Test of Aeras Networks WaveLink 4500 Microwave Fixed Link

To FCC 47 CFR Part 15.407/IC RSS-210

Test Report Serial No.: ARAS01-B1 Rev E

TEST REPORT

FROM

MiCOM Labs

Test of Aeras Networks WaveLink 4500 5.3GHz Microwave Fixed Link

To FCC 47 CFR Part 15.407/IC RSS-210

Test Report Serial No.: ARAS01-B1 Rev E

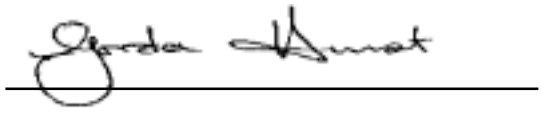
This report supersedes ARAS01-B1 Rev D

Remarks:

Equipment complied with the specification [X]

Equipment did not comply with the specification [ ]

This Test Report is issued Under the Authority of:



Gordon Hurst President & CEO

Copy No: pdf

Issue date: 28th July 2004

Manufacturer: Aeras Networks
18735 Madrone Parkway
Morgan Hill, California 95037
U.S.A.

UKAS TESTING

2106

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1 Executive Summary

The purpose of this test program was to demonstrate compliance of the Aeras Networks WaveLink 4500 all outdoor microwave fixed link unit(s) operating in the 5.3GHz band against the current USA and Canadian specifications. The equipment demonstrated compliance against FCC 47 CFR Subpart C Part 15.407 (Intentional Radiator) and Canada's IC/RSS-210 Low Power License-Exempt Radio Communication Devices RSS-210.

The microwave fixed link operates fully duplex and consists of two outdoor units (ODU). Transmit and receive frequencies are separated by 60MHz. System operation requires two separate ODU's one transmitting high band frequencies the other low band frequencies. The system utilizes two types of modulation QPSK and 16QAM. Frequency separation between channels is 60MHz, 16QAM.

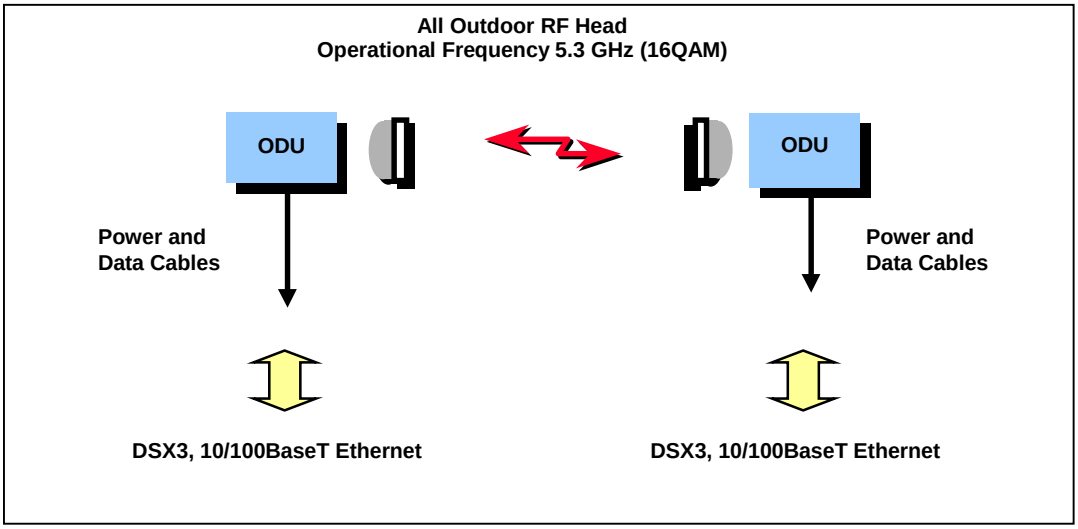
Product Information

The WaveLink 4500 family is a series of high capacity, point-to-point microwave radios. The Wavelink 4500 family supports full duplex DSX3, 10/100Base-T Ethernet traffic (45Mbit/s) with Telco grade performance. The radios feature license-free operation in the 5.3 GHz ISM Band. Each radio is easy to deploy, allowing pole mounted installations, and is optimized for all traditional T1 voice, data and video services. Each WaveLink 4500 is an all-outdoor compact unit, which houses all RF equipment near the antenna.

The WaveLink 4500 family supports a variety of wireless applications, including:

- Cellular back-haul
- Rural telecom infrastructure development
- High Speed Internet connectivity
- LAN extensions for Campus and Corporate networks

The WaveLink family can provide wireless providers with reliable data, voice and video transfers without the hassles of leasing and/or laying out cables.



2 Technical Details

Purpose	To verify compliance of the 5.3GHz WaveLink 4500 microwave fixed link to FCC and Industry Canada specifications
Applicant / Client	Aeras Networks 18735 Madrone Parkway Morgan Hill, California 95037
Manufacturer	Aeras Networks
Laboratory performing the tests	MiCOM Labs, Inc. 3922 Valley Avenue, Suite "B" Pleasanton, California 94566 USA
Test report reference number	ARAS01-B1 Rev E
Date EUT received	7th February '04
Standard applied	FCC 47 CFR Part 15.407/IC RSS-210
Dates of test (from - to)	7th February '04 – 3rd March '04
No of Units:	Two
Equipment Category:	Microwave Fixed Link
Trade Name:	WaveLink
Type Number:	4500
Type of Equipment:	All Outdoor Microwave Fixed Link
Type Designation:	4500
ITU Emission Code(s):	16M0D7W
Full Frequency Range:	5,250MHz - 5,350MHz
Frequency Channel Range:	5,262MHz – 5,338MHz Device is limited to operate only in the band specified above
Modulation:	16QAM,- 16MHz separation between channels
Client Declared Nominal Output Power:	+8.0dBm
Transmit/Receive Spacing	60MHz
Rated Input Voltage:	120Vac, 60Hz
Aggregate Bit Rates:	45Mbit/s
Temperature Range:	-33°C to +40°C
Microprocessor(s):	Motorola MPU,MPC850 at 50 MHZ
Clock/Oscillator(s):	VCOs: 1840-1940 MHZ and 3380-3510 MHz
Frequency Stability:	±5ppm, 0.005%
Primary Function:	To initiate and receive Data Transmission, Telemetry, Telecommand, Voice
Installation Procedure:	Professionally installed only

Antenna	
Antenna's and Gain(s) to be used with radio system:	21dBi, integral flat panel Dish Antenna 1ft – 22dBi 2ft – 28.5dBi–spurious emission test 1-40GHz 3ft – 31.4dBi 4ft – 34.8dBi 6ft – 37.4dBi 8ft – 39.4dBi
High-Band Transmit – All Outdoor	
Type of Unit:	Non-Protected All Outdoor Unit
Frequency Range:	Transmitter 5,322 and 5,338MHz Receiver 5,262 and 5,327MHz
EUT Filter Frequency Range:	Transmitter: 5,310 - 5,350MHz Receiver: 5,250 - 5,290MHz
Low-Band Transmit – All Outdoor	
Type of Unit:	Non-Protected All Outdoor Unit
Frequency Range:	Transmitter 5,262 and 5,327MHz Receiver 5,322 and 5,338MHz
EUT Filter Frequency Range:	Transmitter: 5,250 - 5,290MHz Receiver: 5,310 - 5,350MHz

2.1 Normative References

Ref.	Publication	Year	Title
(i)	FCC 47 CFR Parts 15.407	2001	Code of Federal Regulations
(ii)	Industry Canada RSS-210	2001	Low Power Licence-Exempt Radiocommunication Devices (All Frequency Bands)
(iii)	ANSI C63.4	1992	American National Standards for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9KHz to 40GHz
(iv)	CISPR 22 & EN 55022	1997 1998	Limits and Methods of Measurements of Radio Disturbance Characteristics of Information Technology Equipment
(v)	CISPR 16-1	1999	Specification for Radio Disturbance and Immunity measuring apparatus and methods
(vi)	M 3003 Addition 1	1997	Expression of Uncertainty and Confidence in Measurements
(vii)	LAB 34 Addition 1	2002	Expression of Uncertainty in EMC Testing
(viii)	FCC Public Notice – DA 02-2138	2002	Guidelines for Assessing Unlicensed National Information Infrastructure (U-NII) Devices

2.2 Test and Uncertainty Procedures

Both conducted and radiated emission measurements were conducted in accordance with American National Standards Institute ANSI C63.4, Normative Reference **(ii)**.

Measurement uncertainties stated are based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95% in accordance with UKAS document M 3003 and LAB 34, Normative Reference(s) **(v)** and **(vi)**.

3 Test Summary

3.1 List of Measurements

The following table represents the list of measurements for Spread Spectrum, Direct Sequence devices under the **FCC, Part 15 Subpart C, 15.407** and **Industry Canada RSS-210**.
List of Measurements and Results

Section(s)	Test Items	Description	Condition	Pass/Fail	Test Report Section
15.407(a)(2) 6.2.2 (q1)(ii)	26dB/99% Emission BW	Emission bandwidth measurement	Conducted	Pass	4.2.1.1
15.407(a)(2) 6.2.2 (q1)(ii)	Output Power	250mW or 11dBm+26dB emission bandwidth	Conducted	Pass	4.2.1.2
15.407(a)(2) 6.2.2 (q1)(ii)	Peak Power Spectral Density	Not to exceed +11dBm in any 1MHz band	Conducted	Pass	4.2.1.3
15.407(a)(2)	Antenna Gain Power Calculation	Reduce power if antenna gain greater than 6dBi	Calculation	Pass	4.2.1.4
15.407(a)(6)	Peak Excursion Ratio	<13dB in any 1MHz bandwidth	Conducted	Pass	4.2.1.5
15.407(c)	Transmission Discontinuity	Manufacturer's declaration			4.2.1.6
15.407(g) 15.31 6.2.2 (q1)(iv)(e)	Frequency Stability	Limits: contained within band of operation at all times. Supply voltage variation	Manufacturer declaration Conducted	Compliant Pass	4.2.1.7
15.407(f) 6.2.2 (q1)(iv)(g)	RF Radiation Exposure	Exposure to radio frequency energy levels	Calculation	Compliant	4.2.1.8
15.407(b)/15.207 6.6/7.4	AC Wireline Conducted Emissions 150kHz–30MHz	AC Conducted Emissions	Conducted	Pass	4.2.1.9
15.407(b)(5)/ 15.209 6.2.2 (q1) (ii)	Spurious Emissions	Spurious emissions below 1GHz	Radiated	Pass	4.2.1.10
15.407(b)(2) 6.2.2 (q1) (ii)	Spurious Emissions/Band -edge	Spurious emissions above 1GHz (1-40GHz)	Radiated	Pass	4.2.1.11

Note 1: *Test results reported in this document relate only to the items tested*
Note 2: *No equipment modifications were required to achieve the results reported in this document*
Note 3: *The required tests demonstrated compliance as per client declaration of test configuration, monitoring methodology and associated pass/fail criteria.*

3.2 Test Configurations

Operational Modes of EUT
The EUT was delivered as two separate items high-band and low-band transmit RF units. Both units can cover the entire 5,250-5,350MHz operational frequency bands. The high band and low band units have identical components and PCB's installed internally.

Conducted measurements were made from the available N-type connector.

Table 3.3(a) – Channels Exercised

Operating Channel No.	Operating Frequency (MHz) Declared Power Level: +6dBm	
	High Band Tx	Low Band Tx
1	5,338	5,322
2	5,278	5,262

Test Configuration
The test configuration was a standalone all outdoor RF unit. The unit operates full duplex i.e. both transmitter and receiver operating simultaneously.

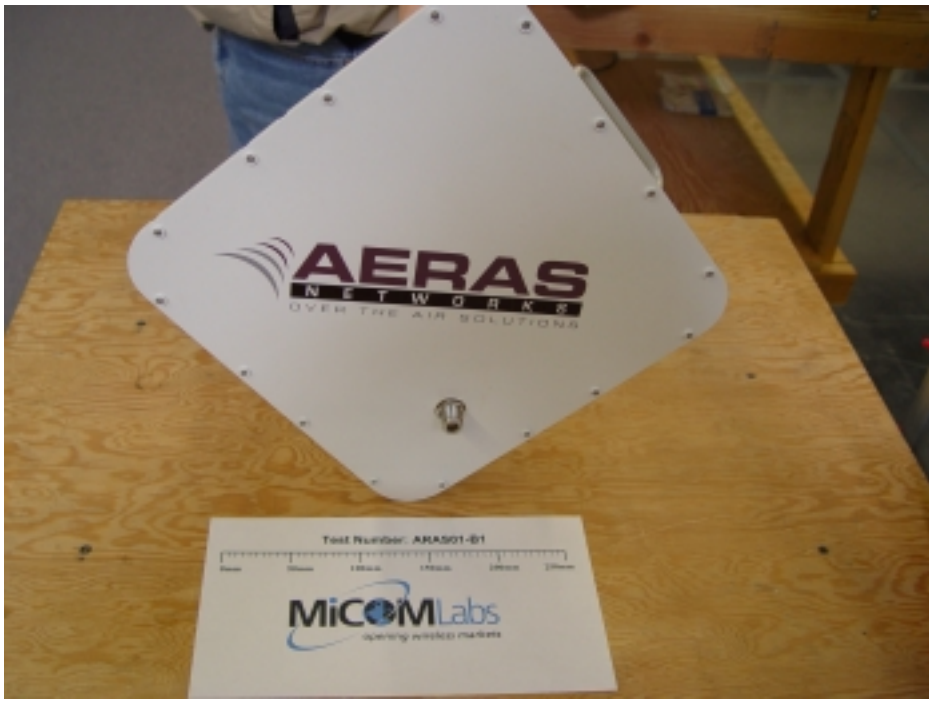
Test Cabling Supplied
Data Port Test Cable (10/100BT) – 3 meter length

Craft Port Cabling – 2 meter length

Power Supply Cable – 10 meter length

WaveLink 4500 - All outdoor RF unit operating in the 5.3GHz frequency band

Power, Data and Craft Ports



N-Type Antenna Connector

4 Measurements, Examinations and Derived Results

4.1 General observations

Equipment model and serial number(s)

Module:	Model Number:	Serial Number:
WaveLink 4500 High-band transmit	WL-4500	M100747
WaveLink 4500 Low-band transmit	WL-4500	M100746
2ft Radiowaves Dish Antenna (28.5dBi)	SP2-5.2NS	7224
Data Port Test Cable (10/100BT)	903015-001 Rev A	Not Available
Craft Port (10/100BT)	Test-100652-00X	Not Available
Power Supply Cable (10/100BT)	Not Available	Not Available

*The WaveLink WL-4500 equipment submitted for testing was full production models

This report provides summarised test results of each test performed. Detailed test results were recorded in Test Results Booklets and retained within the laboratory.

4.2 Test Results

4.2.1 Device Characteristics

4.2.1.1 26dB and 99% Emission Bandwidth and Power Limits

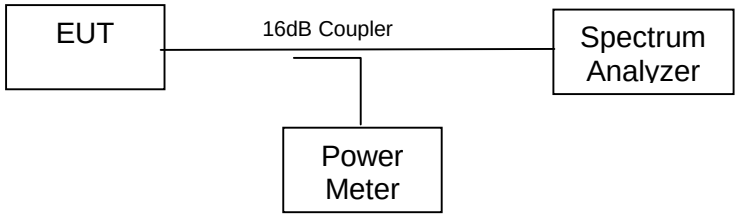
FCC, Part 15 Subpart C §15.407(a)(2) – 26dB Bandwidth
Industry Canada RSS-210 §6.2.2 (q1)(ii) – 99% Bandwidth

Test Procedure

The 26dB and 99% bandwidth is measured using a spectrum analyser connected to the antenna port. The measurement reference for the 26dB bandwidth is from the peak value measured within the in-band emission while the EUT is operating in transmission mode at the appropriate centre frequency. The spectrum analyzer was set to:
26dB & 99% BW setting: RBW=1MHz, VBW=1MHz*1, Span=30MHz, Sweep = 5mS

*1: To be adjusted accordingly based on the spectrum stability

Measurement set up for 26dB/99% bandwidth test



Measurement Results

Ambient conditions.
Temperature: 16 to 21 °C Relative humidity: 34 to 55% Pressure: 999 to 1012 mbar

TABLE OF RESULTS – **HIGH BAND 26dB Bandwidth**

Centre Frequency (MHz)	Low Frequency (MHz)	Plot #, see Section 7	26dB BW (MHz)	Power Limit (dBm)
5,322	5,312.2	On file in lab	15.75	22.97
5,338	5,330.1	ARAS01-B1/01	15.84	23.00

TABLE OF RESULTS – **LOW BAND 26dB Bandwidth**

Centre Frequency (MHz)	Low Frequency (MHz)	Plot #, see Section 7	26dB BW (MHz)	Power Limit (dBm)
5,262	5,254.0	On file in lab	15.93	23.02
5,278	5,270.0	ARAS01-B1/02	15.93	23.02

TABLE OF RESULTS – **HIGH BAND 99% Bandwidth**

Centre Frequency (MHz)	Low Frequency (MHz)	Plot #, see Section 7	26dB BW (MHz)	Power Limit (dBm)
5,322	5,315.4	ARAS01-B1/03	13.45	22.29
5,278	5,331.4	On file in lab	13.39	22.27

LOW BAND

TABLE OF RESULTS – **LOW BAND 99% Bandwidth**

Centre Frequency (MHz)	Low Frequency (MHz)	Plot #, see Section 7	99% BW (MHz)	Power Limit (dBm)
5,262	5,255.3	On file in lab	13.51	22.31
5,278	5,271.3	ARAS01-B1/04	13.51	22.31

Maximum Power Limits Calculation
FCC Power Limit – +23.02dBm

Industry Canada Power Limit - +22.31dBm

Specification

Limits

§15.407 (a)(2) For the band 5.25-5.35GHz, the peak transmit power over the frequency band of operation shall not exceed the lesser of 250mW (+24dBm) or 11dBm + 10Log10 B, where B is the 26dB bandwidth in MHz.

RSS-210 §6.2.2 (q1)(ii) The maximum transmitter power shall not exceed 250mW (+24dBm) or 11 + 10Log10 B (dBm), whichever is less. The power spectral density shall not exceed 11dBm in any 1MHz band. The maximum EIRP shall not exceed 1Watt or 17 + 10Log10 B (dBm), whichever is less. B is the 99% power bandwidth in MHz.

Laboratory Measurement Uncertainty for Spectrum Measurement

Measurement uncertainty	± 2.81dB

Traceability

METHOD	TEST EQUIPMENT USED
Measurements were made per work instruction WI-03 'Measurement of RF Spectrum Mask'	Bar 1, 3F50N002, ReCVR 1, coupler

4.2.1.2 Output Power

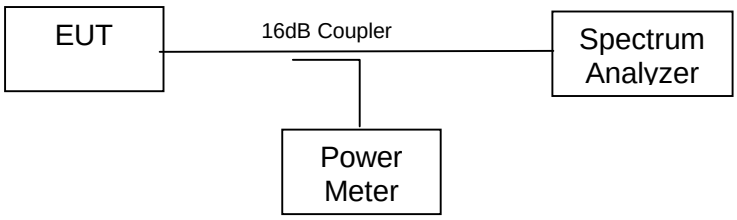
FCC, Part 15 Subpart C §15.407(a)(2)
Industry Canada RSS-210 §6.2.2 (q1)(ii)

Test Procedure

- A transmitter antenna terminal of EUT is connected to the input of an RF power sensor.
- Measurement is made while EUT is operating in transmission mode at the appropriate centre frequency.

Test Measurement Set up

Measurement set up for Transmitter Output Power



Measurement Results for Output Power

Ambient conditions.
Temperature: 16 to 21 °C Relative humidity: 34 to 55% Pressure: 999 to 1012 mbar

NOMINAL OUTPUT POWER LEVEL - +8dBm

TABLE OF RESULTS – **High Band**

Centre Frequency (MHz)	Duty Cycle (%)	Path Loss (dB)	Measured Peak O/P Power (dBm)	Conducted Power (dBm)
5,322	100	16.41	-10.92	+7.49
5,338	100	16.41	-10.51	+7.90

TABLE OF RESULTS – **Low Band**

Centre Frequency (MHz)	Duty Cycle (%)	Path Loss (dB)	Measured O/P Power (dBm)	Conducted Power (dBm)
5,262	100	16.41	-11.28	+7.13
5,278	100	16.41	-11.12	+7.29

Specification

Limits

§15.407 (a)(2) For the band 5.25-5.35GHz, the peak transmit power over the frequency band of operation shall not exceed the lesser of 250mW (+24dBm) or 11dBm + 10Log10 B, where B is the 26dB bandwidth in MHz.

From Section 4.2.1.1 26dB Emission Bandwidth and Power Limits, maximum power limits - FCC Power Limit – +23.02dBm

RSS-210 §6.2.2 (q1)(ii) The maximum transmitter power shall not exceed 250mW (+24dBm) or 11 + 10Log10 B, dBm, whichever is less. The power spectral density shall not exceed 11dBm in any 1MHz band. The maximum EIRP shall not exceed 1Watt or 17 + 10Log10 B, dBm, whichever is less. B is the 99% power bandwidth in MHz.

From Section 4.2.1.1 99% Emission Bandwidth and Power Limits, maximum power limits - Industry Canada Power Limit - +22.31dBm

Laboratory Measurement Uncertainty for Power Measurements

Measurement uncertainty (dB)	±1.33

Traceability

METHOD	TEST EQUIPMENT USED
Measurements were made per work instruction WI-01 ‘Measuring RF Output Power’	Bar 1, PMtr 1, PSnsr 1, coupler

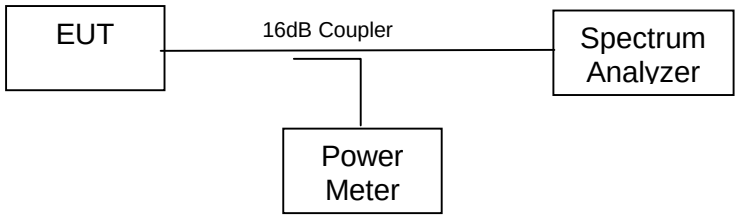
4.2.1.3 Peak Power Spectral Density

FCC, Part 15 Subpart C §15.407(a)(5)
Industry Canada RSS-210 §6.2.2 (q1)(ii)

Test Procedure

This is an antenna conducted measurement using a spectrum analyzer. The transmitter output is connected to a spectrum analyser in peak detector mode with max hold implemented. Method 1 in Reference (viii) was used in order to prove compliance. The Peak Power Spectral Density is the highest level found across the emission in any 1MHz reference bandwidth.

The spectrum analyzer was set as follows:
RBW= 1MHz, VBW=3MHz, Span 20MHz and 5mS sweep time



Test Measurement Set up

Measurement set up for Peak Power Spectral Density

Measurement Results for Peak Power Spectral Density

Ambient conditions.
Temperature: 16 to 21 °C Relative humidity: 34 to 55% Pressure: 999 to 1012 mbar

HIGH BAND - highest power levels

TABLE OF RESULTS – **High Band**

Centre Frequency (MHz)	Path Loss (dB)	Spectrum Analyzer Reading (dBm) including Path Loss Offset
5,322	3.50	-4.19
5,338	3.50	-4.45

Specification

Limits

§15.407 (a)(2) Peak Power Spectral Density shall not exceed +11dBm in any 1MHz band
RSS-210 §6.2.2 (q1)(ii) The power spectral density shall not exceed +11dBm in any 1MHz band.
RSS-210 §6.2.2 (q1)(iv) Within the emission bandwidth, when the peak spectral density per MHz over any continuous transmission exceeds the average ($10Log_{10}$ B) value by more than 3 dB, the permissible power spectral density shall be reduced by the excess amount.

Laboratory Measurement Uncertainty for Spectrum Measurement

Measurement uncertainty	± 2.81dB

Traceability

METHOD	TEST EQUIPMENT USED
Measurements were made per work instruction WI-03 ‘Measurement of RF Spectrum Mask’	Bar 1, 3F50N002, ReCVR 1, coupler

4.2.1.4 Antenna Gain - Power Reduction Calculations

FCC, Part 15 Subpart C §15.407(a)(2)

Limit

FCC, Part 15 Subpart C §15.407(a)(2) If transmitting antennas of directional gain greater than 6 dBi are used, both the peak transmit and peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

Using the measured and calculated results from Section **4.2.1.1 26dB and 99% Emission Bandwidth and Power Limits** and the manufacturer's declared antenna gain for each antenna the following are the maximum Peak Power and Peak Power Spectral Density that can be transmitted.

Peak Power calculation with maximum measured 15.93MHz bandwidth - +**23.02dBm**
Peak Power Spectral Density - **+11dBm**

Transmitting Antennas

Type/Gain (dBi)	Peak Power & Peak Power Spectral Density Reduction (dB) (Antenna Gain – 6dBi)	Maximum Allowable Peak Power (dBm)	Maximum Allowable Peak Power Spectral Density (dBm)
Integral – 21.0	15.0	+8.02	-4.0
1ft Dish – 22.0	16.0	+7.02	-5.0
2ft Dish – 28.5	22.5	+0.52	-11.5
3ft Dish – 31.4	25.4	-2.38	-14.4
4ft Dish – 34.8	28.8	-5.78	-17.8
6ft Dish – 37.4	31.4	-8.38	-20.4
8ft Dish – 39.4	33.4	-10.38	-22.4

4.2.1.5 Peak Excursion Ratio

FCC, Part 15 Subpart C §15.407(a)(6)

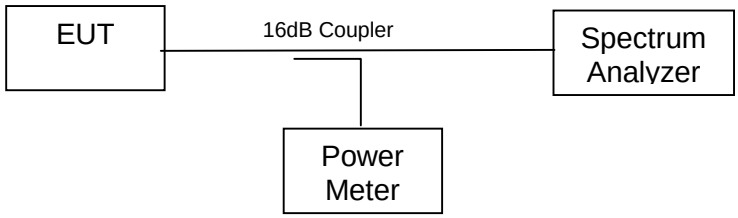
Test Procedure

This is an antenna conducted measurement using a spectrum analyzer. The transmitter output is connected to a spectrum analyser in peak hold operational mode. Method 1 in Reference (viii) was used in order to prove compliance. The Peak Excursion Ratio is the difference in amplitude (dB) between the two traces.

The spectrum analyzer setting was as follows:
RBW= 1MHz, VBW=3MHz, Span 20MHz and 5mS sweep time

Test Measurement Set up

Measurement set up for Peak Excursion Ratio



Measurement Results for Peak Excursion Ratio

Ambient conditions.
Temperature: 16 to 21 °C Relative humidity: 34 to 55% Pressure: 999 to 1012 mbar

Radio parameters.
QPSK, 16QAM

NOMINAL OUTPUT POWER LEVEL - +6dBm

TABLE OF RESULTS – **High Band**

Centre Frequency (MHz)	Duty Cycle (%)	Plot #, see Section 7 (only worst case plot reported)	Measured Excursion Ratio (dB)
5,322	100	On file in lab	+2.7
5,338	100	ARAS01-B1/05	+2.9

TABLE OF RESULTS – **Low Band**

Centre Frequency (MHz)	Duty Cycle (%)	Plot #, see Section 7 (only worst case plot reported)	Measured Excursion Ratio (dB)
5,262	100	ARAS01-B1/06	+3.2
5,278	100	On file in lab	+2.8

Specification

Limits

§15.407 (a)(6) The ratio of the peak excursion of the modulation envelope (measured using a peak hold function) to the peak transmit power (measured as specified in this paragraph) shall not exceed 13dB across any 1MHz bandwidth or the emission bandwidth whichever is less.

Laboratory Measurement Uncertainty for Spectrum Measurement

Measurement uncertainty	± 2.81dB

Traceability

METHOD	TEST EQUIPMENT USED
Measurements were made per work instruction WI-03 'Measurement of RF Spectrum Mask'	Bar 1, 3F50N002, ReCVR 1, coupler

4.2.1.6 Automatic Discontinuation of Transmission

FCC, Part 15 Subpart C §15.407(c)

Manufacturer's Declaration

The WaveLink 4500 is always transmitting data in the form of telemetry and management regardless of the state of the user interface. As such, the WaveLink 4500 transmitter will normally be on except in the case of a hardware failure. In order to transmit, the WaveLink 4500 must have all of its synthesizers programmed and locked to the correct frequency. Any time one of the synthesizers goes out of lock, the transmitter is automatically turned off. This prevents the WaveLink 4500 from transmitting out of band due to a hardware or software failure.

4.2.1.7 Frequency Stability

FCC, Part 15 Subpart C §15.407(g)
Industry Canada RSS-210 §6.2.2 (q1)(iv)(e)

Test Procedure
No testing was performed for Frequency Stability.

The manufacturer of the equipment is responsible for ensuring that the frequency stability is such that emissions are always maintained within the band of operation under all conditions.

Manufacturer Declaration
The WaveLink 4500 is a fully synthesized radio and all the sources that determine transmit and receive frequencies are phased locked to a master 60MHz TXCO having a ±5ppm stability across the entire operating temperature range of the radio.

±5ppm at 5.3GHz translates to a maximum frequency shift of ±26.5KHz. As the edge of the channels are at least one MHz from either of the band edges, ±26.5KHz is more than sufficient to guarantee that the intentional emission will remain in the band over the entire operating range of the radio.

Voltage Variation
The ac supply voltage was varied between 85% and 115% of the nominal rated supply voltage. No change in fundamental frequency was observed during the variation. The equipment was found to be compliant.

Temperature Variation
The temperature was set at the extremes of equipment operation –33°C and +60°C. No change in fundamental frequency was observed during this period. The equipment was found to be compliant.

4.2.1.8 RF Radiation Exposure

FCC, Part 15 Subpart C §15.247(f)
Industry Canada RSS-210 §6.2.2(q1)(iv)(g)

Calculations for Maximum Permissible Exposure Levels

Given

$E = \sqrt{(30 * P * G)} / d$

and

$S = E^2 / 3770$

where
E = field strength in volts/meter
P = power in watts
G = numeric antenna gain
d = distance in meters
S = power density in milliwatts / square centimeter

Combining and rearranging the terms to express the distance as a function of the variables, yields:

$d = \sqrt{(30 * P * G)} / (3770 * S)$

Rearrange to milliwatts and centimeters

P(mw) = P(watts) / 1000

d(cm) = d(m) * 100

yields
$d = 100 * \sqrt{(30 * (P / 1000) * G)} / (3770 * S)$

$d = 0.282 * \sqrt{(P * G / S)}$

where

d = distance in centimetres
P = Power in mW
G = Numeric Antenna Gain
S = Power Density in centimetres^2

Substituting the logarithmic form of power and gain using:

P(mW) = 10 ^ (P(dBm)/10) and

G(numeric) = 10 ^ (G(dBi) /10)

Yields:

d = 0.282 * 10 ^ ((P + G) / 20) /√ S

where

d = MPE distance in centimetres
P = Power in dBm
G = Antenna Gain in dBi
S = Power Density Limit in mW / centimetres^2 (Limit S = 1mW / cm^2 from §1.310 Table 1)

Maximum output power observed from power measurements – +**7.9dBm**
Maximum antenna gain – **28.5dBi**

Power Density Limit (mW / cm^2)	Maximum Measured Output Power (dBm)	Antenna Gain (dBi)	MPE Distance (cm)
1	7.9	28.5	18.6

Specification

Maximum Permissible Exposure Limits

§15.247 (b)(5) Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency levels in excess of the Commission's guidelines. See §1.1307 (b)(1) of this chapter.

Limit S = 1mW / cm^2 from 1.310 Table 1

Note: for mobile or fixed location transmitters the minimum separation distance is 20cm, even if calculations indicate the MPE distance to be less.

Traceability

METHOD	TEST EQUIPMENT USED
Measurements were made per work instruction WI-01 'Measuring RF Output Power'	Bar 1, PMtr 1, PSnsr 1, coupler, 3dB & 30dB pads

Laboratory Measurement Uncertainty for Power Measurements

Measurement uncertainty (dB)	±1.33

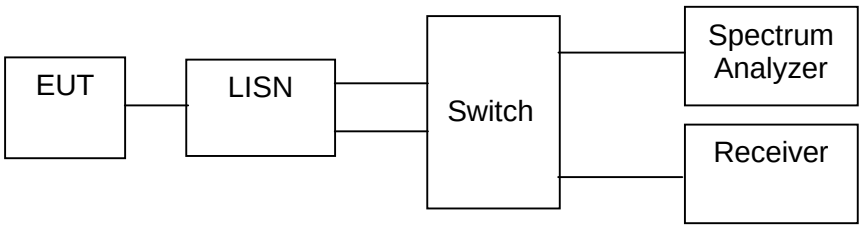
4.2.1.9 AC Wireline Conducted Emissions (150KHz – 30MHz)

FCC, Part 15 Subpart C §15.407(b)/15.207
Industry Canada RSS-210 §6.6(b), §7.4

Test Procedure

The EUT is configured in accordance with ANSI C63.4. The conducted emissions are measured in a shielded room with a spectrum analyzer in peak hold in the first instance. Emissions closest to the limit are measured in the quasi-peak mode (QP) with the tuned receiver using a bandwidth of 9KHz. The emissions are maximized further by cable manipulation. The highest emissions relative to the limit are listed.

Test Measurement Set up



Measurement Results for AC Wireline Conducted Emissions (150KHz – 30MHz)

Ambient conditions.
Temperature: 16 to 21 °C Relative humidity: 34 to 55% Pressure: 999 to 1012 mbar

The following matrix references the AC Wireline Conducted Emission plot s in Section 7, Graphical Results 'AC Wireline' ARAS01-B1/07-08.

Frequency (MHz)	Peak Voltage (dBµV)	QP Limit (dBµV)	QP Voltage (dBµV)	Phase
11.166	59.02	60.00	-	L
11.166	58.24	60.00	-	N
15.822	55.72	60.00	-	L
15.822	54.82	60.00	-	N
19.774	59.00	60.00	-	L
19.778	57.50	60.00	-	N

L – Live

N – Neutral

Note: The measured Peak Voltage was less than the Quasi-Peak limit, therefore no Quasi-Peak or Average evaluations were required.

Specification

Limit

§15.407(b) / 15.207 (a) Except as shown in paragraphs (b) and (c) of this section, for 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 150KHz to 30MHz shall not exceed the limits in the following table, as measured using a 50μΩ line impedance stabilization network (LISN), see §15.207 (a) matrix below. 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.

6.6(b) Transmitters marketed for use only in a commercial, industrial or business environment and not intended for use in homes are permitted a limit of 1000 μV (0.45 - 1.705 MHz) and 3000 μV (1.705 - 30 MHz).

§15.407 (b) Limit

The lower limit applies at the boundary between the frequency ranges.

Frequency of Emission (MHz)	Conducted Limit (dBμV)	
	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

Laboratory Measurement Uncertainty for Conducted Emissions

Measurement uncertainty (dB)	±2.64

Traceability

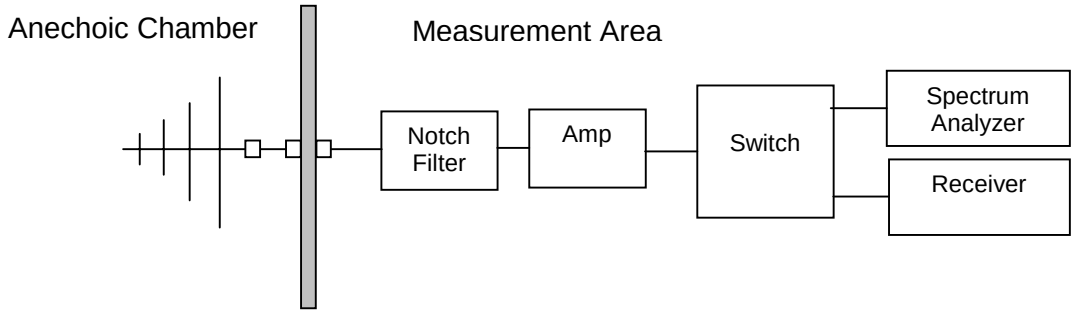
METHOD	TEST EQUIPMENT USED
Measurements were made per work instruction WI-EMC-01 'Measurement of Conducted Emissions'	Bar 1, ReCVR 1, LISN 1

4.2.1.10 Radiated Emissions (30MHz – 1GHz)

FCC, Part 15 Subpart C §15.407(b)(5)/ §15.209
Industry Canada RSS-210 §6.2.2(q1)(ii)

Test Procedure
Preliminary radiated emissions are measured in the anechoic chamber at a 3-meter distance on every azimuth in both horizontal and vertical polarity. The emissions are recorded with a spectrum analyzer in peak hold mode. Emissions closest to the limits are measured in the quasi-peak mode with the tuned receiver using a bandwidth of 120kHz on the Open Area Test Site (OATS). The highest emissions relative to the limit are listed. The OATS test set up is identified in the photograph in Section 5. The EUT was configured and manipulated to maximize emissions.

Test Measurement Set up



Field Strength Calculation
The field strength is calculated by adding the Antenna Factor and Cable Loss, and subtracting Amplifier Gain from the measured reading. In this test facility, the Antenna Factor, Cable Loss, and Amplifier Gains are loaded into the Rohde & Schwarz Receiver and the corrected field strength can be read directly on the receiver.

$$FS = R + AF + CORR$$

where:

FS = Field Strength
R = Measured Receiver Input Amplitude
AF = Antenna Factor
CORR = Correction Factor = CL – AG + NFL
CL = Cable Loss
AG = Amplifier Gain

For example:
Given a Receiver input reading of 51.5dBµV; Antenna Factor of 8.5dB; Cable Loss of 1.3dB; Falloff Factor of 0dB, an Amplifier Gain of 26dB and Notch Filter Loss of 1dB. The Field Strength of the measured emission is:

FS = 51.5 + 8.5 + 1.3 - 26.0 +1 = 36.3dBµV/m

Conversion between dBµV/m (or dBµV) and µV/m (or µV) are done as:

Level (dBµV/m) = 20 * Log (level (µV/m))

40 dBµV/m = 100µV/m
48 dBµV/m = 250µV/m

Measurement Results for Restricted Bands Radiation (30MHz – 1GHz)

Ambient conditions.
Temperature: 16 to 21 °C Relative humidity: 34 to 55% Pressure: 999 to 1012 mbar

TABLE OF RESULTS – **High Band**

Frequency (MHz)	Polarity (H/V)	Antenna Factor (dB)	Correction Factor (dB)	Corrected Field Strength Reading (dBµV/m, **QP**)	Limit (dBµV/m) **(QP)**	Field Strength (µV/m) **(QP)**	Limit (µV/m) **(QP)**
64.24	V	9.3	15.37	37.67	40.0	76.47	100
177.20	V	14.3	16.07	39.78	43.5	97.50	150
200.02	V	15.2	16.17	42.99	43.5	141.09	200
200.02	H	14.8	16.17	43.21	43.5	144.71	200
970.44	V	22.4	20.37	44.06	53.0	159.59	500

Reference Pre-scan data see Section 7 Graphical Results '**Pre-scan (30-1GHz)'** ARAS01-B1/09-10.

Specification

Limits

§15.205 (a) Except as shown in paragraph (d) of 15.205 (a), only spurious emissions are permitted in any of the frequency bands listed.

§15.205 (a) Except as shown in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section §15.209. At frequencies equal to or less than 1000MHz, compliance with the limits in Section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000MHz, compliance with the emission limits in Section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in Section 15.35 apply to these measurements.

§15.209 (a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table.

Frequency(MHz)	Field Strength (µV/m)	Measurement Distance (meters)
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Laboratory Measurement Uncertainty for Radiated Emissions

Measurement uncertainty (dB)	+5.6 / -4.5

Traceability

METHOD	TEST EQUIPMENT USED
Measurements were made per work instruction WI-EMC-07 'Radiated Emissions'	Bar 1, Notch, AMP 3, ANT 1, K-Cbl 11, 10F50N003, 15F50N001, 5F50N001, ReCVR1

4.2.1.11 Spurious Emissions (1GHz - 40GHz)

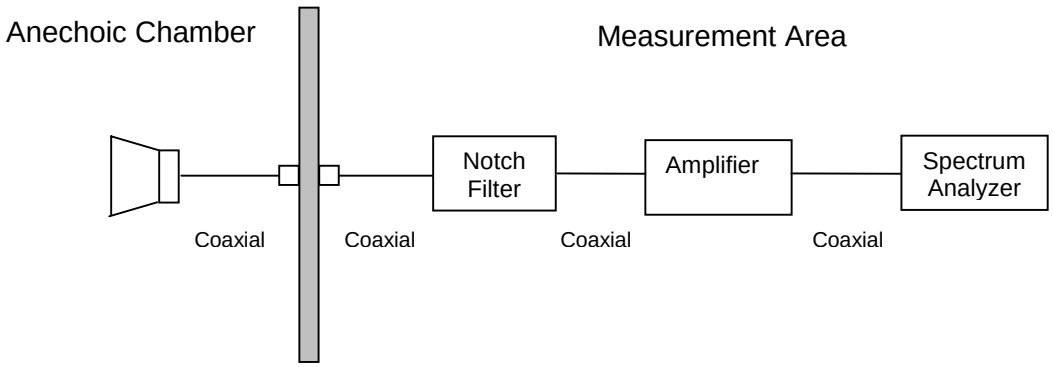
FCC, Part 15 Subpart C §15.407(b)(2)
Industry Canada RSS-210 §6.2.2(q1)(ii)

Test Procedure

Preliminary radiated emissions 1GHz to 40GHz are measured in the anechoic chamber at a 3-meter distance on every azimuth in both horizontal and vertical polarity. The emissions are recorded and maximized as a function of azimuth by rotation through 360° with a spectrum analyzer in peak hold mode. A notch filter is used to remove the fundamental frequency. Emissions closest to the limit are measured with a spectrum analyzer on the Open Area Test Site (OATS). The highest emissions relative to the limit are listed. The OATS test set up is identified in the photograph in Section 5. Frequencies not covered by the 'Restricted Bands of Operation' are compared to the fundamental carrier per 47 CFR 15.247(c). The antenna used to exercise Spurious Emissions 1-40GHz was a 2-foot dish antenna with gain of 28.5dBi. The EUT was configured and manipulated to maximize emissions.

When measuring the emission limits, the nominal carrier frequency was adjusted as close to the upper and lower band edge as the equipment software permitted. The emission measurement was performed using a minimum bandwidth of 1MHz.

Test Measurement Set up



Measurement set up for Radiated Emission Test

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Loss, and subtracting Amplifier Gain from the measured reading. All factors are included in the reported data.

FS = R + AF + CORR - FO

where:

FS = Field Strength
R = Measured Spectrum analyzer Input Amplitude
AF = Antenna Factor
CORR = Correction Factor = CL – AG + NFL
CL = Cable Loss
AG = Amplifier Gain
FO = Distance Falloff Factor
NFL = Notch Filter Loss

For example:
Given receiver input reading of 51.5dBµV; Antenna Factor of 8.5dB; Cable Loss of 1.3dB; Falloff Factor of 0dB, an Amplifier Gain of 26dB and Notch Filter Loss of 1dB. The Field Strength of the measured emission is:

FS = 51.5 + 8.5 + 1.3 - 26.0 +1 = 36.3dBµV/m

Conversion between dBµV/m (or dBµV) and µV/m (or µV) are done as:

Level (dBµV/m) = 20 * Log (level (µV/m))

40 dBµV/m = 100µV/m
48 dBµV/m = 250µV/m

Measurement Results for Restricted Bands Radiation (1GHz - 40GHz)

Ambient conditions.
Temperature: 16 to 21 °C Relative humidity: 34 to 55% Pressure: 999 to 1012 mbar

TABLE OF RESULTS – **HIGH BAND**

Frequency (MHz)	Polarity (H/V)	Antenna Factor (dB)	Correction Factor (dB)	Corrected Field Strength Reading (dBµV/m) **(QP)**	Limit (dBµV/m) **(QP)**	Field Strength (µV/m) **(QP)**	Limit (µV/m) **(QP)**
5,338	H	36.1	3.6	+92.17	OB*	-	-
5,338	V	36.1	3.6	+90.65	OB*	-	-

No emissions were observed and system was found to be compliant with the requirements in the range 1-40GHz. The conducted measurement plots ARAS01-B1/11-13 (see Section 7) have been included to prove compliance.

Specifically in-line with 15.407 (b) (2) All emissions outside of the 5,150-5,350MHz band did not exceed an EIRP of -27dBm/MHz. No emissions were observed in the 5,150-5,250MHz band.

***Note:** OB implies Operational Band (5,250 – 5,350MHz); in this case the limit was measured using the spectrum analyzer
RB implies "Restricted Band"
NRB implies "Non Restricted Bands of Operation"

Frequencies not covered by the Restricted Bands of Operation i.e. Non Restricted Bands are compared to the fundamental carrier per 47 CFR §15.247(c). 'OB' – Operational Band in the matrix identifies the fundamental carrier.

Band-Edge Requirements

FCC, Part 15 Subpart C §15.407(b)(2)

Data plots are available in Section 7'Graphical Results', see plots ARAS01-B1/14 and 15.

The equipment complies with the restricted band and band-edge requirements for 4.5GHz - 5.15GHz and 5.35GHz - 5.46GHz per FCC Sections 15.205 and 15.209.

Specification

Limits

§15.407(b) / §15.209 (a) Except as shown in paragraph (d) of 15.205 (a), only spurious emissions are permitted in any of the frequency bands listed.

§15.205 (a) Except as shown in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section §15.209. At frequencies equal to or less than 1000MHz, compliance with the limits in Section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000MHz, compliance with the emission limits in Section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in Section 15.35 apply to these measurements.

§15.209 (a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table.

Frequency(MHz)	Field Strength (µV/m)	Measurement Distance (meters)
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Measurement Uncertainty Radiated Emissions

Measurement uncertainty (dB)	+5.6/ -4.5

Traceability

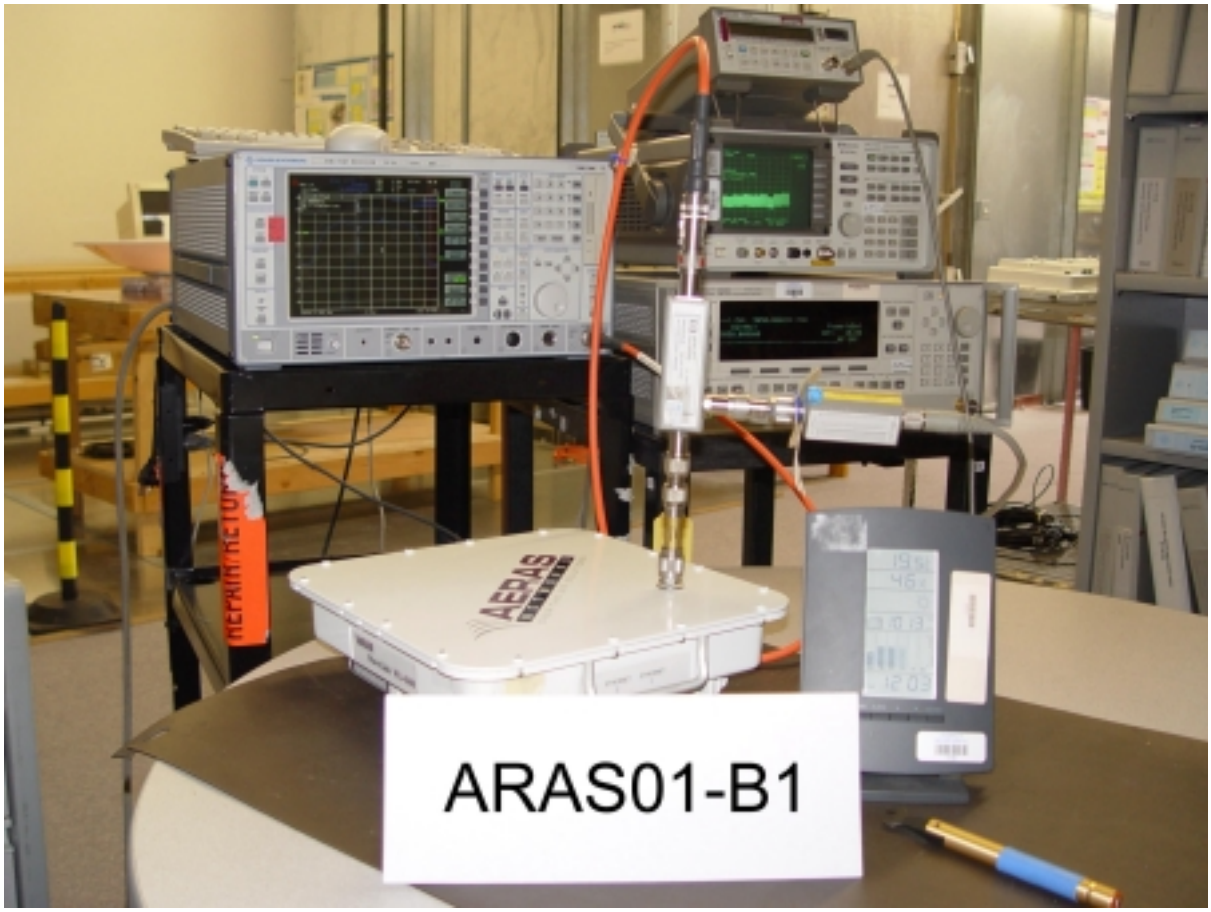
METHOD	TEST EQUIPMENT USED
Measurements were made per work instruction WI-EMC-07	Bar 1, Notch, ANT 1-18, K-Cbl 11, 5F50N001, ReCVR1

5 Photographs

5.1 Radiated Emissions (OATS) Test Set Up (30MHz-1GHz)

5.2 Spurious Emissions Test Set Up (1-40GHz)

5.3 General Measurement Test Set Up



5.4 Equipment Internals

6 Test Equipment Details

Asset Abbrev. #	Instrument	Manufacturer	Part #	Calibration Due Date	Serial #
Bar 1	Barometer/Thermometer	Control Co.	4196	10 Jun '04	E2844
RVA 01	Variable Coaxial Attenuator	Weinschel	940-60-33	22 Jun '04	A6595
K-CBL 08	SMA Cable	Megaphase	Sucoflex 104	27 Jun '04	Unknown
K-CBL 10	SMA Cable	Megaphase	Sucoflex 104	24 Oct '04	Unknown
K-CBL 11	SMA Cable	Megaphase	Sucoflex 104	27 Jun '04	Unknown
K-CBL 12	SMA Cable	Megaphase	Sucoflex 104	27 Jun '04	Unknown
15F50B001	BNC Cable	Megaphase	Unknown	26 Oct '04	Unknown
15F50B002	BNC Cable	Megaphase	Unknown	26 Oct '04	Unknown
10F50B003	BNC Cable	Megaphase	Unknown	26 Oct '04	Unknown
15F50N001	N-Type Cable	Megaphase	Unknown	26 Oct '04	Unknown
5F50N001	N-Type Cable	Megaphase	Unknown	26 Oct '04	Unknown
3F50N002	N-Type Cable	Megaphase	Unknown	26 Oct '04	Unknown
ANT 1	Antenna (30M-2GHz)	Schaffner and Chase	CBLG140A	Not Applicable	1195
ANT1-18	Horn Antenna	The Electro-Mechanics Company	3115	21 Oct '04	9205-3882
ANT2	20-300MHz Antenna	Schwarzbeck	VHBB 9124	30 Apr '04	9124/0257
ANT3	230MHz-1GHz Antenna	Schwarzbeck	VUSLP9111	30 Apr '04	186
AMP 3	Amplifier (0.5-22GHz)	Com-Power	PA-122	Not Applicable	181910
ReCVR 1	EMI Receiver	Rhode & Schwartz	ESI 7	11 Apr '04	838496/007
S-Anlr 3	Spectrum Analyzer	Hewlett Packard	8564E	15th May '04	
LISN 1	LISN	Rhode & Schwartz	ESH3Z5	25 Oct '04	836679/006
PMtr 1	Power Meter	Hewlett Packard	437B	15 Oct '04	3125U13554
PSnsr 1	Power Sensor	Hewlett Packard	R8485A	22 Jun '04	3318A19694
PSnsr 3	Power Sensor	Hewlett Packard	8487D	18 Oct '04	3318A00371
S-Anlr 1	Spectrum Analyser	Hewlett Packard	8565E	20 July '04	3425A00181
SSwpr 4	Synthesized Sweeper	Hewlett Packard	83640A	23 Jun '04	2927A00105
Coupler	Coupler	Hewlett Packard	86205A	N/A	1623
	3dB N-Type Attenuator	ARRA	N9444-30	N/A	
	30dB N-Type Attenuator	NARDA	32319	N/A	

7 Graphical Results

This report contains the following plots as referenced in the test results section

Note only the worst case results are reported, all other results are kept on file in the laboratory.

Bandwidth		**Peak Excursion Ratio**
26dB	**99%**	
ARAS01-B1/01	ARAS01-B1/03	ARAS01-B1/05
ARAS01-B1/02	ARAS01-B1/04	ARAS01-B1/06

Emissions

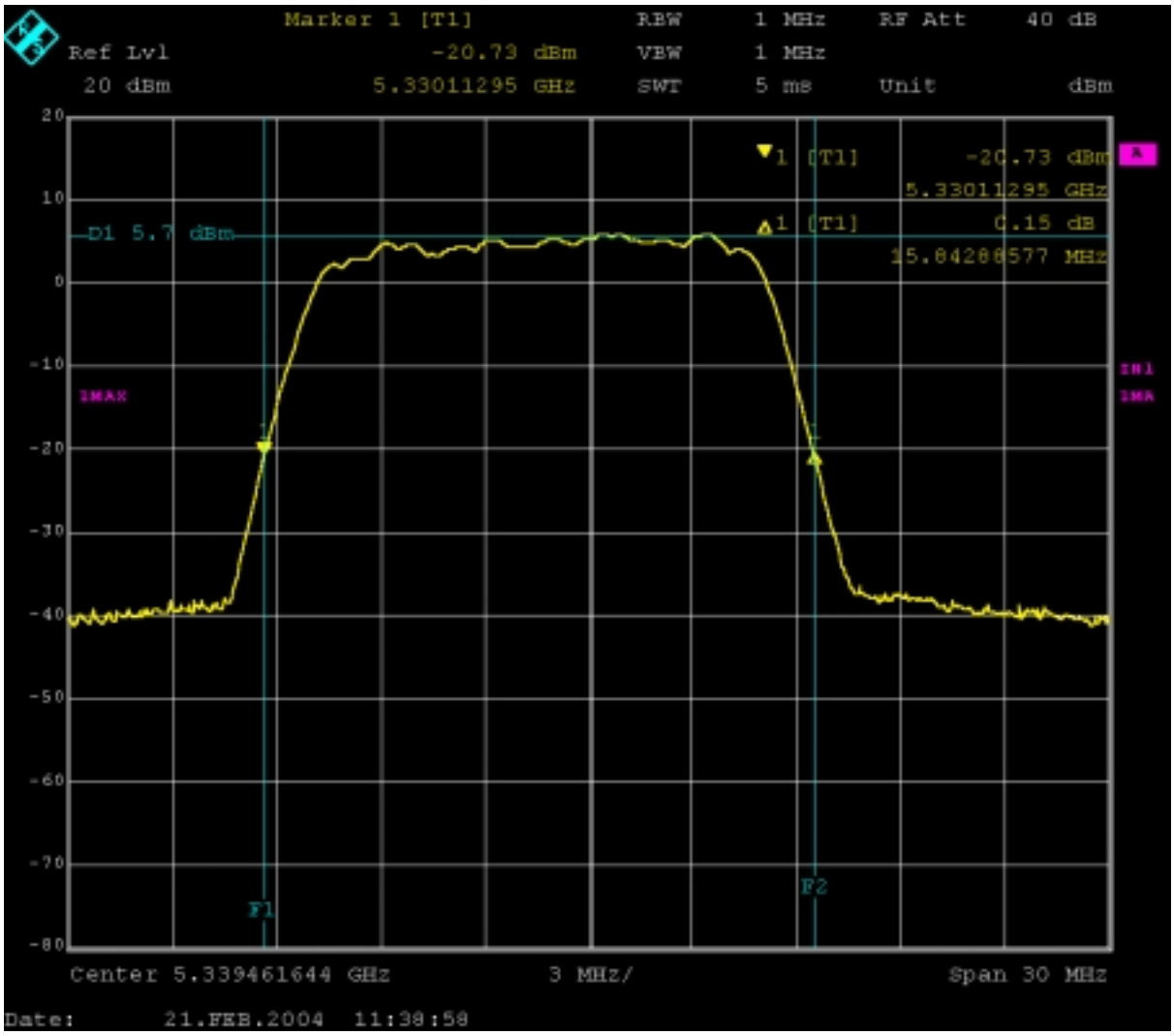
AC Wireline	**Pre-scan (30-1GHz)**	**Spurious Scans (1-40GHz)** (conducted)
ARAS01-B1/07	ARAS01-B1/09	ARAS01-B1/11
ARAS01-B1/08	ARAS01-B1/10	ARAS01-B1/12
		ARAS01-B1/13

Band-Edge

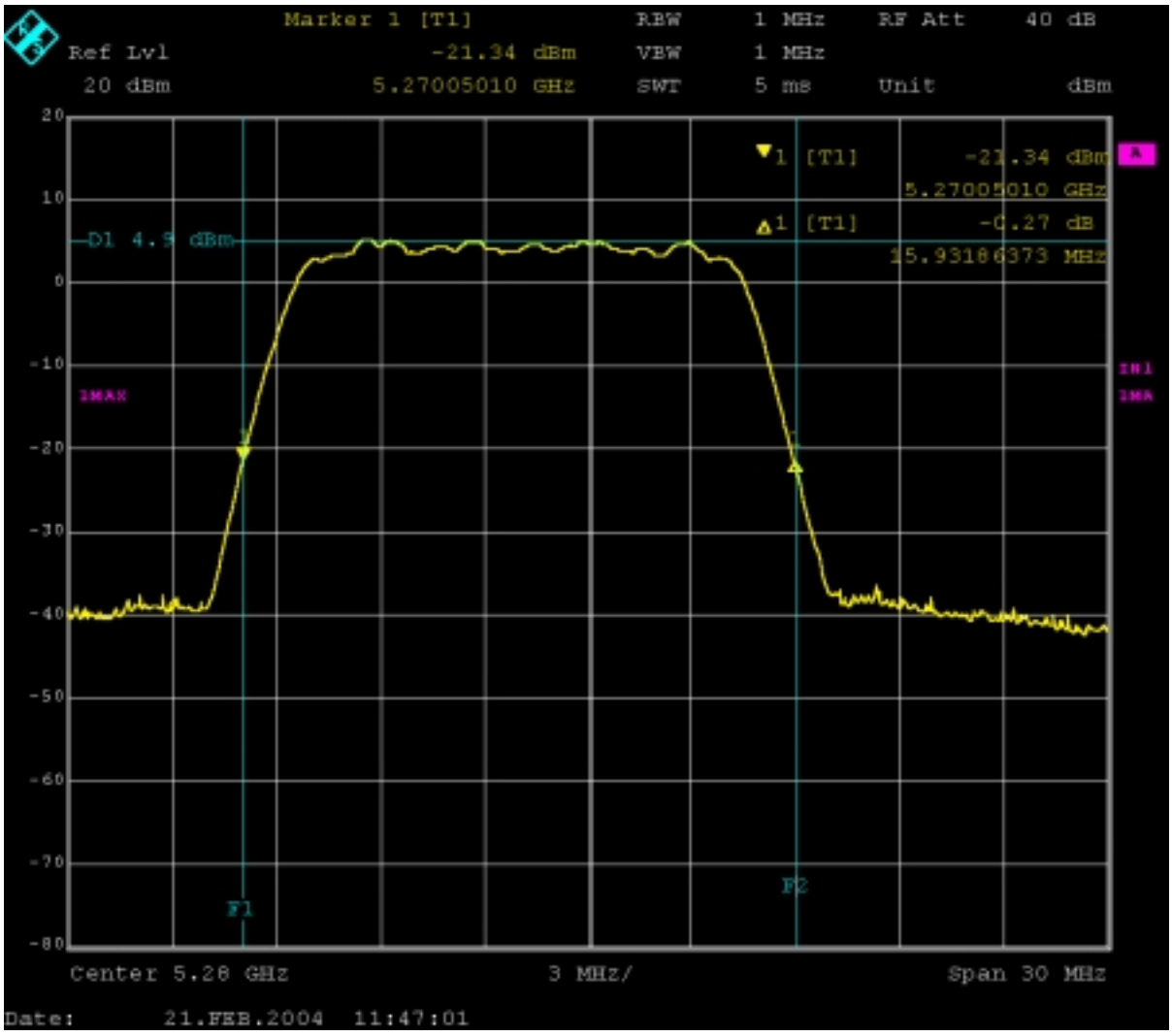
High Band	**Low Band**
ARAS01-B1/14	ARAS01-B1/15

26dB Bandwidth Plots (ARAS01-B1/01-02)

High Band ARAS01-B1/01

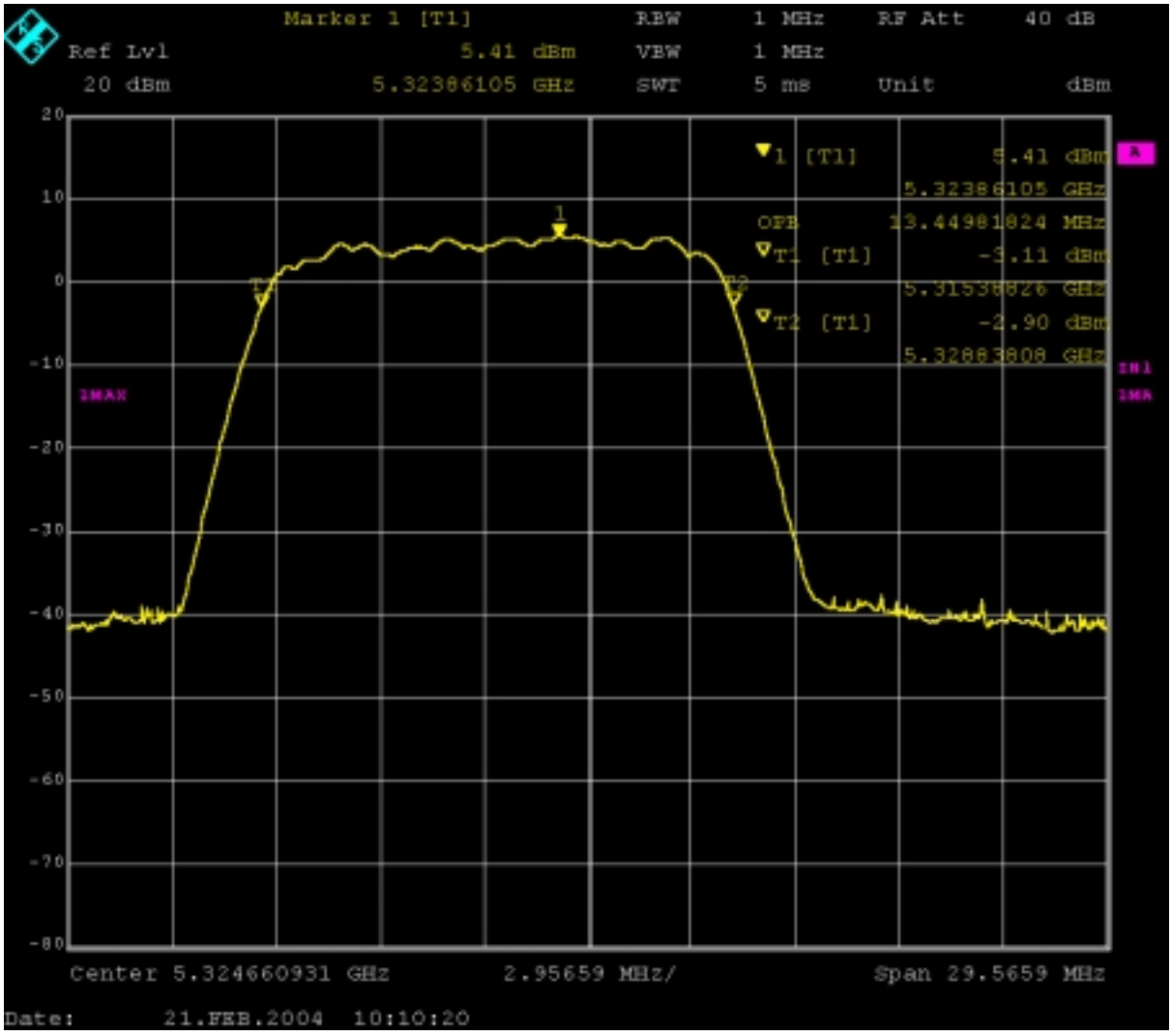


Low Band ARAS01-B1/02

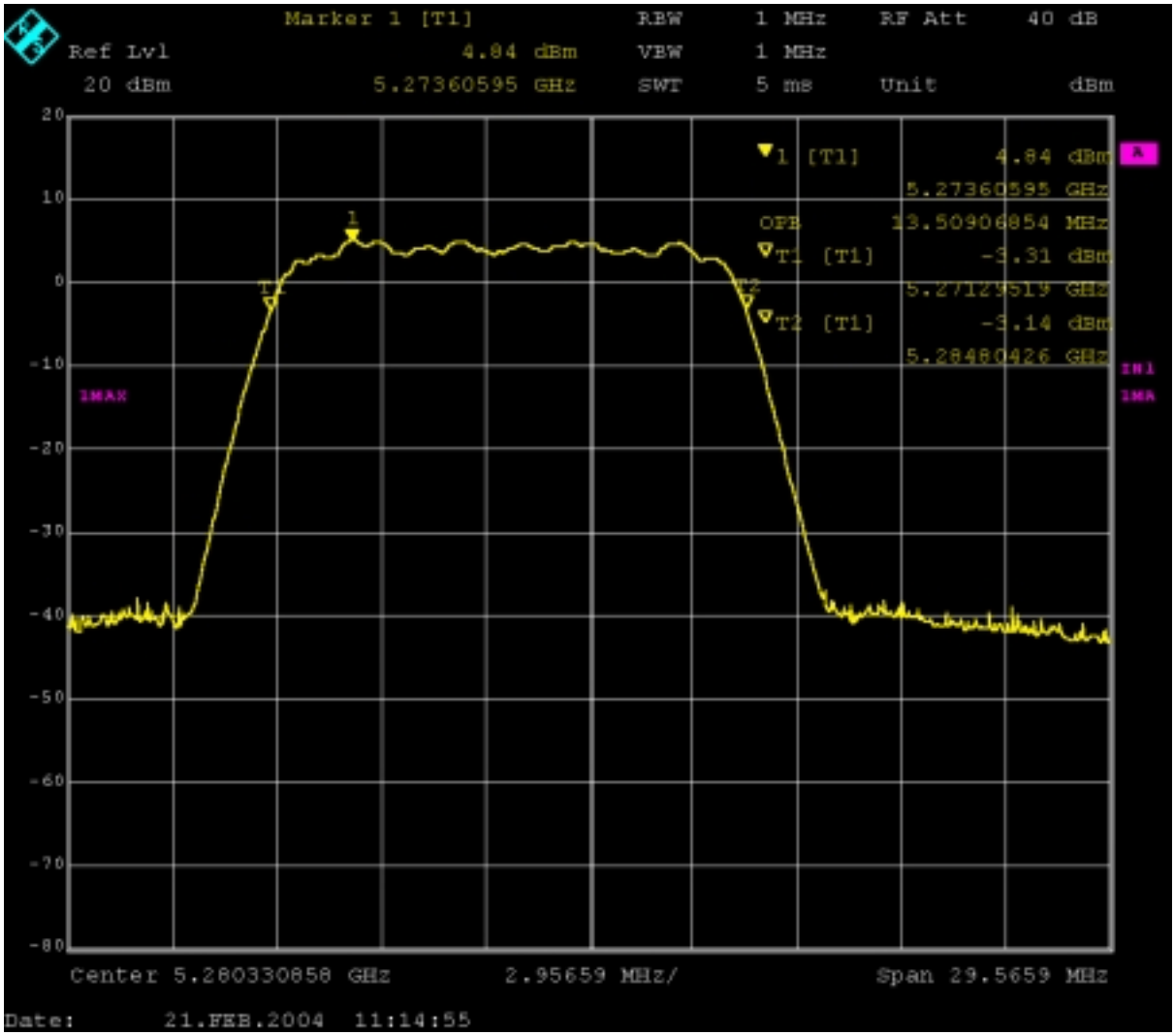


99% Bandwidth Plots (ARAS01-B1/03-04)

High Band ARAS01-B1/03

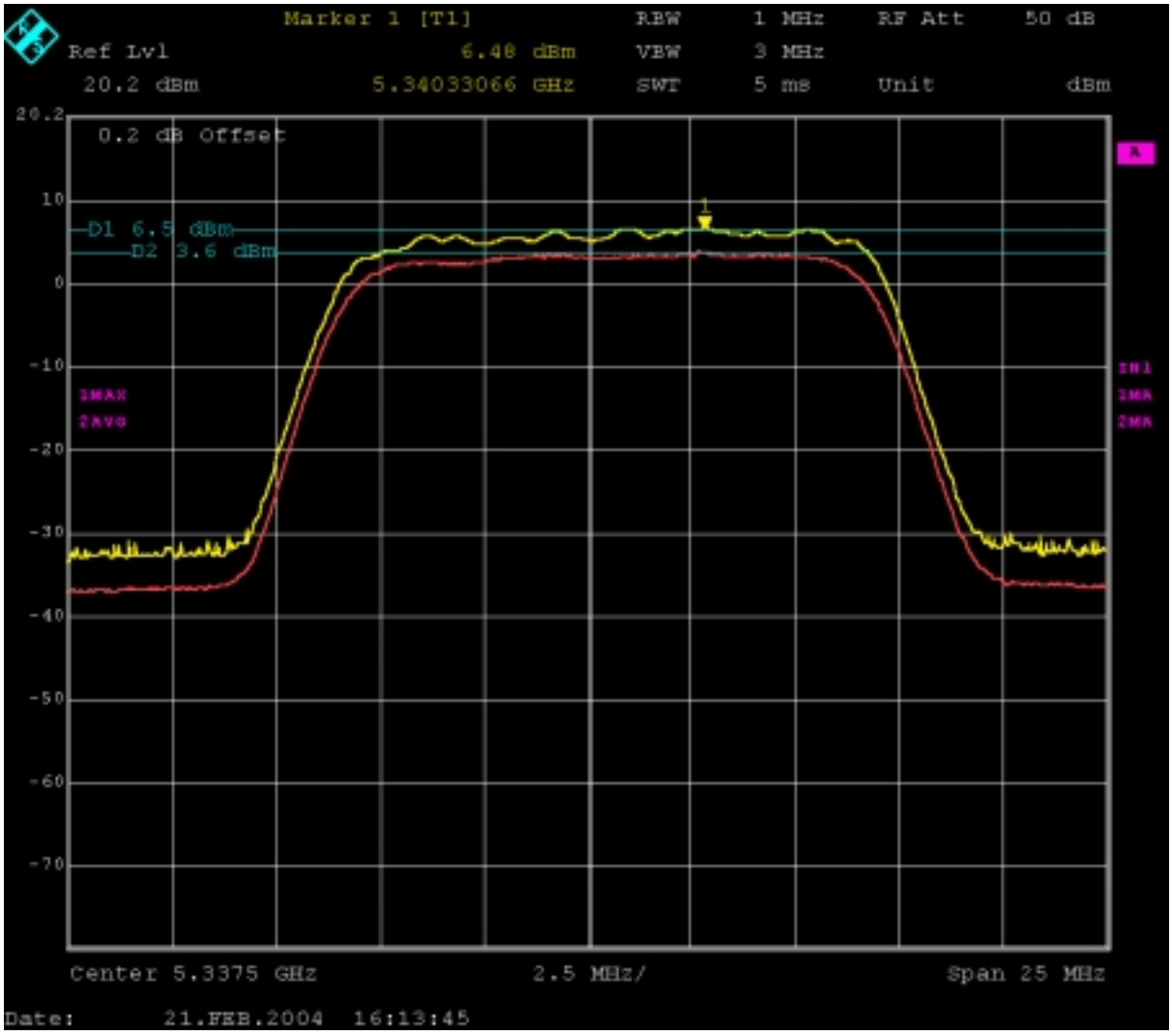


Low Band ARAS01-B1/04

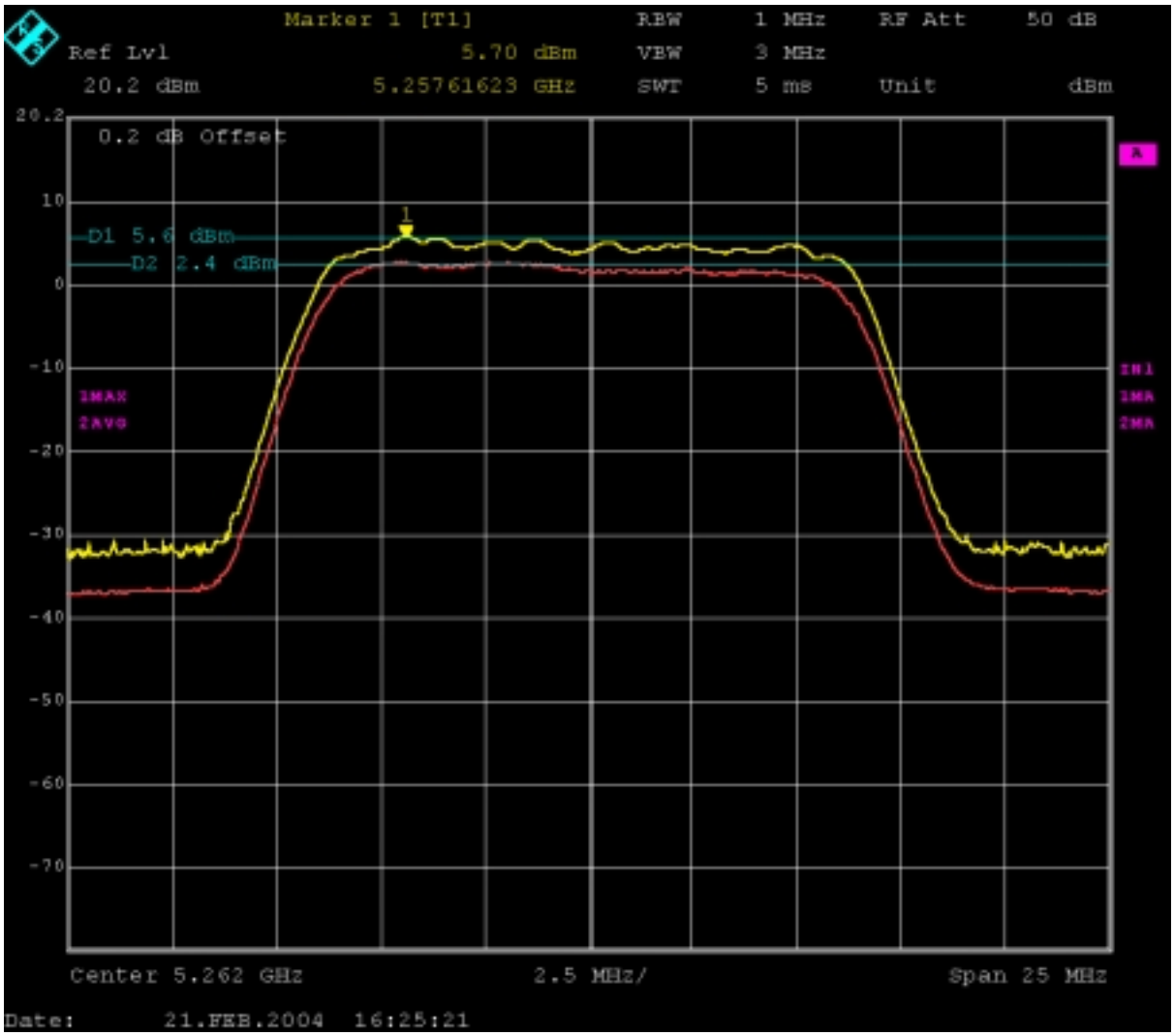


Peak Excursion Ratio (ARAS01-B1/05-06)

High Band ARAS01-B1/05

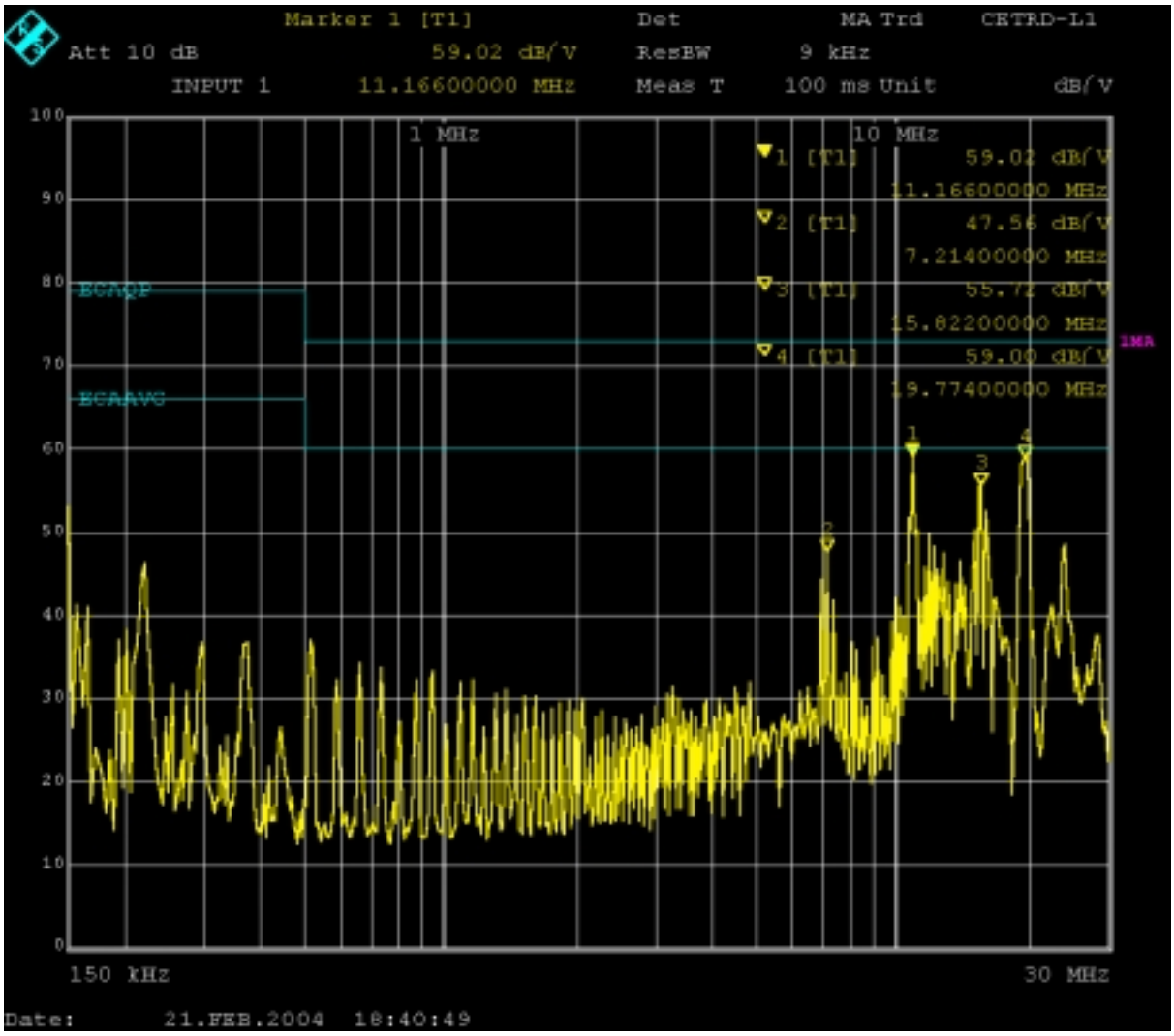


Low Band ARAS01-B1/06

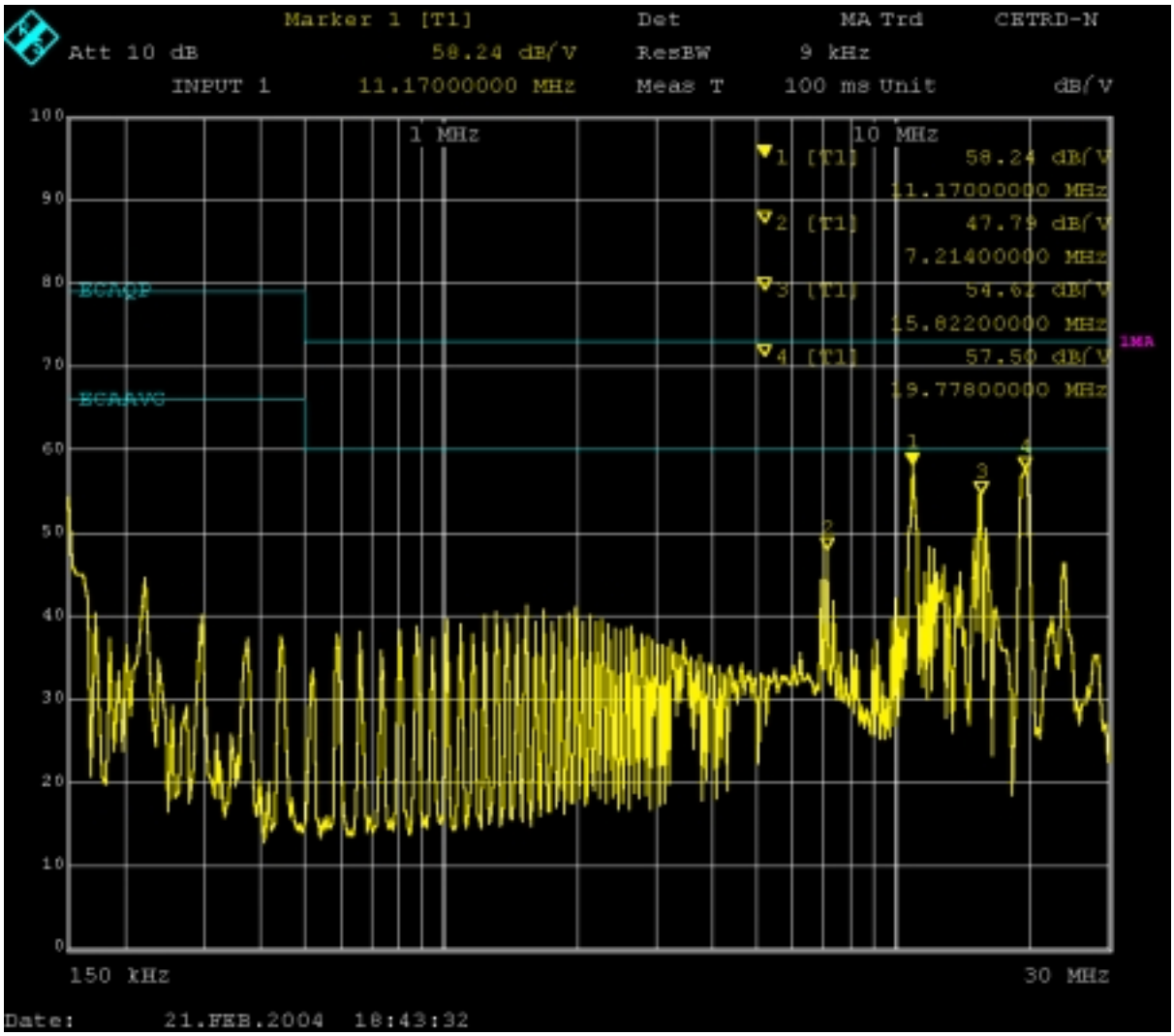


AC Wireline Emissions (ARAS01-B1/07-08)

L (Live) ARAS01-B1/07

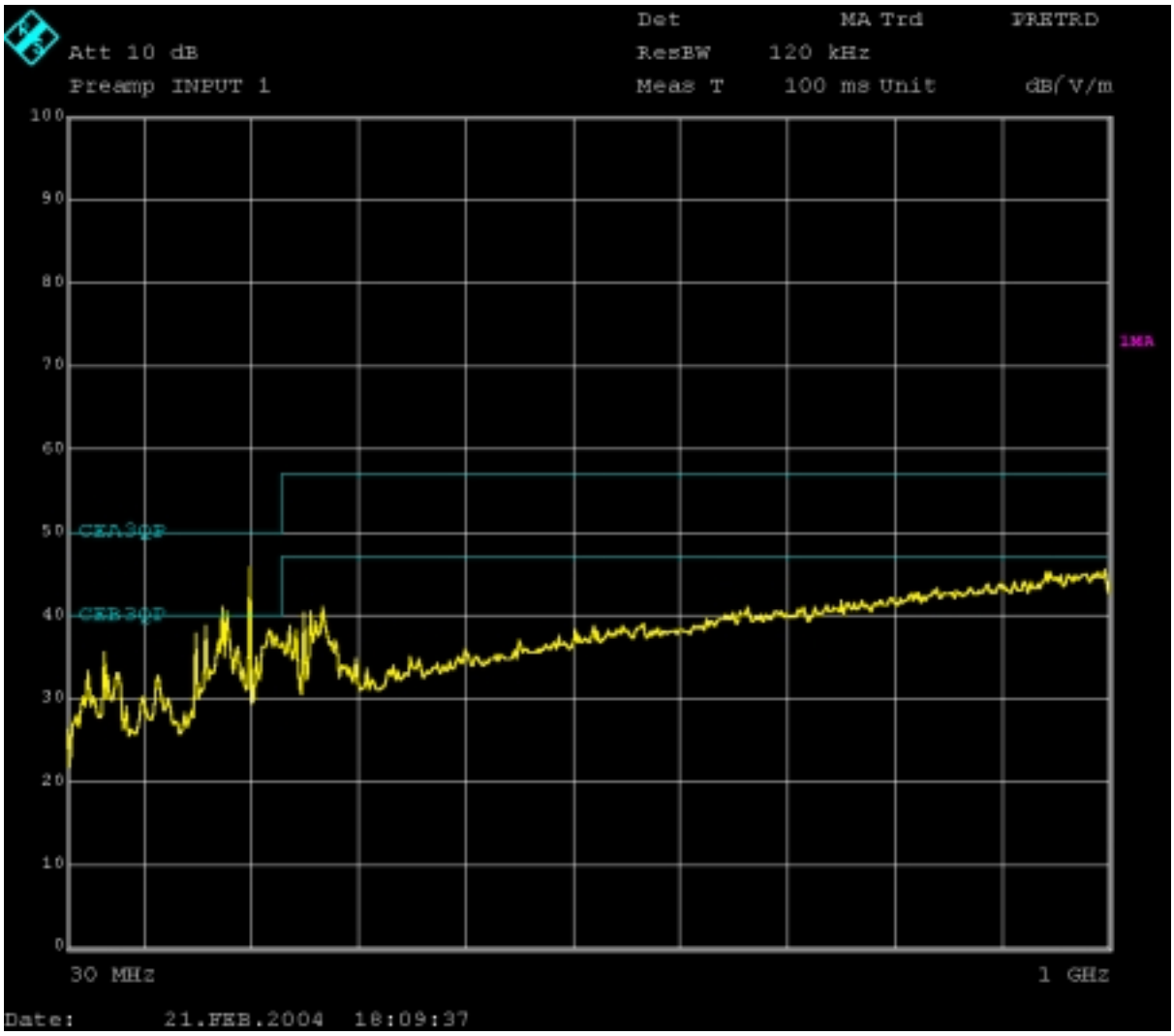


N (Neutral) ARAS01-B1/08

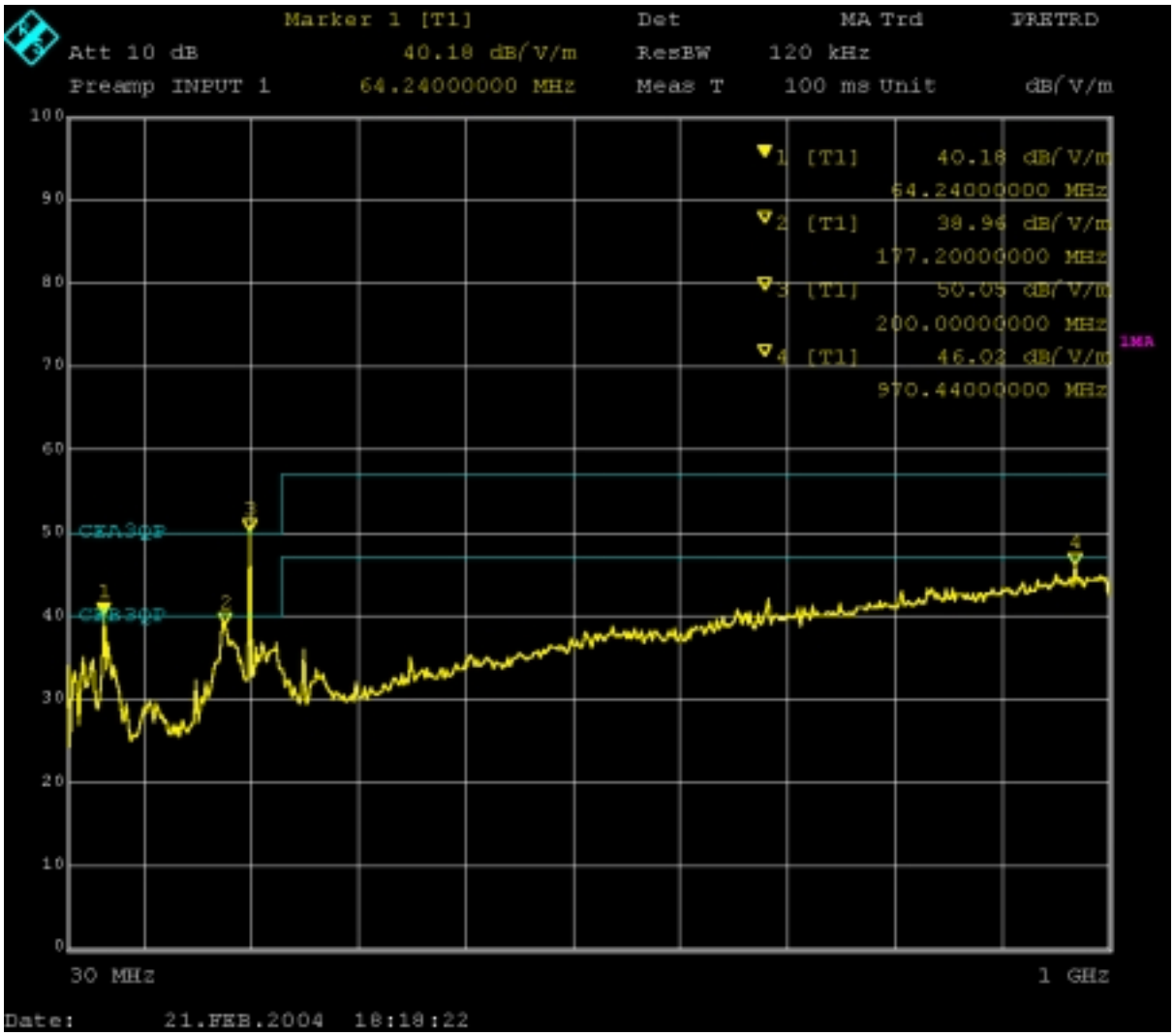


Pre-scan Emission Plots 30-1GHz (ARAS01-B1/09-10)

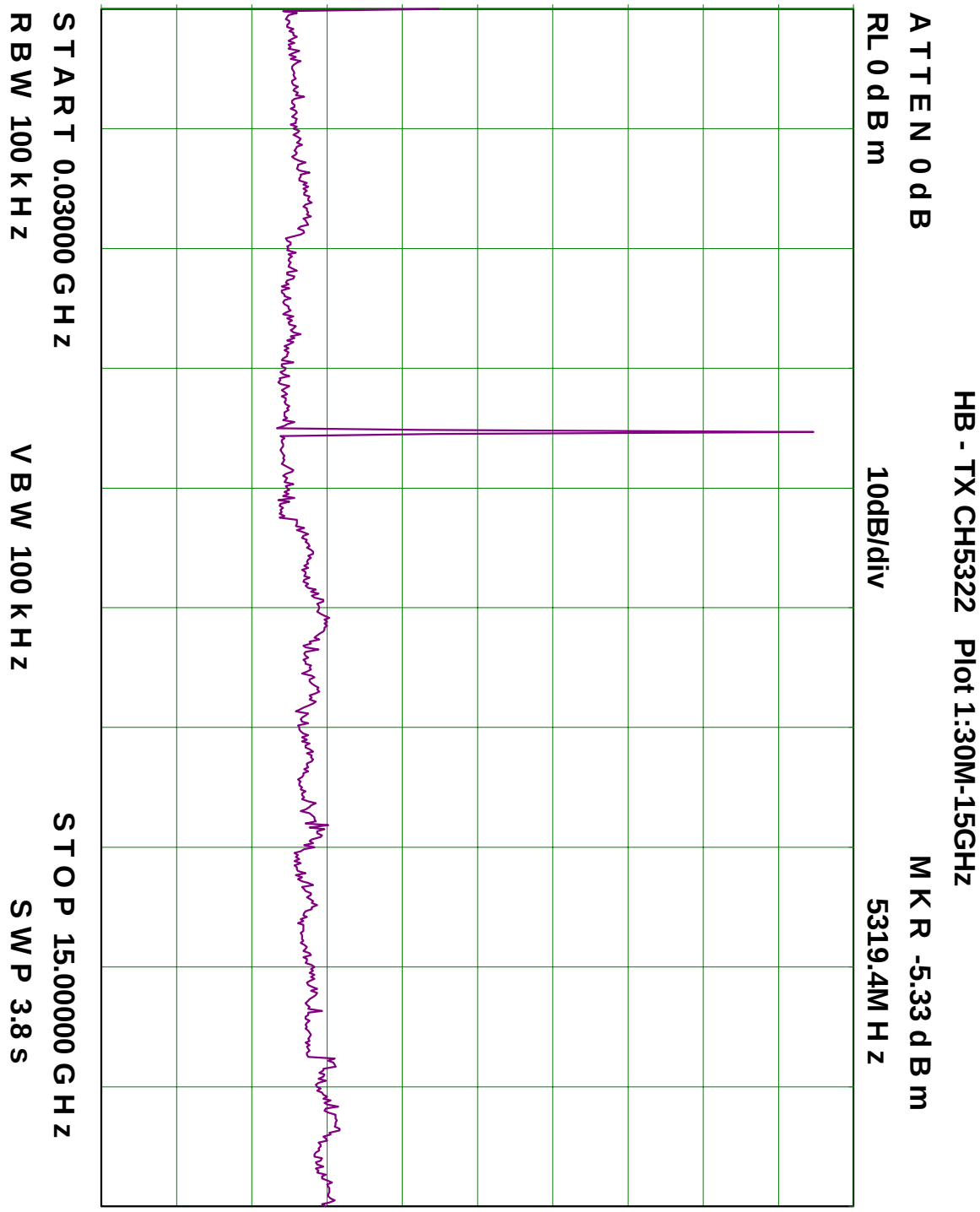
Horizontal Polarization ARAS01-B1/09

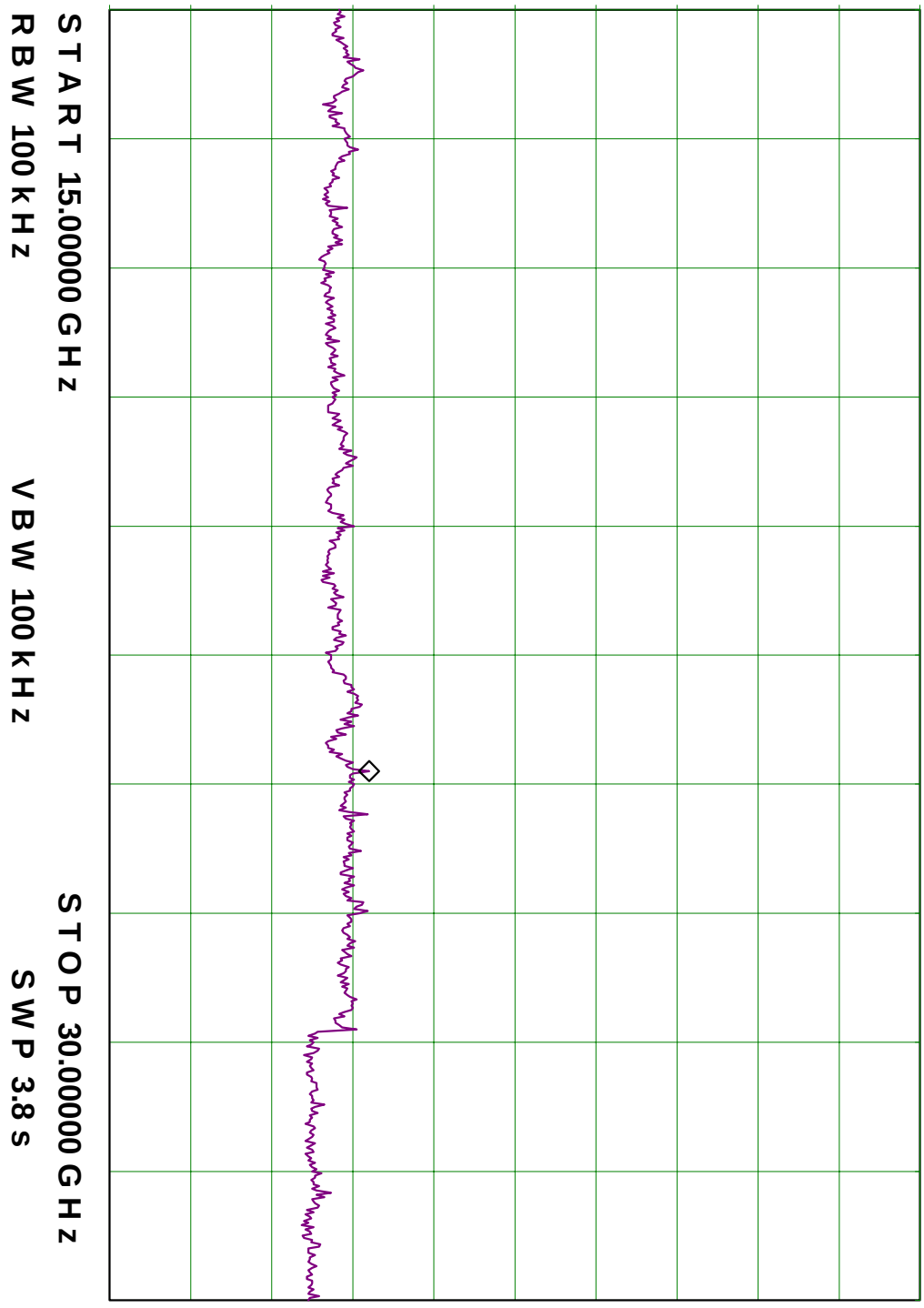


Vertical Polarization ARAS01-B1/10

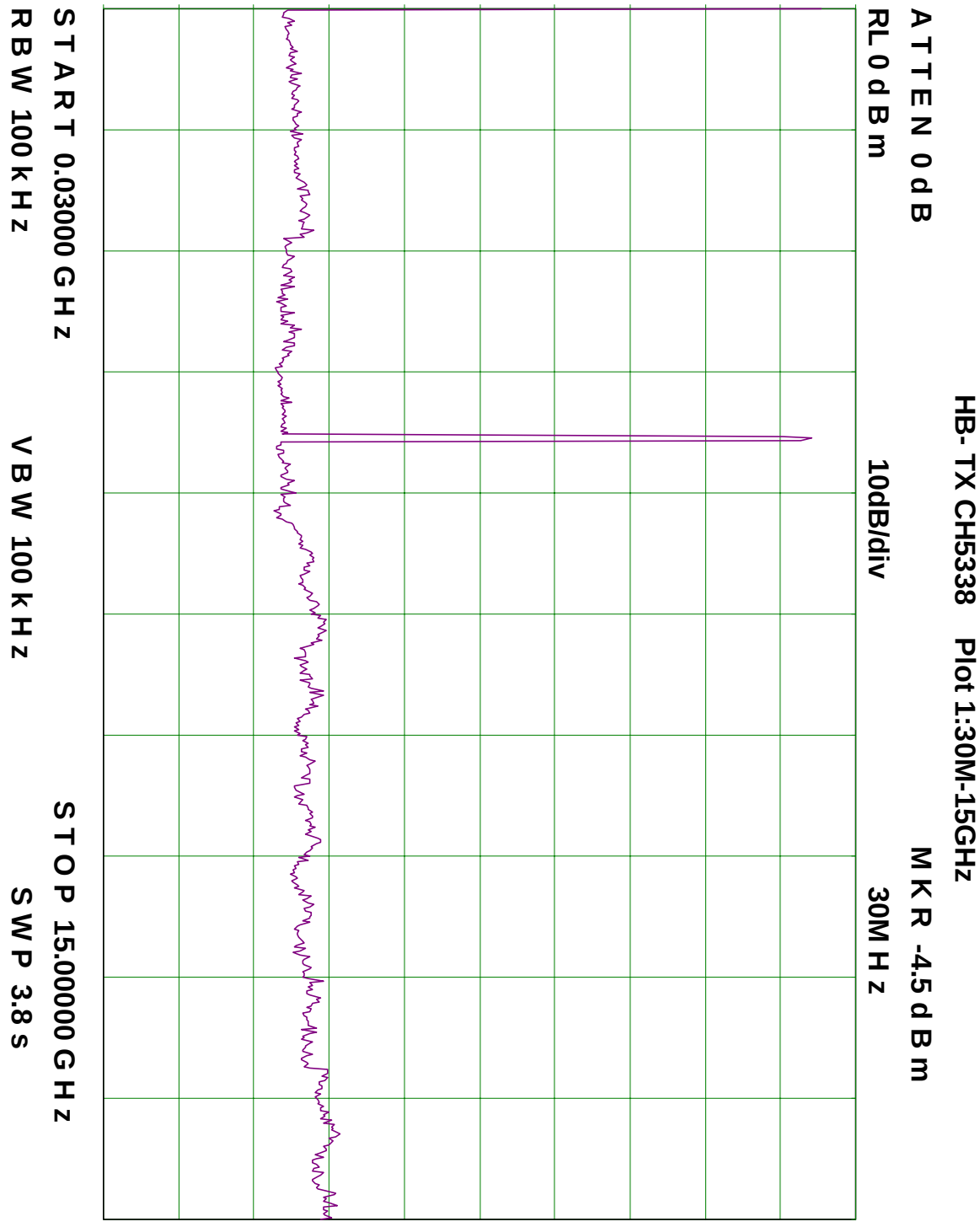


Spurious Emissions Plots 1-40GHz Conducted (ARAS01-B1/11-13)

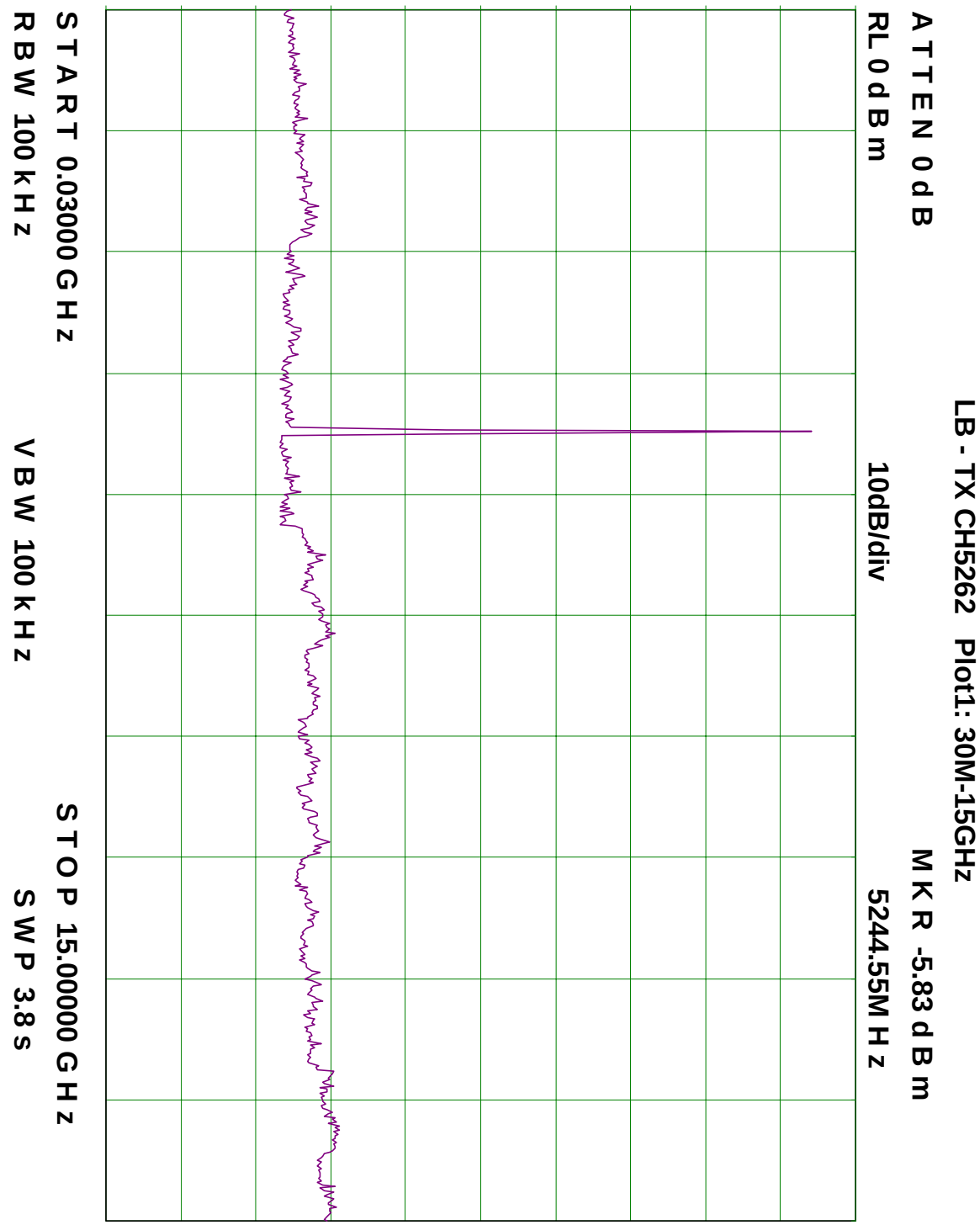



HB - TX CH5322 Plot 2: 15-30GHz
ATTEN 0 dB
RL 0 dBm
10dB/div
MKR -68.00 dBm
23.85GHz
START 15.00000 GHz
RBW 100 kHz
VBW 100 kHz
STOP 30.00000 GHz
SWP 3.8 s

Band-Edge Plots Conducted 30MHz – 15GHz, High-Band (ARAS01-B1/14)



Band-Edge Plots Conducted 30MHz – 15GHz, Low-Band (ARAS01-B1/15)



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