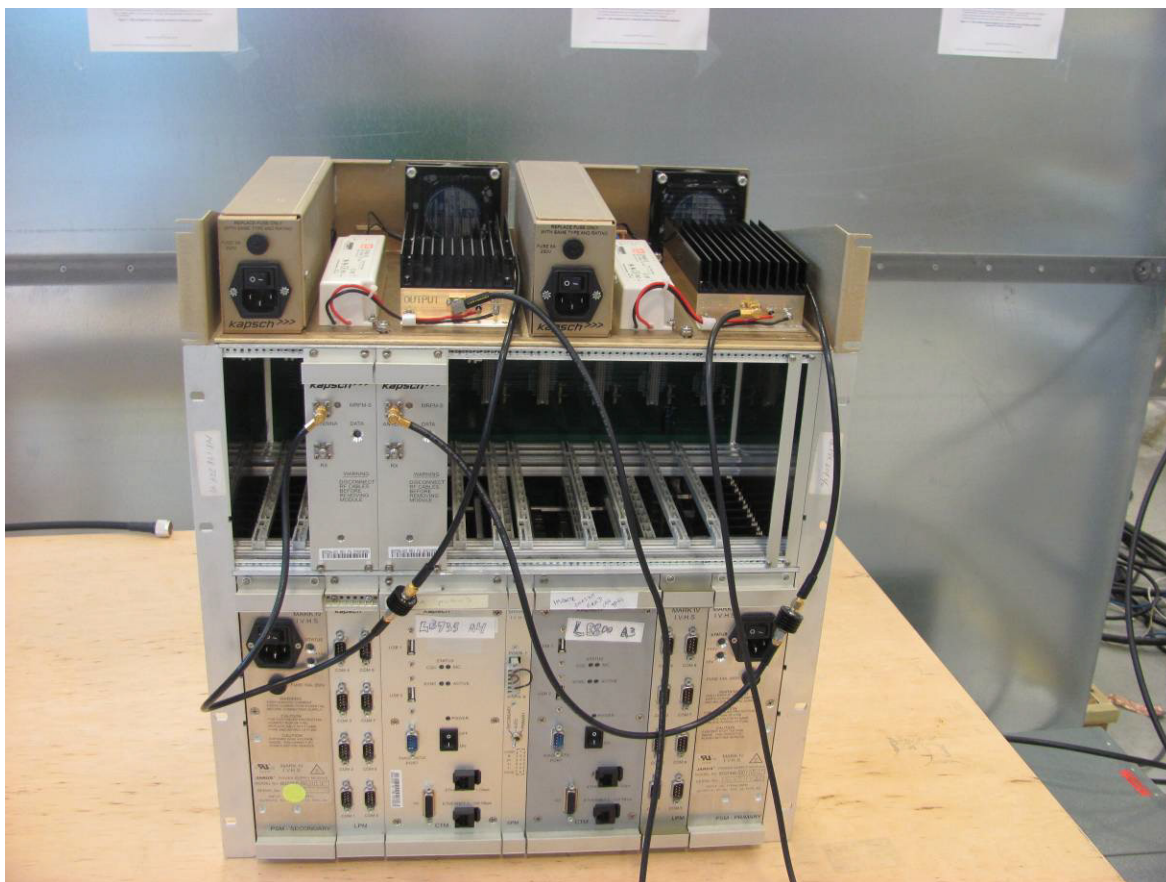


Figure 1: Two instances of 802295AA were installed in the host.

Client	Kapsch TrafficCom Canada Inc	
Product	MRFM-S with External Amplifier (MRFM-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

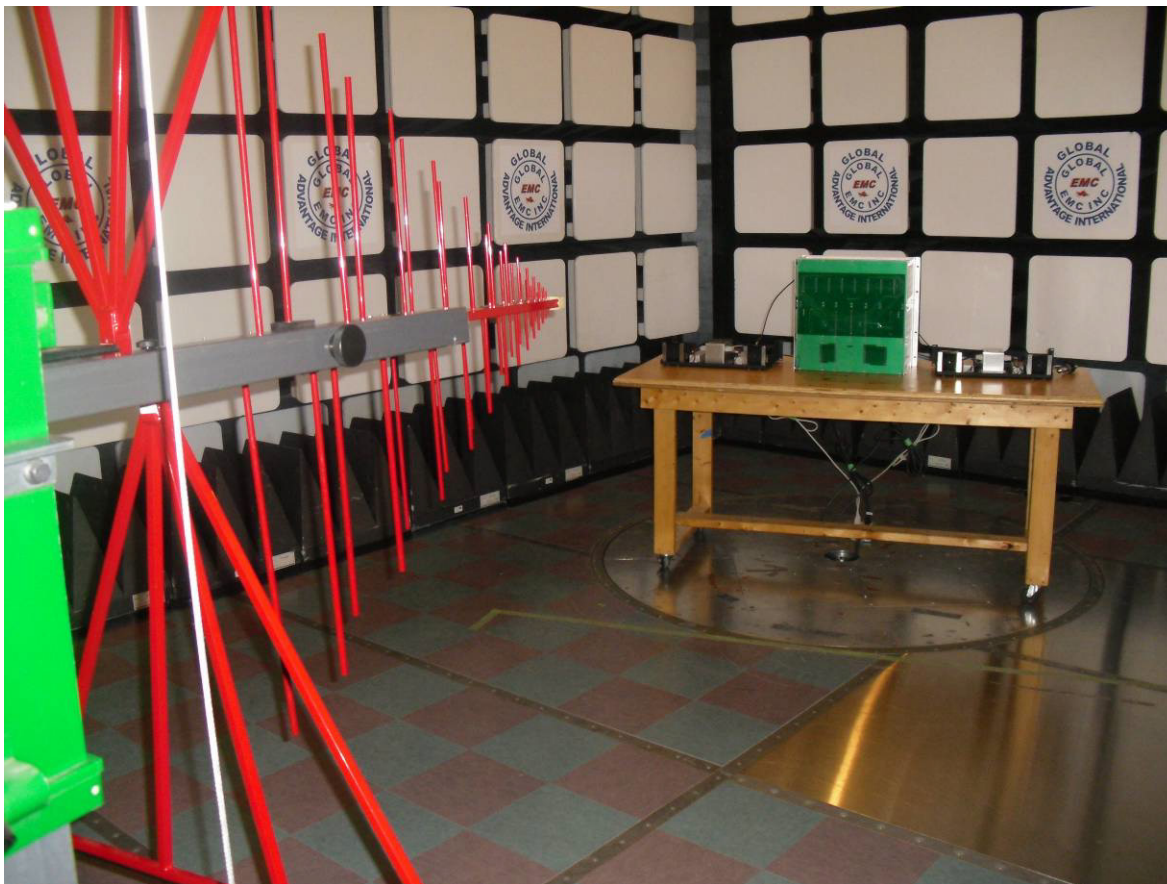


Illustration 6: 802295AA Radiated emission setup – photo 1
Note: 4 instances of 802295AA were present in setup

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	



Illustration 7: 802295AA Radiated emission setup - photo 2
Note: 4 instances of 802295AA were present in setup

Client	Kapsch TrafficCom Canada Inc	
Product	MRMF-S with External Amplifier (MRMF-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	

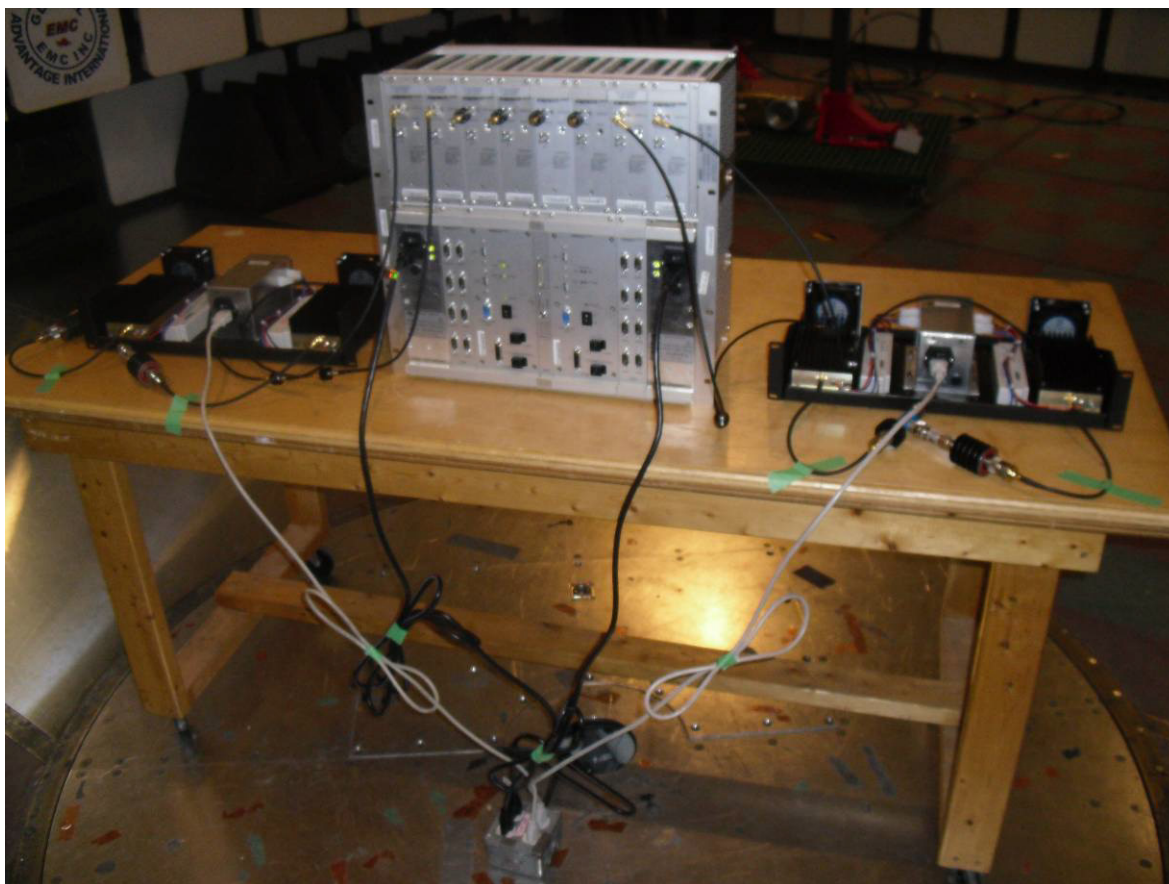


Illustration 8: 802295AA Radiated setup - photo 3
Note: 4 instances of 802295AA were present in setup

Client	Kapsch TrafficCom Canada Inc	
Product	MRFM-S with External Amplifier (MRFM-SEA)	
Standard(s)	RSS-137 Issue 2:2009 / FCC Part 90 Subpart M:2015	



Illustration 9: Antenna conducted emission setup