Svenska EMC Lab
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www.emclab.se e-mail: info@emclab.se

TEST REF. NO: 03/2062A
DATE: October 21, 2003

TEST REPORT

REPORT CERTIFICATE issued by a FCC listed Test Laboratory

CUSTOMER Project No: 03210

Saab Marine Electronics AB
Låsblecksgatan 9
SE-589 41 Linköping
Sweden

MANUFACTURER: Saab Rosemount
Sweden

EQUIPMENT UNDER TEST (EUT): Radar Level Gauge. Model: Rosemount 5401. Prototype No: P3 14.

TEST SPEC.: 47 Cfr Ch. 1 (10-1-01 Edition):
1. Part 15, Subpart B, Class B, Digital Devices.
1.1. § 15.107. Conducted emission
1.2. § 15.109. Radiated emission
2. Part 15, Subpart C, Field Disturbance Sensor.
2.1. § 15.207. Conducted emission
2.2. § 15.209. Radiated emission

DATE OF TEST: September 29 - 31, 2003

TEST SITE: Svenska EMC Lab AB, Karlskrona, Sweden.
FCC registration number: 90967.
SWEDAC accreditation number: 1713

TEST RESULT: The EUT (Equipment Under Test) did pass the above mentioned test.

Approved, Karlskrona October 21, 2003

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Hans Östergren
Manager Svenska EMC Lab AB

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DATE OF RECEIPT: September 29, 2003

CONDITION OF EUT: No remarks. Operates as intended.

TEST PERSONNEL: Svenska EMC Lab AB: Bo Gidlöw.

ASSISTANT PERSONNEL: Saab Marine Electronics AB: Mikael Kleman.

DESCRIPTION OF THE EUT:

The EUT is a Radar Tank Gauge used in industrial environments. The radar frequency is 6.3 GHz. The output power is below 1 mW. To control the radar digital circuits are integrated in the same enclosure as the radar transmitter-receiver. A display and switches for the operation is built-in.
Three different types of antennas were delivered together with the EUT:
1. Horn Antenna, 8”
2. Horn Antenna, 6”
3. Horn Antenna, 4”
The radar is designed for installation in different types of tanks or to operate in open environment. The test sample was measured with tanks of different materials and also measured without any additional tank. The EUT input power range is 18 – 36 VDC. Output signal is 4 – 20 mA in the power cable. This signal could be detected with a simple passive peripheral unit.

CALIBRATION DECLARATION:

The test equipment is calibrated as the calibration information in the Test Equipment list.
Before starting of the tests the check points in the applicable Checklists were confirmed.

ESTIMATED UNCERTAINTY:

Expanded uncertainty (k = 2), Conducted Emission, 0.45 – 30 MHz:	± 1.2 dB
Expanded uncertainty (k = 2), Field Strength, emission 9 kHz – 1000 MHz:	± 2.4 dB
Expanded uncertainty (k = 2), Field Strength, emission 1 to 40 GHz:	± 3 dB
Frequency, 0.45 – 1000 MHz:	± 10 Hz
Frequency, 1 – 40 GHz:	± 100 kHz

The uncertainties are for a confidence level of not less than 95 %.

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TEST EQUIPMENT:

Type/Manufacturer/Bandwidth	s/n	Calibration information	
		Date	Interval
For emission test up to 1 GHz:			
EMI Test System, Monitor EZM, Rohde & Schwarz EP-6, 20 Hz - 1300 MHz	860157/014	0308	12 months
Test Receiver, Rohde & Schwarz ESH-3, 9 kHz - 30 MHz	894979/013	0308	12 months
Test Receiver, Rohde & Schwarz ESVP, 20 - 1300 MHz	893497/006	0308	12 months
Pulse Limiter Rohde & Schwarz ESH3-Z2 DC - 30 MHz	357881052	0308	12 months
Plotter, Rohde & Schwarz DOP 2	893117/0008	0308	12 months
LISN 50 OHM/50 µH, Schwarzbeck NSLK8126, 10 kHz - 30 MHz, 25 A	93-84105	0308	12 months
Software, Rohde & Schwarz EZM K-1	K 1 V 1.06	0308	12 months
Biconical Antenna, Schwarzbeck BBA9106 30 - 300 MHz	93-92196.1	0308	12 months
Log-periodic Antenna, Schwarzbeck UHALP9107, 300 - 1000 MHz	91071205	0308	12 months
Coaxial cable, Suhner RG214	93-1217	0309	12 months
Antenna Mast System, Jyske EMC, h = 1 - 4 m	93-90172	NA	NA
Turn Table, Jyske EMC	93-90171	NA	NA
Shielded Chamber, Jyske EMC, 11 x 6 x 4.5 m	93-90168	0303	36 months
Anechoic Chamber, 8 x 4.5 x 3 m	93-87151	0304	36 months
Open Area Test Site for 3 m antenna distance	-	0304	36 months
For emission test at fundamental frequency 6.3 GHz and for emission test 1 to 18 GHz:			
Spectrum Analyzer, HP 8566B	2950A06284	0003	12 months
Plotter, HP 7475A	2641L16543	NA	NA
Signal Amplifier, HP 8449B, 1 – 26.5 GHz	3008A00514	0306	12 months
Double Ridged Guide Antenna, EMCO 3115, 1 - 18 GHz	2338	0308	36 months
Coaxial Cable, Sucoflex 104, l = 5 m	171288/4	0309	12 months
Coaxial Cable, Sucoflex 104, l = 0.5 m	180067/4	0309	12 months
For emission test at harmonic frequencies above 18 GHz:			
Spectrum Analyzer, HP 8566B	2950A06284	0309	12 months
Plotter, HP 7475A	2641L16543	NA	NA
Signal Mixer, HP 11970K, 18 - 26.5 GHz	UA-004	0105	36 months
Signal Mixer, HP 11970A, 26.5 - 40 GHz	UA-005	0105	36 months
Mixer Amplifier, HP 11975A, 2 - 8 GHz	FO-003	0105	36 months
Standard Gain Horn Antenna, Microguide AN180-DR, 18 - 40 GHz.	AT-001	0003	36 months
Adapter coaxial to waveguide, Sealectro 18 – 40 GHz	DA-001	0003	36 months

TEST SET-UP AND PROCEDURE:

See Appendix 1 to 3. As laid out in ANSI C.63.4:1992 Document. Tested as table top equipment. Radiated emission test: Over-head cable. The signal cables were fixed on a wooden stand of 2.3 m in height and 1.5 m in width.

TEST CONDITIONS:

Rating: 115 VAC, 60 Hz, to the peripheral Power Supply. 24 VDC 22 mA to the Tank Radar.
Peripherals: AC/DC Power Supply, Trio PR-630, 115 VAC / 24 VDC. Class I. Modem HART. 250 Ω resistor. Current Meter. PC for configuration of the system.
Cables: Unshielded combined power line and signal cable of 15 m length without protective earth. Unshielded mains cable of 2.5 m length to the Power Supply.
Configuration: See Appendix 4.
Clock Frequency: 3.686 MHz. Radar center frequency 6.3 GHz.
Effective radiated power: Less than 0.1 mW.
Radar Pulse data: Pulse length 1 nanosecond. Repetition frequency: 1.84 MHz.
Tested at 100 % duty cycle.
Modulation type: No modulation.
Modifications: No modifications.
Operating Condition: Normal operating condition. Active level gauging with level measurements. The EUT was configured to continuously transmit at 100 % duty cycle in measurement mode. The normal operating measurement mode is a radar pulse with a duty cycle less than 1:40. The EUT was programmed for the different Antenna types used during the tests.

DESENSITIZATION FACTOR:

By configuring the unit to transmit continuously in the continuous measurement mode desensitization factor was not required. This approach was used because the EUT produces extremely low output power.

TEST PERFORMANCE:

1.1, § 15.107 and 2.1, § 15.207: Conducted Emission test.
The conducted emission was measured on the Power input terminals (115 V) to the peripheral Power Supply through a 50 ohm 50 micro-Henry LISN (Line Impedance Stabilization Network) in the frequency range 0.15 to 30 MHz. The neutral line and the phase line were measured with a quasi-peak detector and also with an Average Detector. See Appendix 5 and 6.

1.2, § 15.109 and 2.2, § 15.209: Radiated Electromagnetic Field (30 - 1000 MHz).
Pre-test: A pretest was performed in the Anechoic Chamber to determine the radiated frequencies. The EUT was measured at an Antenna distance of 3 m. EUT without any Tank. The antenna polarization was both vertical and horizontal during the test.

TEST PERFORMANCE (CONTINUED):

Final Test: Measured in the frequency range 30 - 1000 MHz at an antenna distance of 3 m, on the open area test site. The EUT was placed free on the turn table at 0.8 m height. Over-head cable. The emission was maximized by rotating the table, varying the antenna height and the antenna polarization. Test instruments: Rohde & Schwarz EP-6 System, 30 MHz - 1000 MHz. Antennas: Schwarzbeck BBA9106, 30 - 300 MHz and UHALP9107, 300 - 1000 MHz. Worst case was recorded. See Appendix 7 and 8.

1.2, § 15.109 and 2.2, § 15.209: Radiated Electromagnetic Field (1 - 40 GHz):
Measured in the frequency range 1 - 40 GHz on the open area test site. Measured with the analyzer in max. hold and with Peak Detector (RBW = 3 MHz, VBW = 3 MHz) and with Average Detector (RBW = 3 MHz, VBW = 10 kHz). Test instruments according to "TEST EQUIPMENT" list on page 3. Test equipment set-up as in Appendix 9.

Measurements on the fundamental, 6.3 GHz:

A. Antenna distance of 3 m. Measured with the EUT fixed into a) Tank of metal, b) Tank of concrete, c) Tank of plastic, and d) Tank of glass.
The emission was maximized by rotating the table, varying the antenna height 1 to 4 m and the antenna polarization in vertical or horizontal positions. Worst case was with EUT on a Tank of glass and with the 8" horn antenna. See Appendix 10 (peak detector) and Appendix 11 (Av. detector).
The limit at 3 m distance is with average detector 54 dBµV/m (500 µV/m) and with peak detector 74 dBµV/m (same limit for Subpart B Class B, § 15.109, and for Subpart C, § 15.209).

B. The emission level at 3 m was too low for accurate measurements. The distance was changed to 0.3 m and the limit linearly converted to this distance by adding 20 dB.
The peak limit is at 3 m 20 dB + AV. limit = 74 dBµV/m. At 0.3 m then the peak limit is 74 dBµV/m plus 20 dB = 94 dBµV/m. The AV. limit is at 0.3 m = 74 dBµV/m. No emission could be measured with the EUT in the Tank. Instead was the antenna faced direct against the EUT antenna opening to receive maximum signal. This set-up is worst case for an open installation. See Appendix 12 and 13.

Measurements on the harmonics:
Harmonics: Approx. 12.6, 18.9, 25.2, 31.5 and 37.8 GHz. Measurement at 3 m distance was not possible because the harmonics were too low. The distance was changed to 0.3 m and the limit linearly converted to this distance by adding 20 dB. The peak limit is at 3 m 20 dB + AV. limit = 74 dBµV/m. At 0.3 m then the peak limit is 74 dBµV/m plus 20 dB = 94 dBµV/m. The AV. limit is at 0.3 m 74 dBµV/m. The antenna was faced direct against the EUT antenna opening to receive maximum signal. See Appendix 14 to 22.

Output power, conducted:
The conducted power output from the device at the measurement operating mode is - 43.4 dBm at 6.3 GHz. This information was provided by the manufacturer and verified by Svenska EMC Lab AB. The fast pulse rise time (< 1 ns) does not affect the final total power output when the EUT is operating in a 100 % continuous duty cycle mode.

SUMMARY OF RESULTS:

Emission in the frequency range 0.15 kHz to 1000 MHz:

§ 15.107 and § 15.207:
The conducted emission margin to limit was – 3.5 dB (QP) at 0.15 MHz, and – 12.5 dB(AV.) at 0.15 MHz. See Appendix 5 and 6. The emission source was the peripheral AC/DC power supply.

§ 15.109 and § 15.209:
The radiated emission margin to limit was more than – 14 dB (Peak) in the whole frequency range. See Appendix 7 and 8.

Emission in the frequency range 1 to 40 GHz:
See Appendix 23.

Fundamental:
- Mounted in a Tank of glass, 3 m distance:
Margin to limit (Class B) was with average detector – 14.8 dB and with peak detector – 21.7 dB as worst case (8" Antenna). See Appendix 10 and 11.

- Faced directly into the EUT Antenna at 0.3 m distance:
Margin to limit (Class B) was with average detector – 3.0 dB and with peak detector – 12.0 dB as worst case (8" Antenna). See Appendix 12 and 13.

Harmonics:
- Faced directly into the EUT Antenna at 0.3 m distance:
Margin to limit (Class B) were with average detector more than – 18 dB (noise level) and with peak detector more than – 11.9 dB (noise level). See Appendix 14 to 22.

CONCLUSION:

The Radar Level Gauge. Model Rosemount 5401. Prototype No. P3 14, did pass the above mentioned tests,
- Part 15, Subpart B, Class B for Digital Devices
- Part 15, Subpart C, for Field Disturbance Sensor.

Karlskrona October 21, 2003

Hans Östergren
Manager Svenska EMC Lab AB
Sr. EMC Engineer

Bo Gidlöw
Test Engineer

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3	Test set-up, photo
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6	CE, 0.45 - 30 MHz, neutral
7	RE, 30 – 1000 MHz
8	Calculation of radiated emission
9	Test equipment set-up
10	Fundamental, peak, 6.3 GHz. 3 m. 8” Antenna
11	Fundamental, average, 6.3 GHz. 3 m. 8” Antenna
12	Fundamental, peak, 6.3 GHz. 0.3 m. 8” Antenna
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23	Calculation of Final Emission Levels, 1 - 40 GHz

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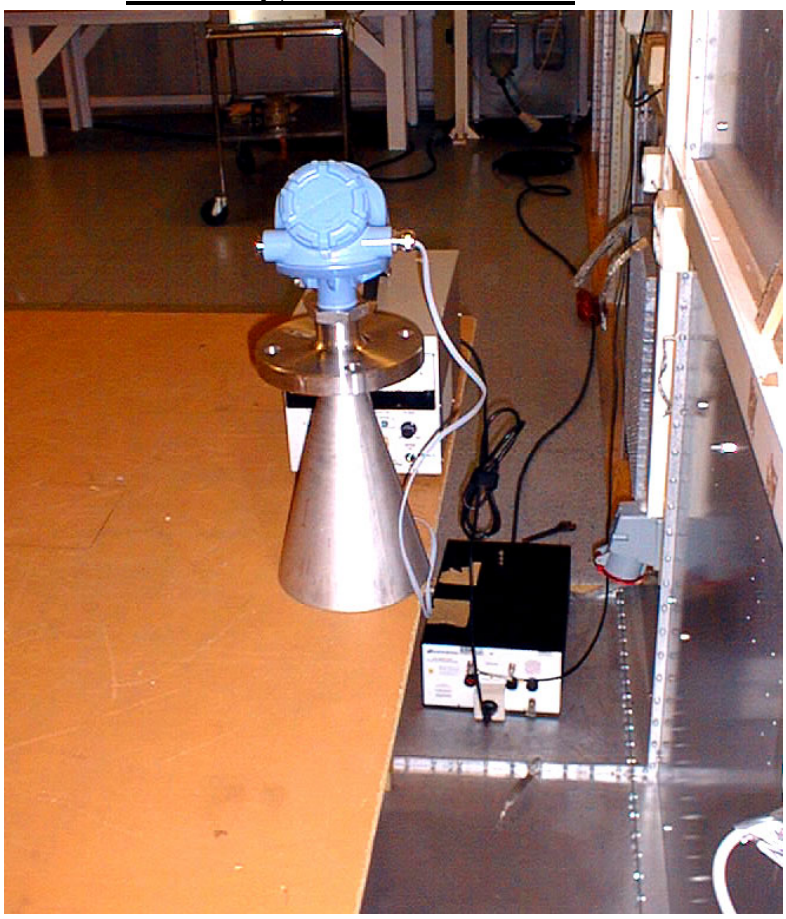
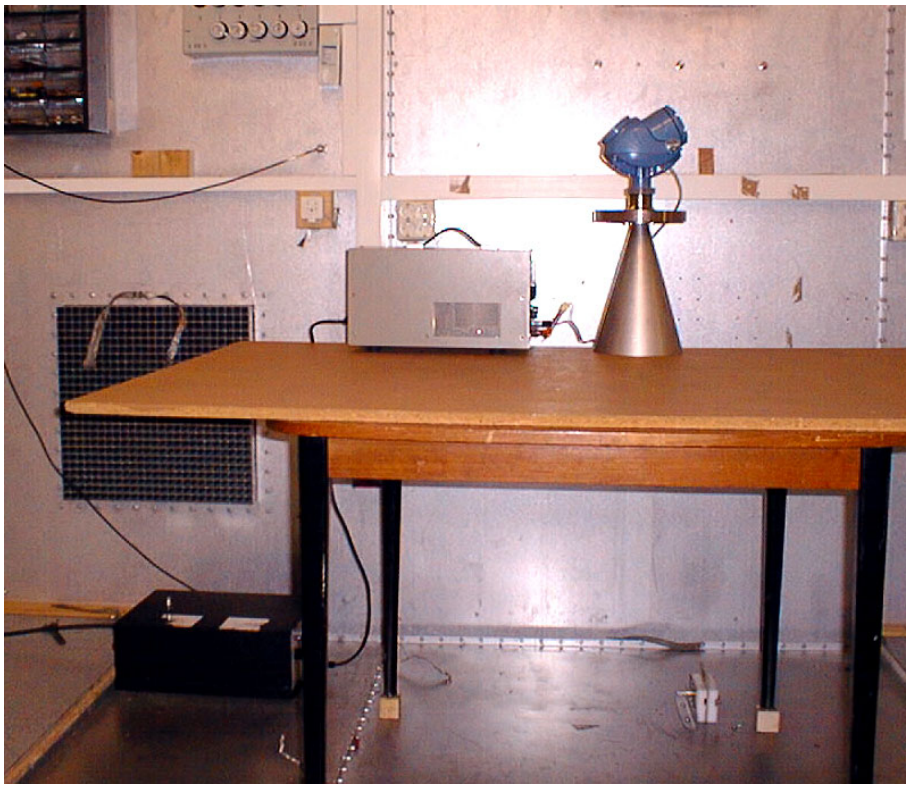
Test set-up, Conducted Emission



Test set-up, Conducted Emission



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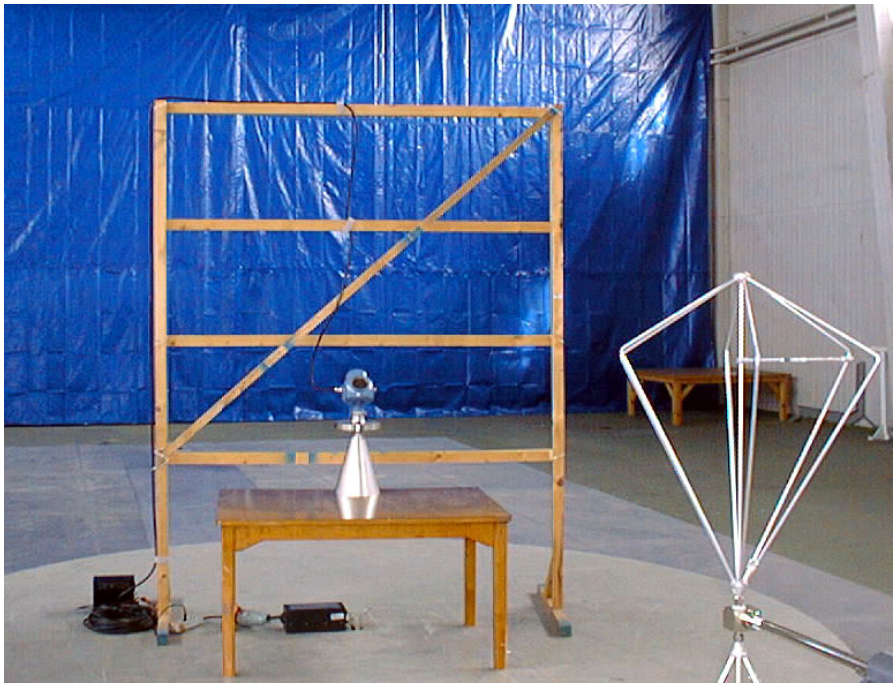
Test set-up, Radiated Emission 30 - 1000 MHz

Test set-up, Radiated Emission 30 - 1000 MHz



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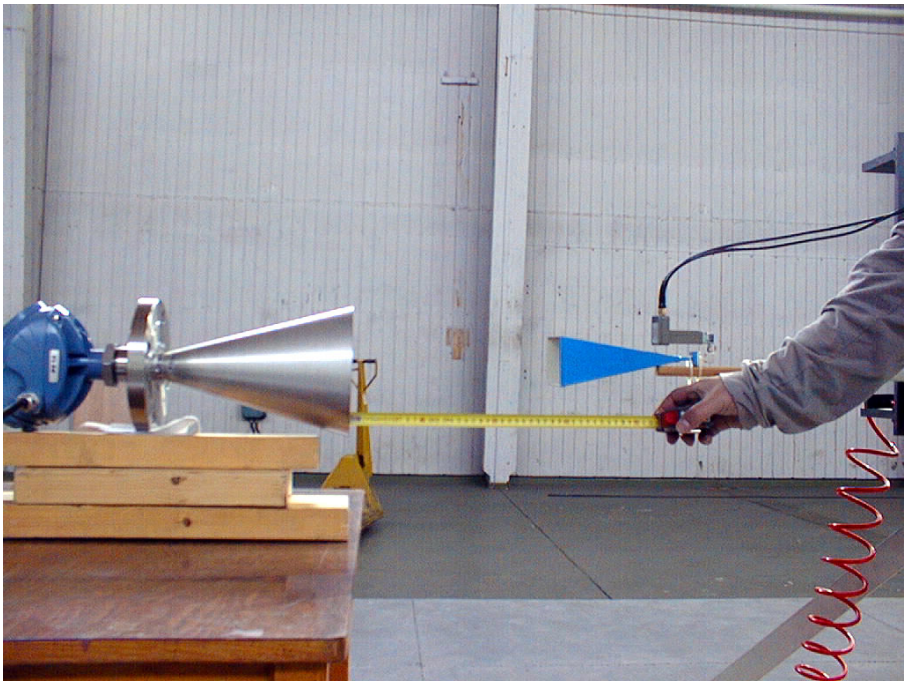
Radiated emission, check of harmonics



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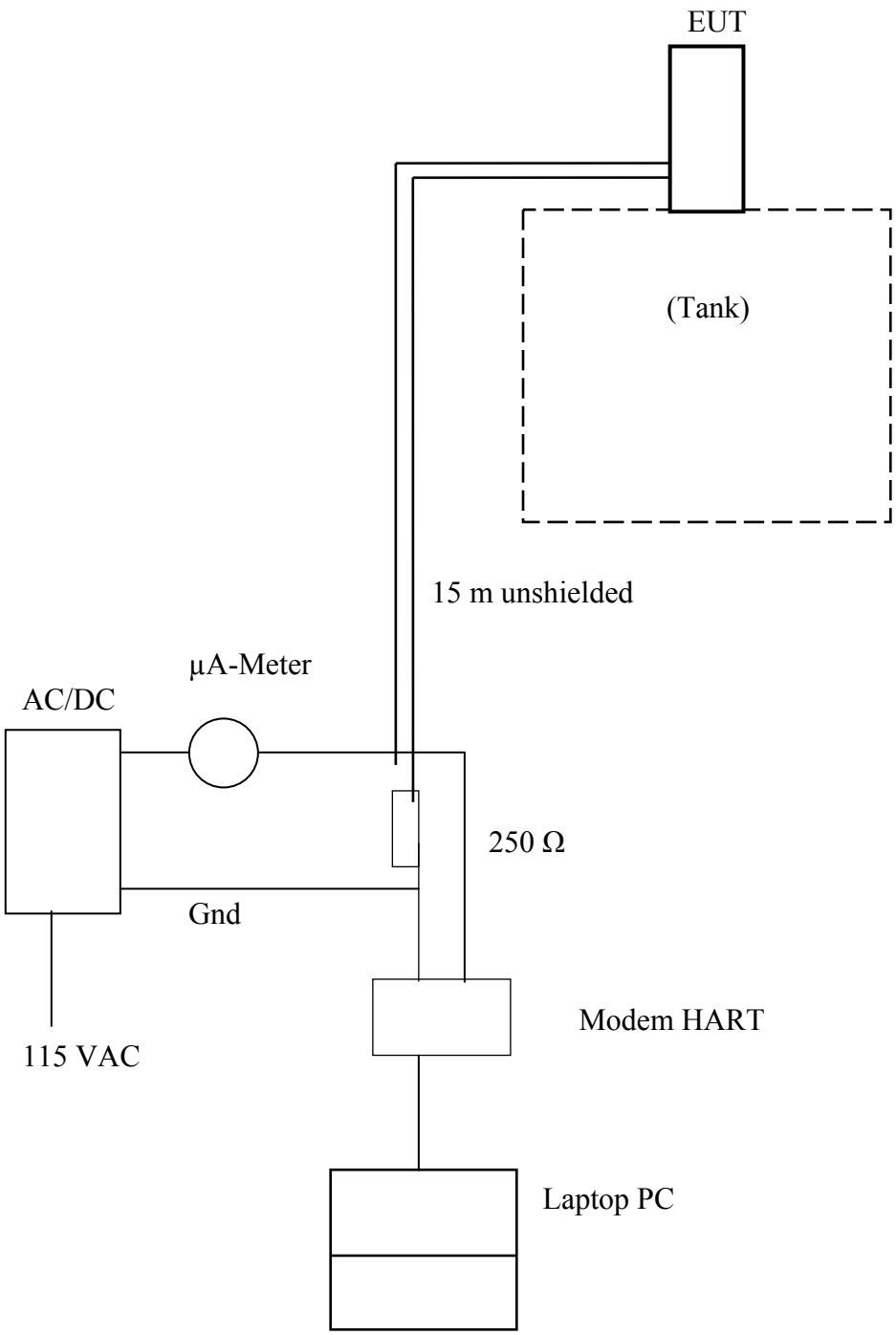
Configuration



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SAAB ROSEMOUNT AB
Conducted Emission Test

Start of Test: 01.OCT'03 . 13:48

E.u.T.: 5400 Series

Oper. Condition: ACTIVE

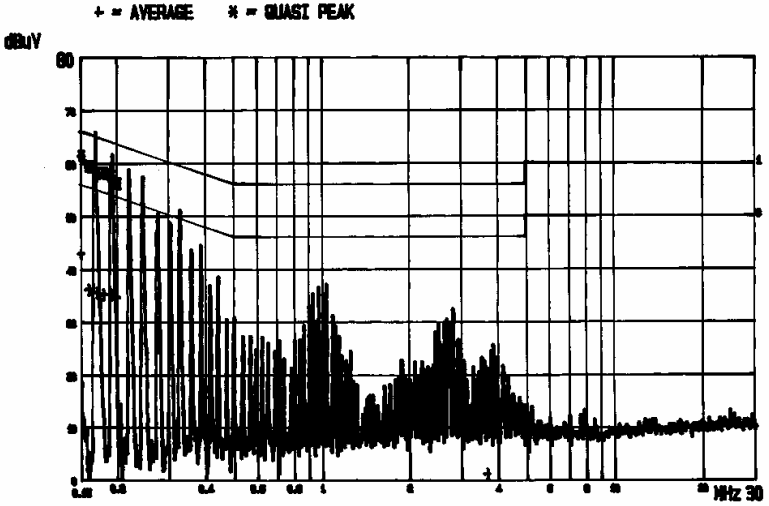
Operator: BO GIDLOEW

Test Spec:
FCC Part 15, Subpart B Conducted RFI, Class B

Start Fr. MHz	Stop Fr. MHz	IF-BW kHz	Display Mode	Att. dB	Transducer type
0.1500	30.0000	10.00	Max Hold	0	EM7820L1

Frequency MHz	Average dBuV	AV-Margin dBuV	Quasi Peak dBuV	QP-Margin dBuV
0.1500	42.8	-13.2	61.2	-4.8
0.1600	36.0	-19.6	59.2	-6.4
0.1700	35.5	-19.5	58.1	-6.9
0.1800	35.1	-19.5	58.1	-6.5
0.1900	35.1	-19.1	57.4	-6.6
0.2000	34.5	-19.3	56.1	-7.7
3.6640	1.0	-45.0	16.1	-39.9

* Limit exceeded



CONDUCTED EMISSION ON 115 V AC L 2 TERMINAL

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SAAB ROSEMOUNT AB
Conducted Emission Test

Start of Test: 01.OCT'03 . 12:43

E.u.T.: 5400 Series

Oper. Condition: ACTIVE

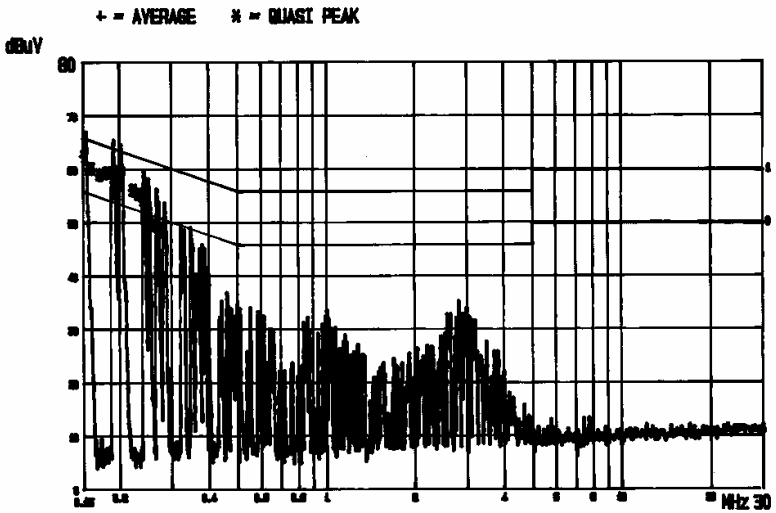
Operator: BO GIDLOEW

Test Spec:
FCC Part 15, Subpart B Conducted RFI, Class B

Start Fr. MHz	Stop Fr. MHz	IF-BW kHz	Display Mode	Att. dB	Transducer type
0.1500	30.0000	10.00	Max Hold	0	EM7820L2

Frequency MHz	Average dBuV	AV-Margin dBuV	Quasi Peak dBuV	QP-Margin dBuV
0.1500	43.5	-12.5	62.5	-3.5
0.1600	42.2	-13.4	60.1	-5.5
0.1700	35.9	-19.1	58.9	-6.1
0.1800	35.9	-18.7	59.2	-5.4
0.1900	35.5	-18.6	58.5	-5.7
0.2000	35.0	-18.8	57.5	-6.3
0.2200	34.0	-19.0	56.0	-7.0
0.2300	34.0	-18.6	55.3	-7.3
0.2400	33.5	-18.7	54.1	-8.1
0.2500	32.5	-19.3	51.6	-10.2
0.2600	25.9	-25.7	49.4	-12.2
0.2700	25.2	-25.0	48.3	-12.9

* Limit exceeded



CONDUCTED EMISSION ON 115 V AC L 1 TERMINAL

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Appendix 7 of 23
TEST REF. NO: 03/2062A
DATE: October 21, 2003

SAAB ROSEMOUNT AB
Radiated Emission test on OATS

Start of Test: 01.OCT'03 , 11:57
E.U.T.: 5400 Series
Oper. Condition: ACTIVE
Operator: BO GIDLOEW
Test Spec:
FCC Part 15, Subpart B. Class B, 3 m OATS

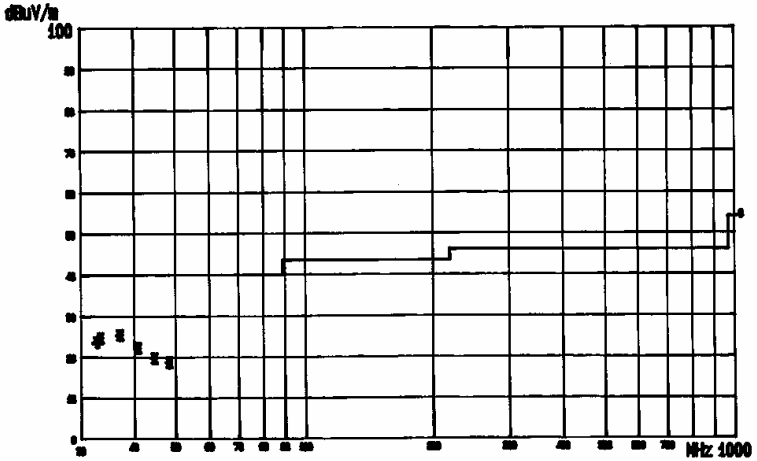
Start Fr. MHz	Stop Fr. MHz	IF-BW kHz	Detector	Att. dB	Meas.T. s	Transd. type
30.0000	299.9999	120	Peak	LN	0.020	BBA9106
300.0000	1000.0000	120	Peak	LN	0.020	UHALP

measured QP values

Frequency MHz	Level. dBuV/m	Margin dB	Pol h/v	Height m	Azimuth deg.
32.4996	23.5	-16.5	v	1.00	0
33.1763	24.5	-15.5	v	1.00	0
36.6647	25.4	-14.6	v	1.00	0
40.5511	22.2	-17.8	v	1.00	0
44.2391	19.5	-20.5	v	1.00	0
47.9256	16.7	-21.3	v	1.00	0

* Limit exceeded

* = QUASI PEAK



RADIATED EMISSION ON OATS AT 3 m. DISTANCE

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Radiated Fieldstrength Test. Calculation of Final Emission Levels, 30 – 1000 MHz

EUT: Radar Level Gauge. Model: Rosemount 5401. Prototype No: P3 14.

Test spec.: 47 Cfr Ch. 1 (10-1-01 Edition):
Part 15, Subpart C, Field Disturbance Sensor.
§ 15.109: Radiated emission, Open Area Test Site
3 m Antenna distance.

Date of Test: September 29 - 31, 2003

Operation: Normal operating conditions

Field strength (dBµV/m) = Amplitude (dBµV) + Antenna factor (dB/m) + cable loss (dB)

Tested frequency range: 30 - 1000 MHz

Measured quasi-peak values.

Freq.	App.	Amplitude	Cable loss	Ant. factor	Field strength	Limit	Dist	Margin	Ant. height	Ant. polar
MHz	No	dBµV	dB	dB/m	dBµV/m	dBµV/m	m	dB	m	v/h
32.5	7	4.4	1.4	17.7	23.5	40.0	3	-16.5	1.0	v
33.2	7	5.6	1.4	17.5	24.5	40.0	3	-15.5	1.0	v
35.9	7	7.6	1.4	16.4	25.4	40.0	3	-14.6	1.0	v
40.6	7	5.9	1.5	14.8	22.2	40.0	3	-17.8	1.0	v
44.2	7	4.5	1.6	13.4	19.5	40.0	3	-20.5	1.0	v
47.9	7	5.0	1.7	12.0	18.7	40.0	3	-21.3	1.0	v

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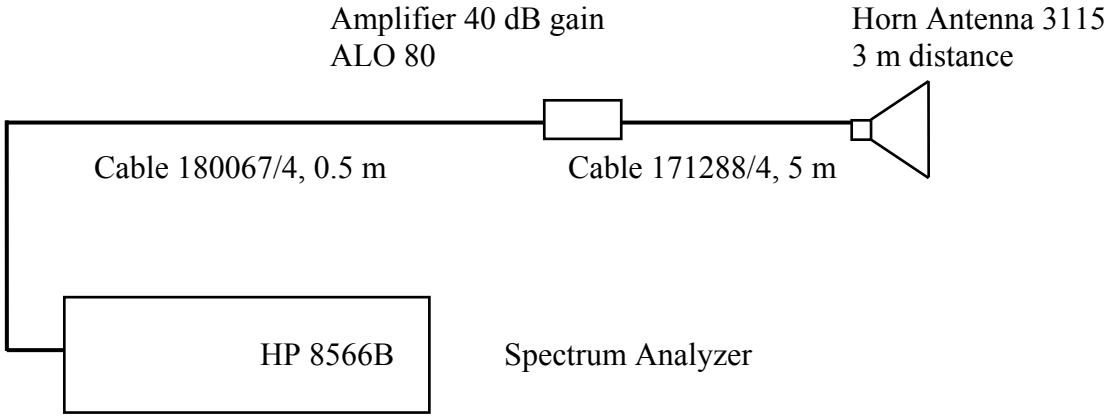
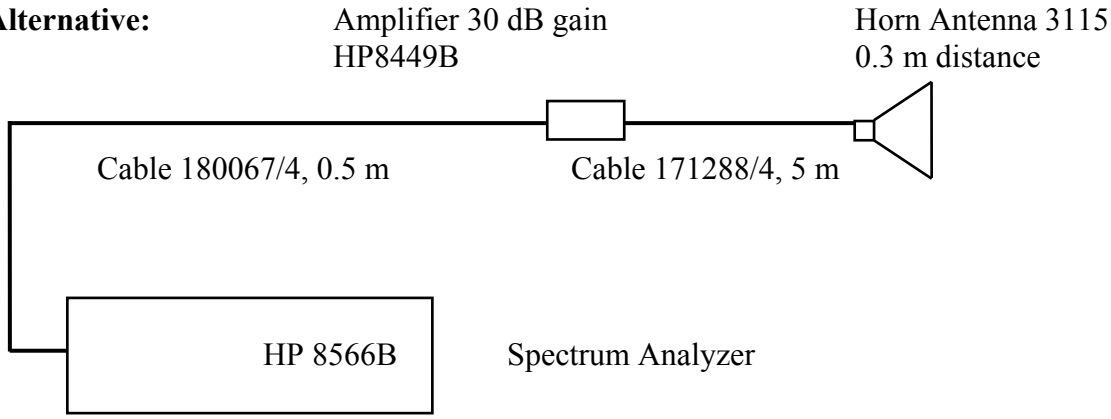
Test equipment set-up

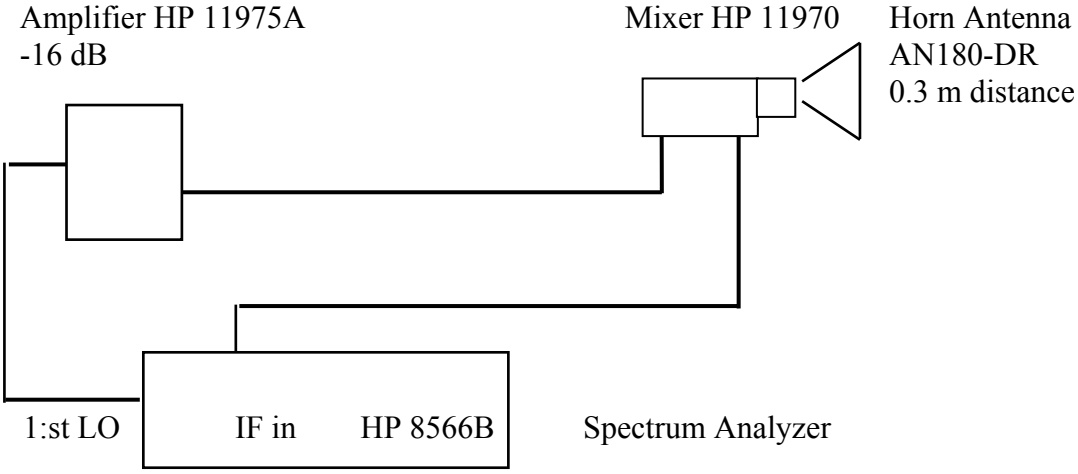
1 - 18 GHz:



Alternative:



18 - 40 GHz:



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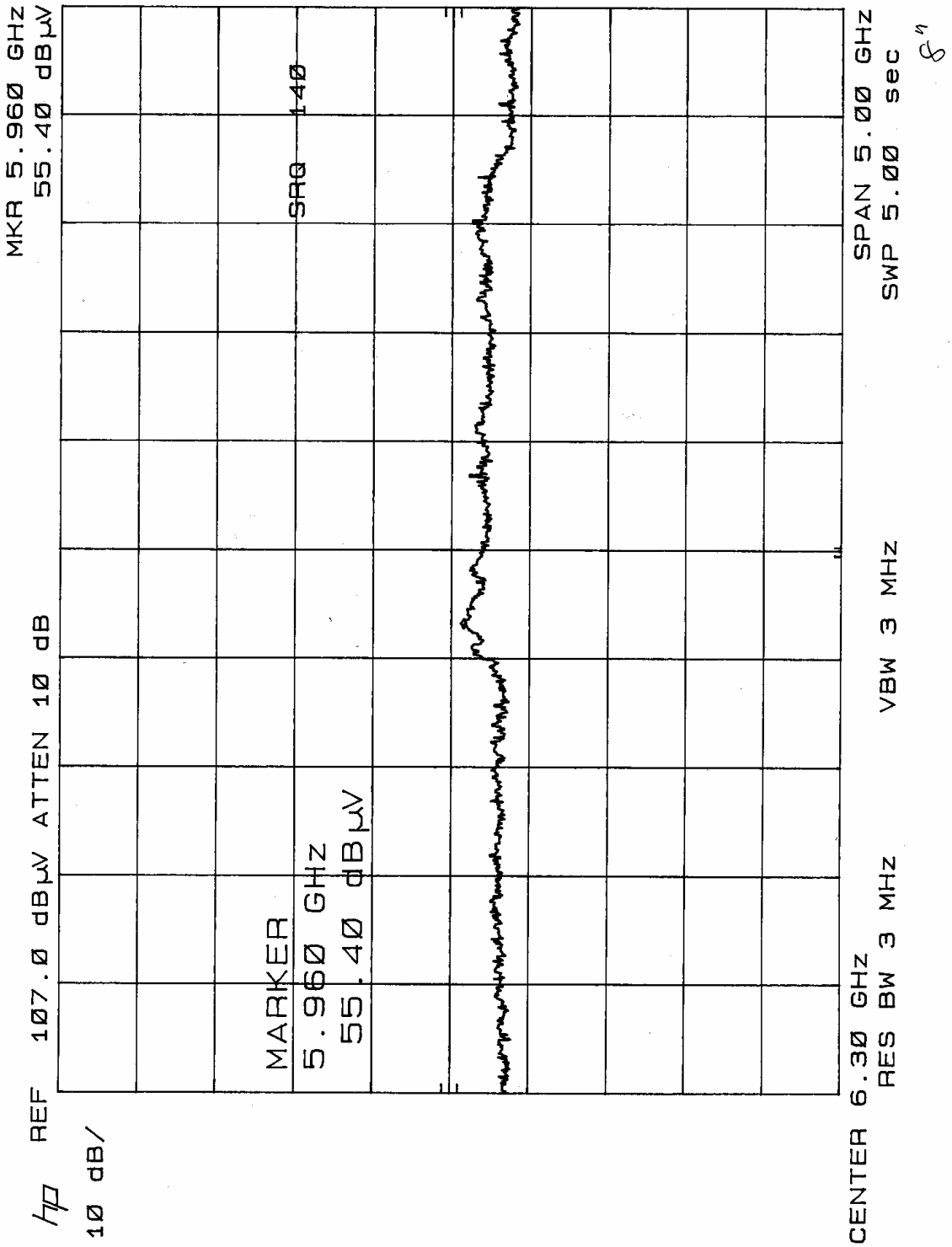

8"

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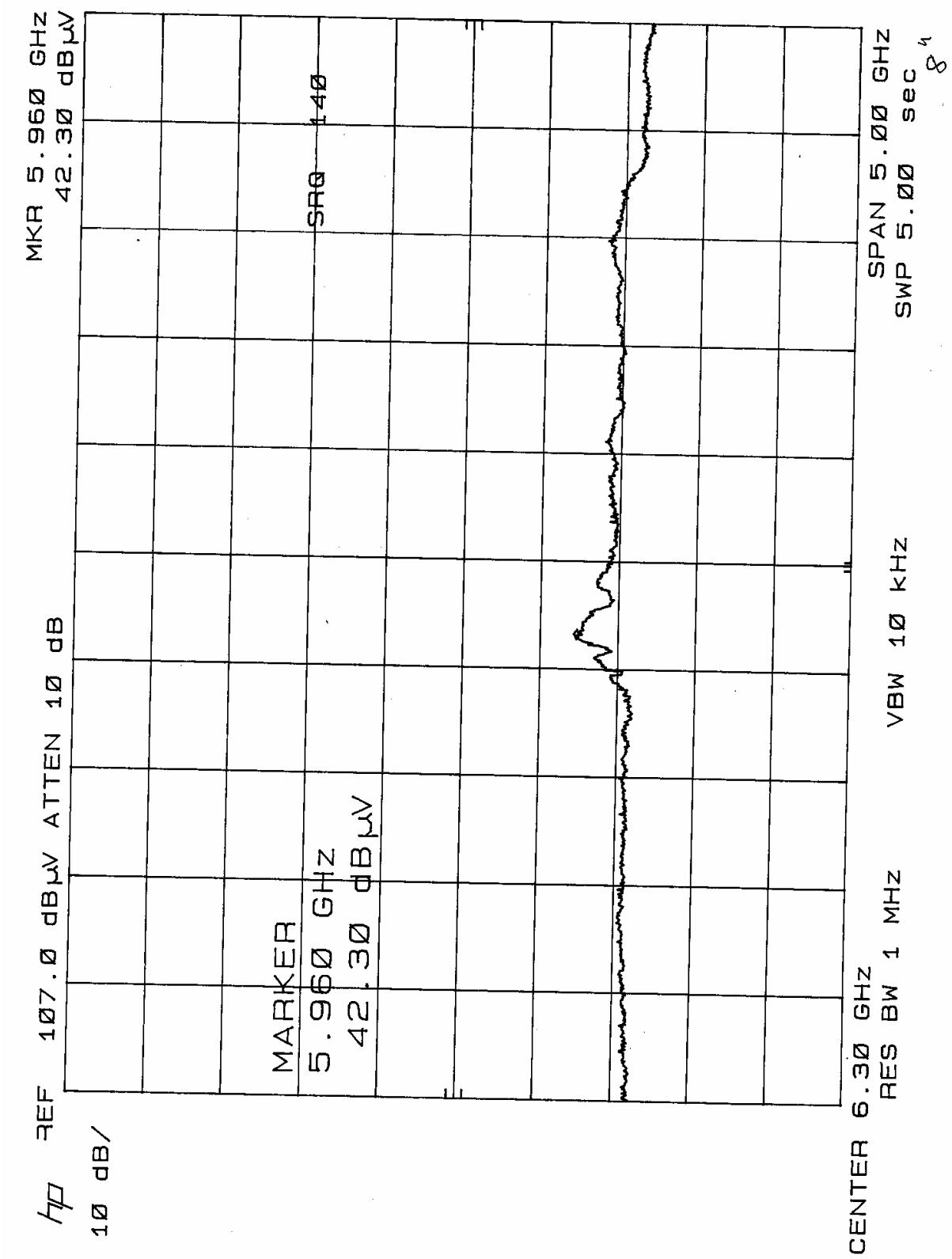

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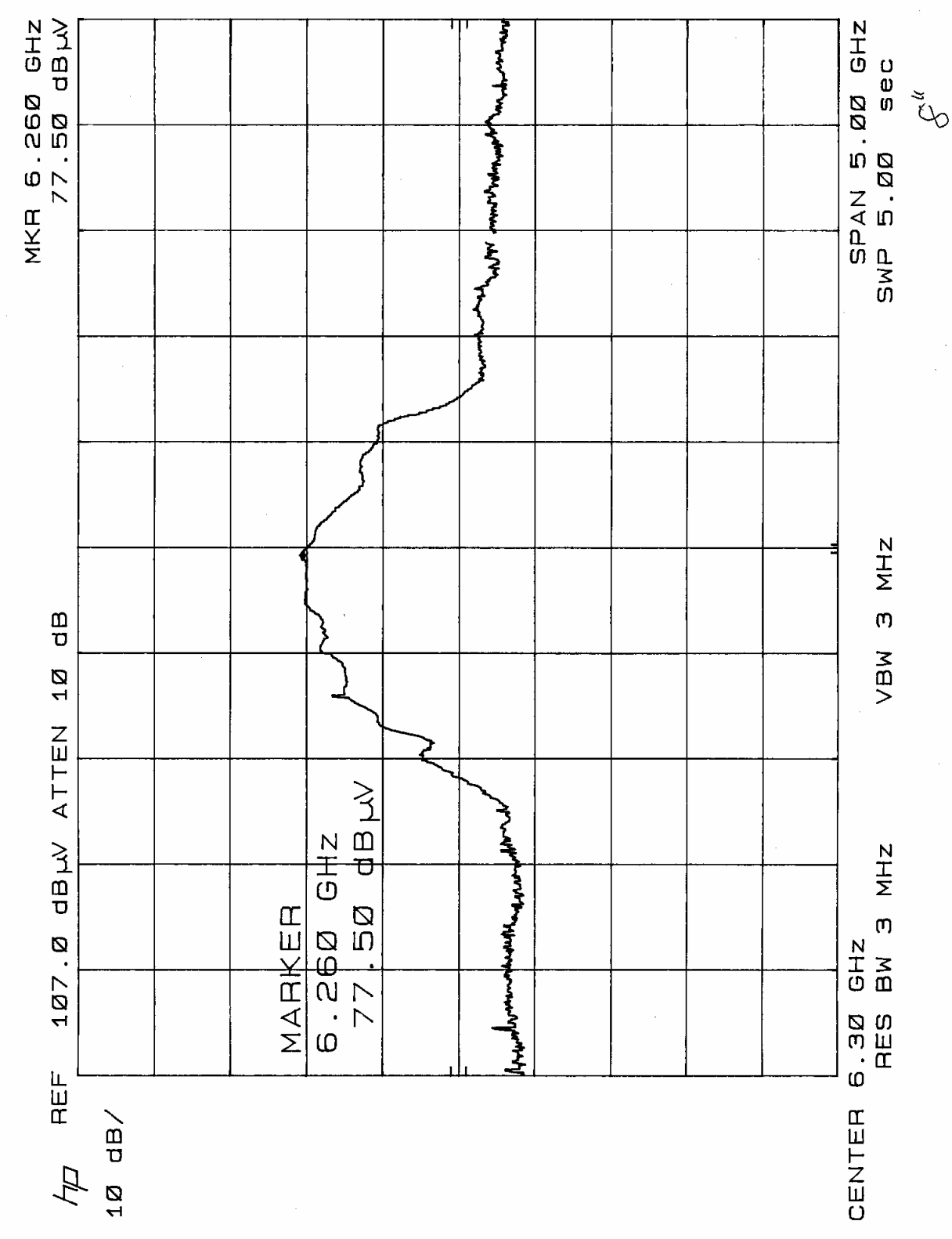

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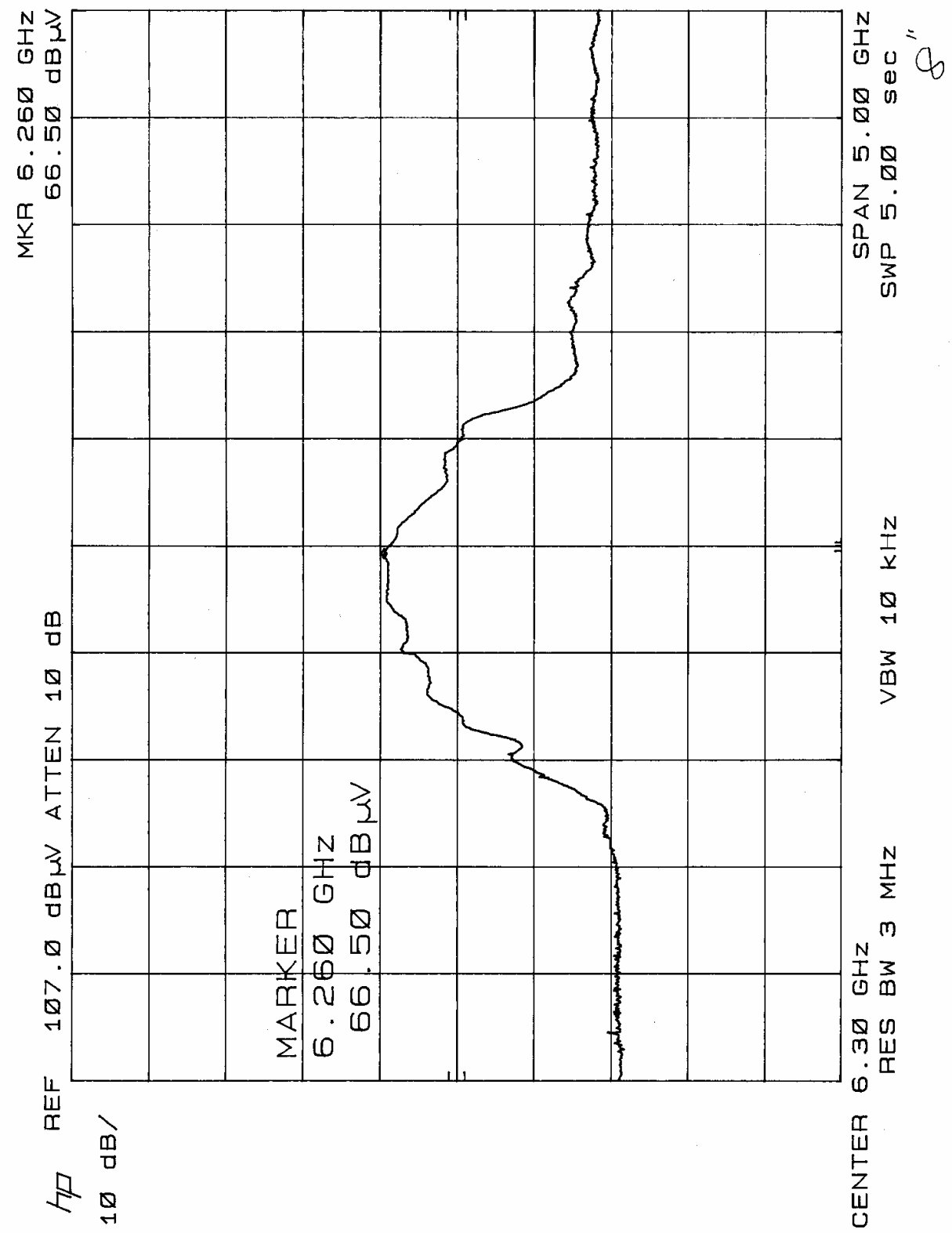

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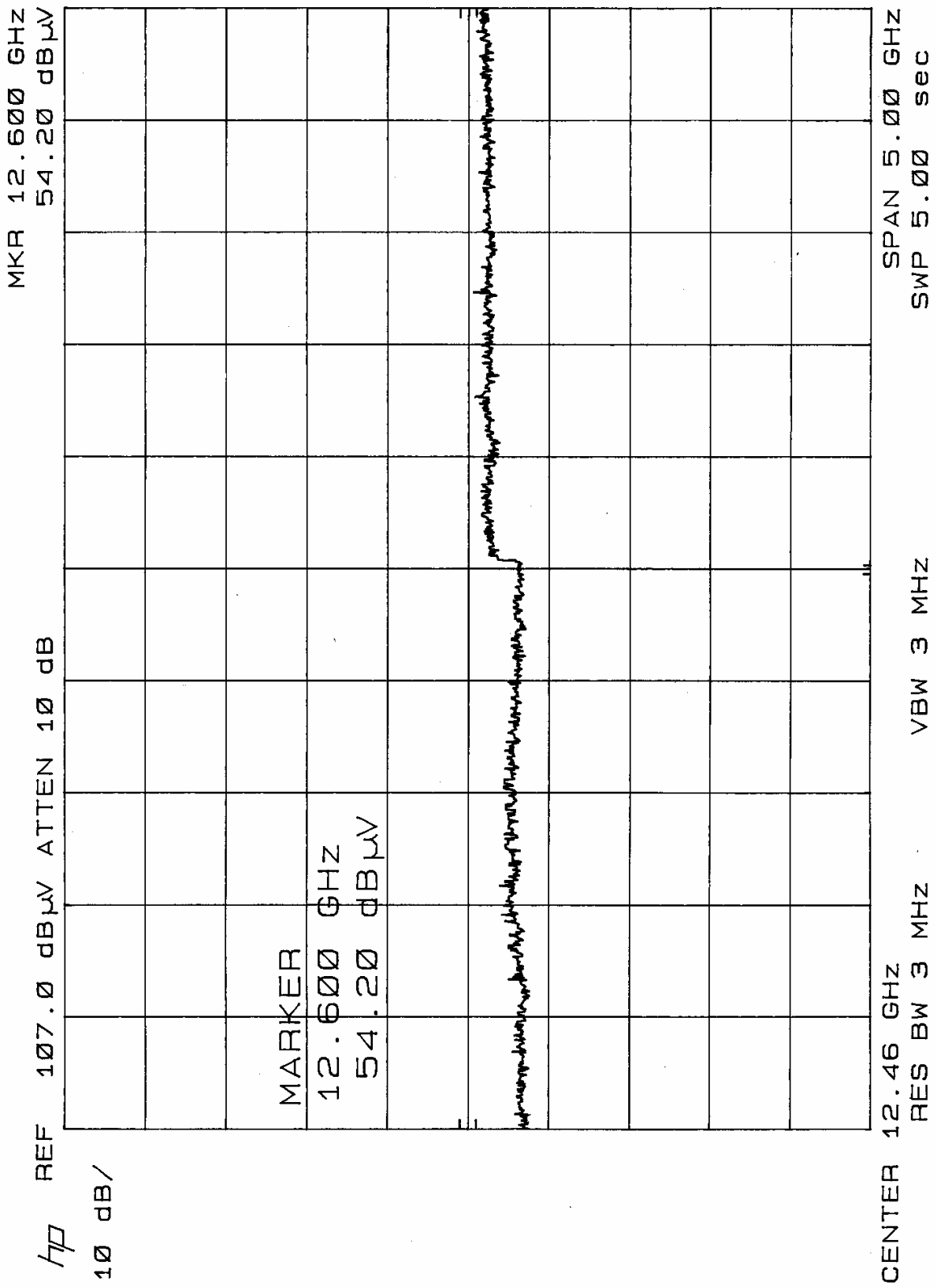

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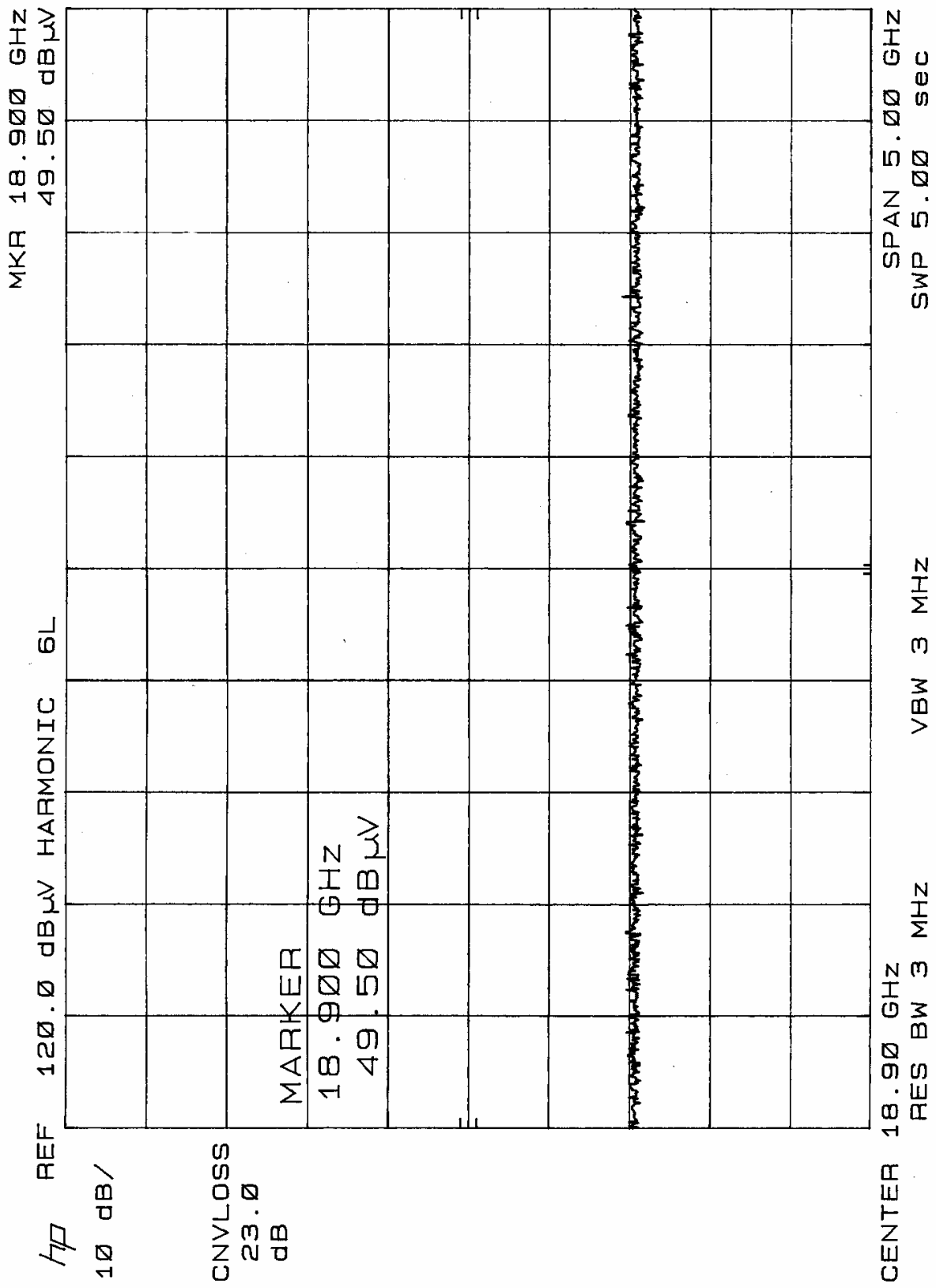

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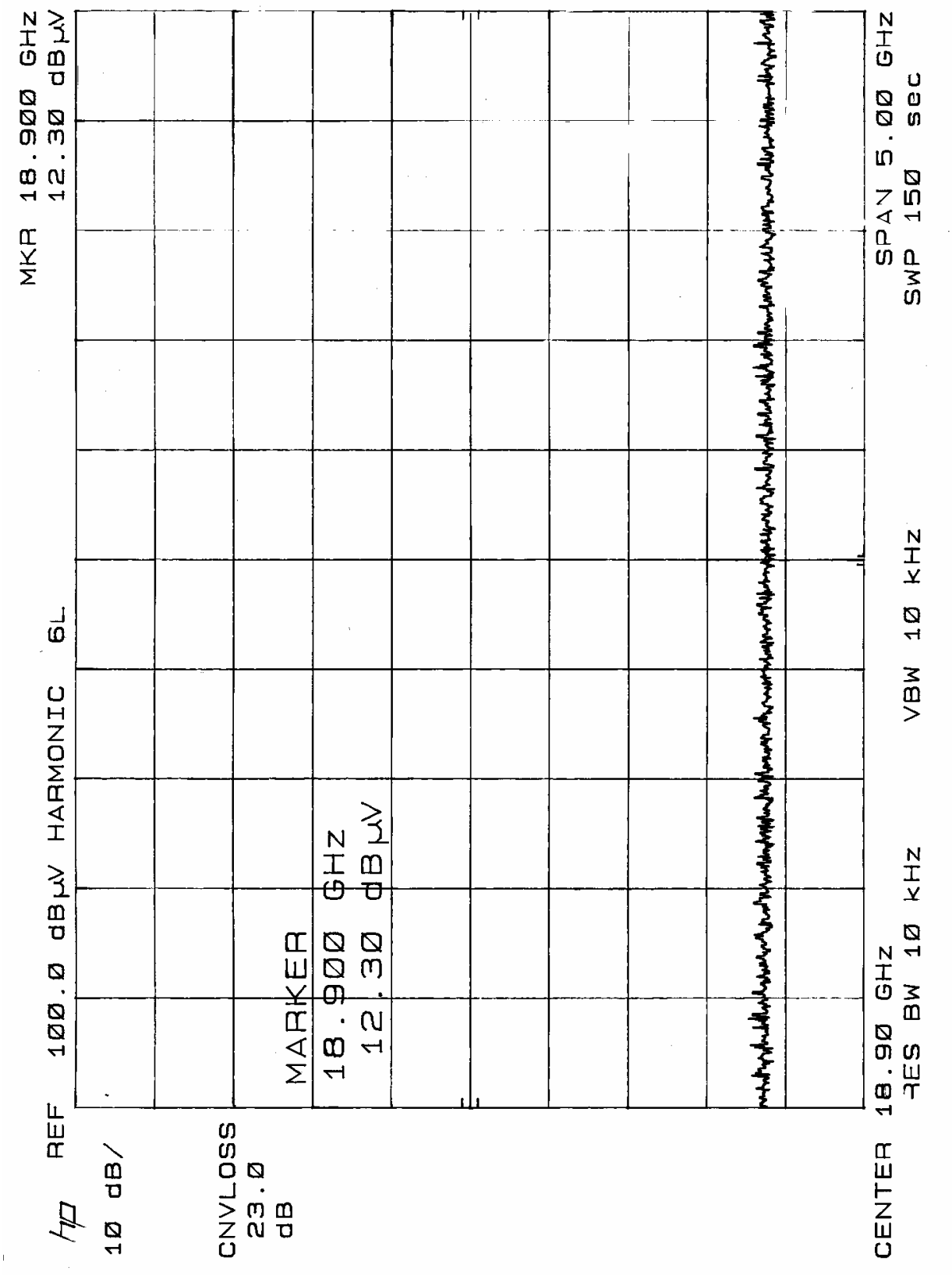

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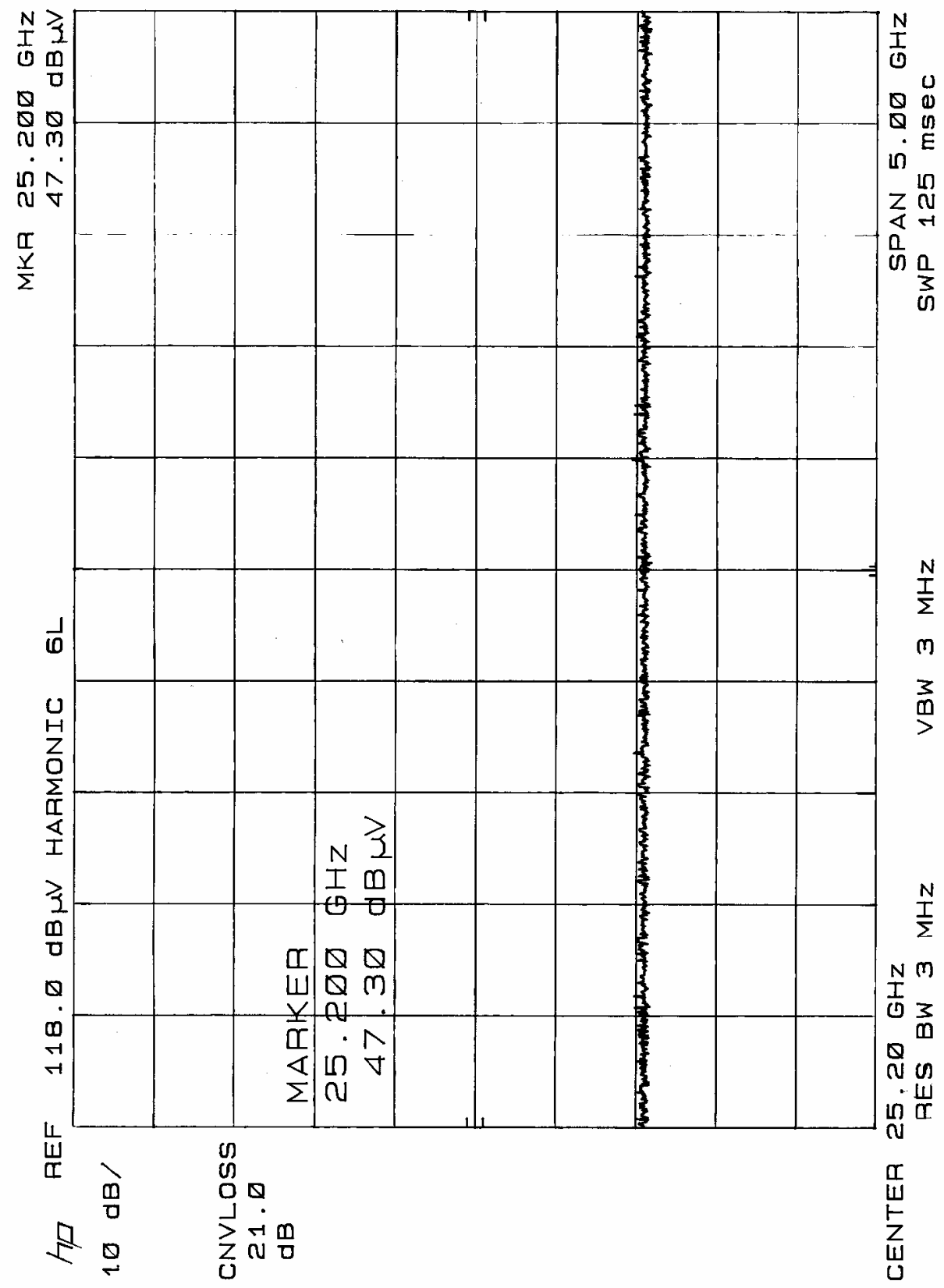

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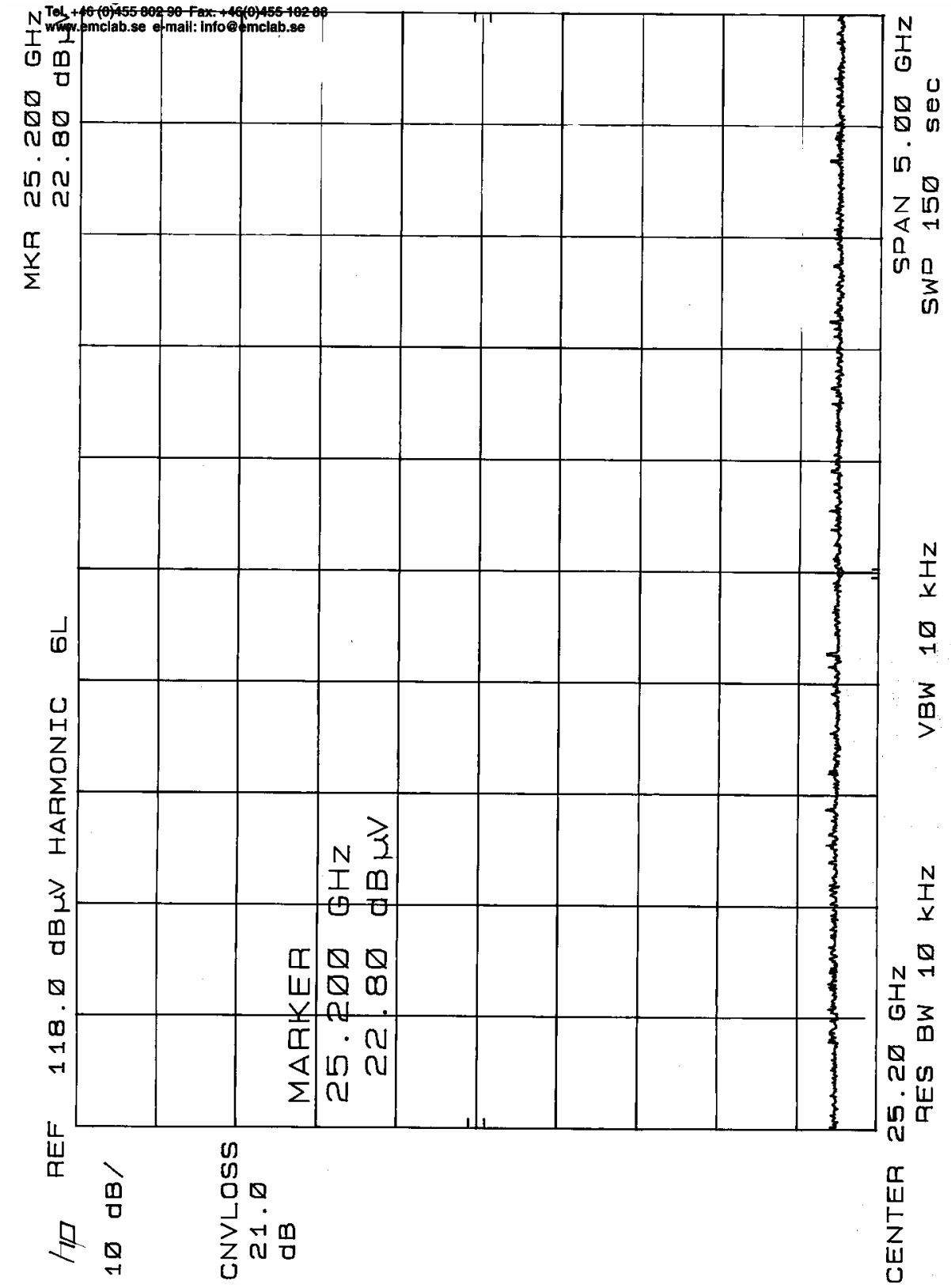

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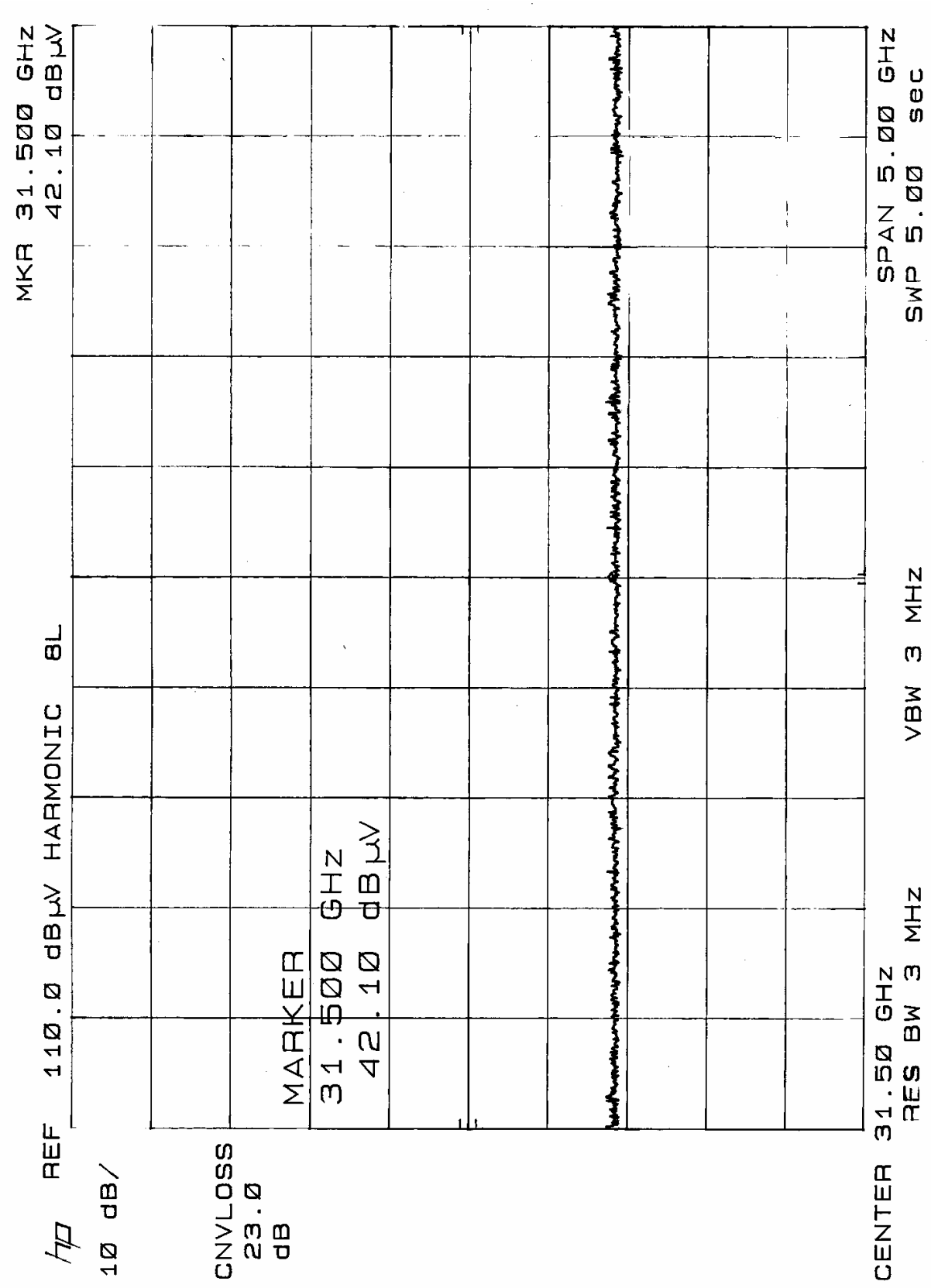

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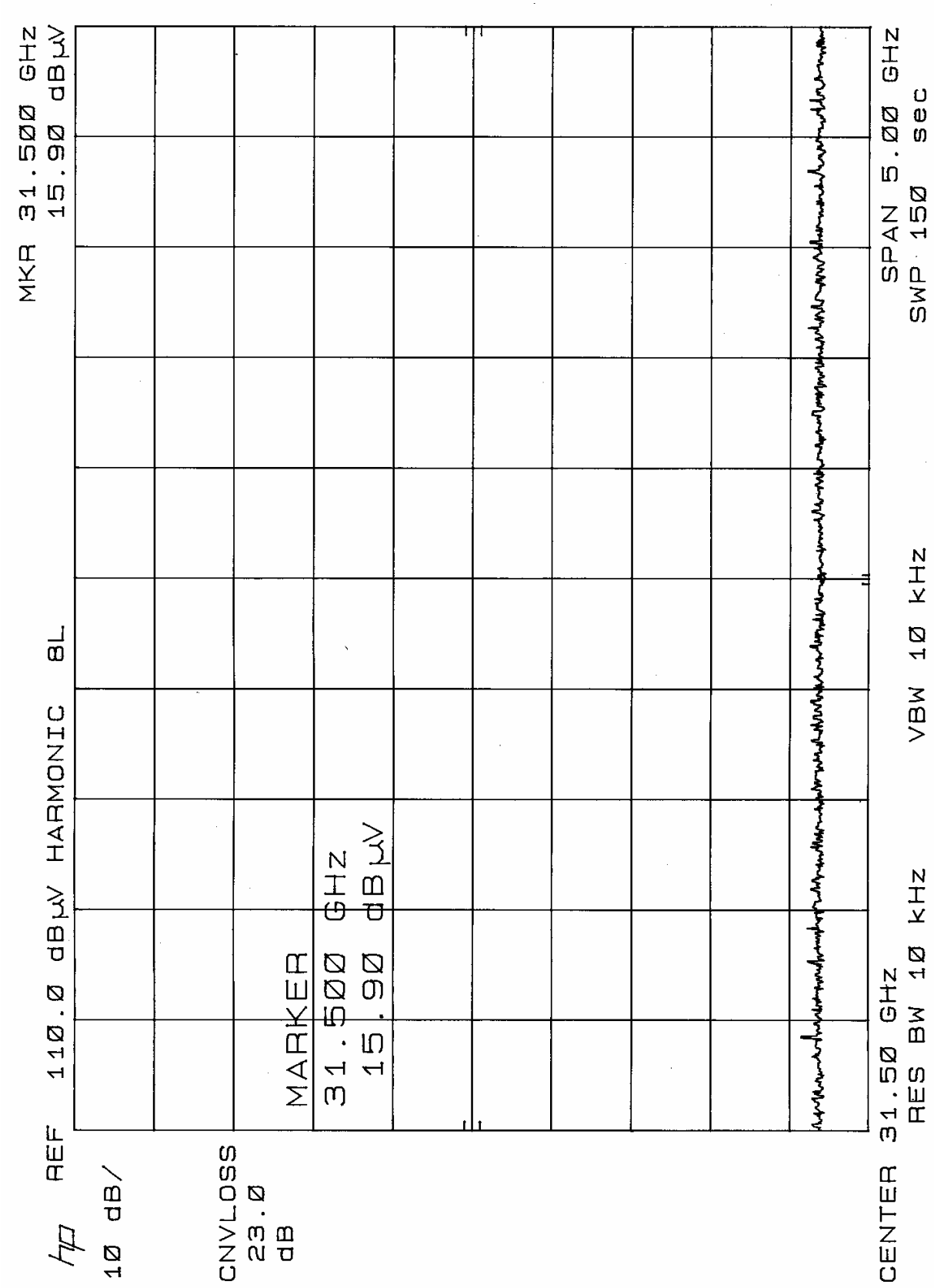

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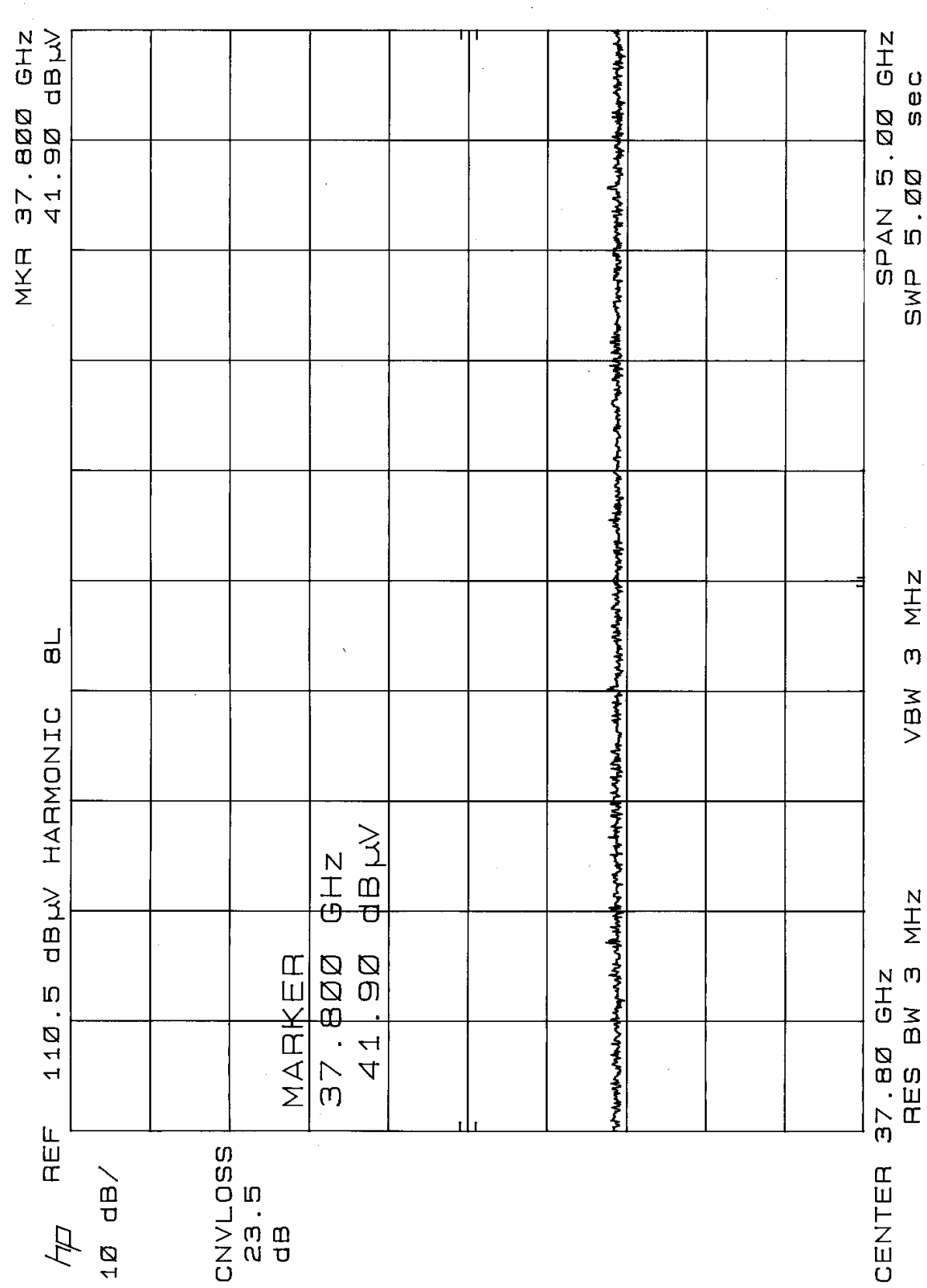

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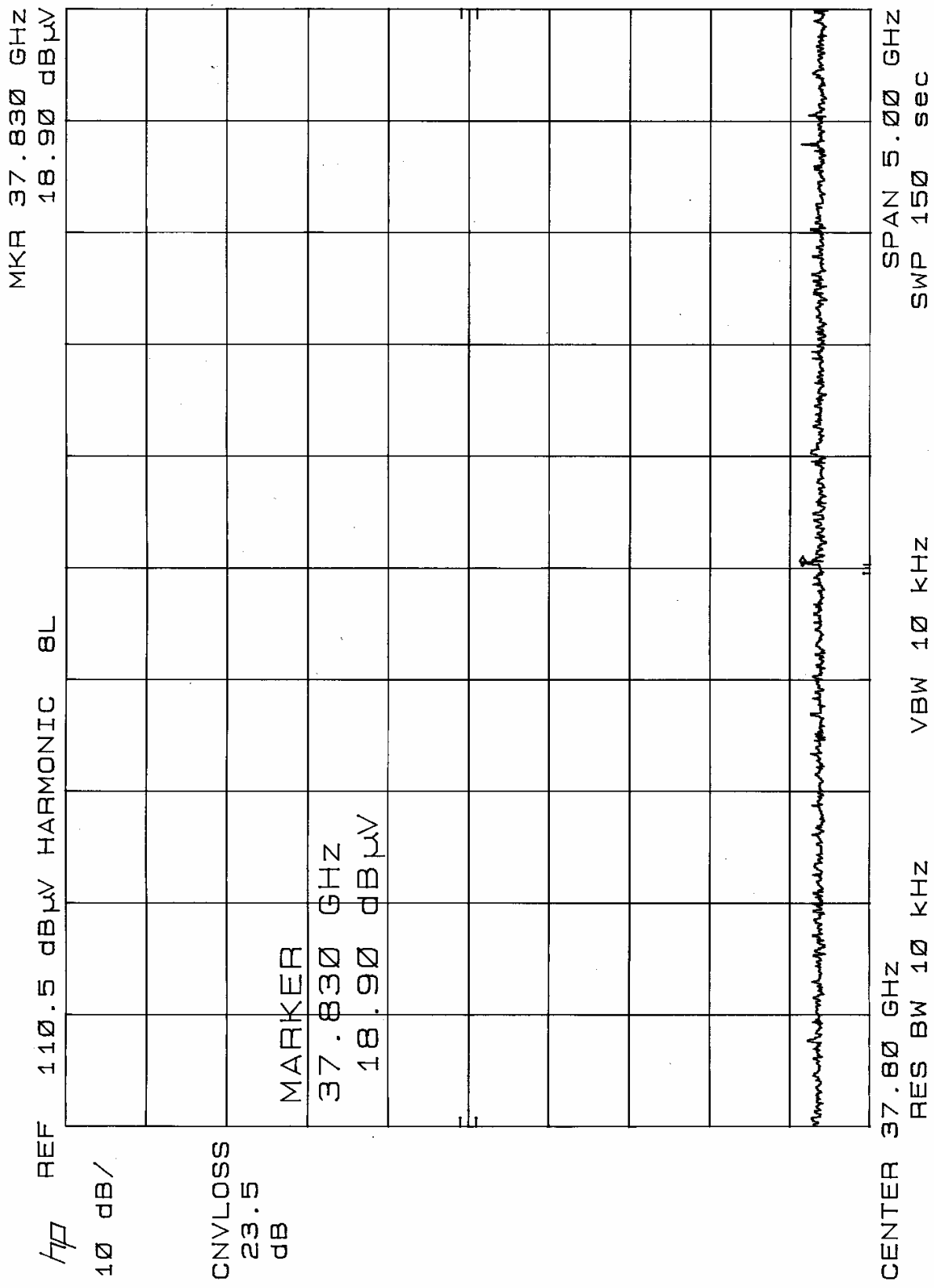

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Radiated Fieldstrength Test. Calculation of Final Emission Levels, 1 – 40 GHz

EUT: Radar Level Gauge. Model Rosemount 5401. Prototype No. P3 14.

Test spec.: 47 Cfr Ch. 1 (10-1-01 Edition):
Part 15, Subpart C, Field Disturbance Sensor.
§ 15.209: Radiated emission, Open Area Test Site
3 m and 0.3 m antenna distance.

Date of Test: September 29 - 31, 2003

Operation: The EUT was configured to continuously transmit at 100% duty cycle. This was done because of the low output power of the device. Normal operation is a radar pulse with a duty cycle less than 1:40.

Field strength (dBµV/m) = Amplitude (dBµV) + Antenna factor (dB/m) + cable loss (dB) + Gain (dB)

Tested frequency range: 1 - 40 GHz
Measured maximum peak and average values.

Freq. (appr.)	Ant-enna type	Appe-ndix	Amplitude peak / av.	RBW / VBW	Antenna factor	Preamp gain	Cable loss C1	Cable loss C2	Field strength	Dist	Limit (1–40 GHz)	Margin to limit	Note
GHz		No	dBµV	kHz / kHz	dB/m	dB	dB	dB	dBµV/m	m	dBµV/m	dB	
6.3	8”	10	55.4 / -	3000 / 3000	36.1	- 42.6	3.0	0.4	52.3	3	74	- 21.7	peak
6.3	8”	11	- / 42.3	1000 / 10	36.1	- 42.6	3.0	0.4	39.2	3	54	- 14.8	av.
6.3	8”	12	77.5 / -	3000 / 3000	36.1	- 35.0	3.0	0.4	82.5	0.3	94	- 12.0	peak
6.3	8”	13	- / 66.5	3000 / 10	36.1	- 35.0	3.0	0.4	71.5	0.3	74	- 3.0	av.
12.6	8”	14	54.2* / -	3000 / 3000	39.6	- 34.0	3.0	0.4	63.2*	0.3	94	- 30.8	peak
12.6	8”	-	- / -	10 / 10	-	-			-	-	-	-	av.**
18.9	8”	15	49.5* / -	3000 / 3000	32.6	-	-	-	82.6*	0.3	94	- 11.9	peak
18.9	8”	16	- / 12.3*	10 / 10	32.6	-	-	-	44.9*	0.3	74	- 29.1	av.
25.2	8”	17	47.3* / -	3000 / 3000	33.9	-	-	-	81.2*	0.3	94	- 12.8	peak
25.2	8”	18	- / 22.8*	10 / 10	33.9	-	-	-	56.7*	0.3	74	- 17.3	av.
31.5	8”	19	42.1* / -	3000 / 3000	35.0	-	-	-	77.1*	0.3	94	- 16.9	peak
31.5	8”	20	- / 15.9*	10 / 10	35.0	-	-	-	50.9*	0.3	74	- 23.1	av.
37.8	8”	21	41.9* / -	3000 / 3000	36.8	-	-	-	78.7*	0.3	94	- 15.3	peak
37.8	8”	22	- / 18.9*	10 / 10	36.8	-	-	-	55.7*	0.3	74	- 18.3	av.

* = Noise level
** = Not measured