2.3 SUMMARY OF TEST REPORT

MANUFACTURER:	T.T.I. WIRELESS
MODEL:	RCB
SERIAL:	14363, 14364
DESCRIPTION:	SPREAD SPECTRUM RADIO MODULE
FREQUENCY RANGE:	2400MHz-2483.5MHz

The T.T. I. Wireless model RCB was found to "meet" the radiated emission specification of Title 47 CFR FCC, Part 15, subpart C. for an intentional radiator

The T.T.I. Wireless model RCB was also found to "meet" the radiated emission specification of Title 47 CFR, FCC Part 15, subpart B for emissions with regards to the receiver and digital sections of the product.

This product is a composite device, with the receiver and the digital sections subject to verification. Therefore this technical report will primary contain data that is pertinent to the certification of the transmitter section of the product.

FCC ID: LXX-11

APPENDIX C:

GRAPHS

SIGNATURE PAGE

Prepared By:

Brian Petted Engineering group Manager — *Date* 10 AUG 1998

Prepared By:

Kenneth L. Boston, EMC Lab Manager — *Date* 10 Aug 1998

PE #31926

Registered Professional Engineer

(State of Wisconsin)

L. S. COMPLIANCE, Inc.

FCC ID: LXX-11

EXHIBIT 2

FCC COMPLIANCE TESTING

OF

T.T.I. WIRELESS

MODEL RCB

SPREAD SPECTRUM MODULE

~ TEST REPORT ~

MAY 6TH –8TH , JUNE 25TH , 1998

Prepared for:

Pete Bonk

T.T.I. Wireless

Cleveland, Ohio

FCC ID: LXX-11

Table of Contents:

FCC ID: LXX-11

EXHIBIT 1

DESCRIPTION OF MEASUREMENT FACILITIES

Site on File with the FCC

ID Number: 31040/SIT

1300F2

" The site referenced above has been found to comply with the test site criteria found in ANSI C63.4-1992 and 47CFR Section 2.948."

FCC ID: LXX-11

2.7 Conducted (AC LINE) Test Setup and measurements

The conducted emission tests were performed within an 8 by 10 foot shielded room located at L. S. Compliance, Inc. in Cedarburg, WI. The test item was placed on a non-conductive rubber cart, with a height of 80 cm above the reference ground plane. The test object was spaced 40 cm from the rear wall of the shielded room and further than 80 cm from adjacent walls, and the test object power supply was plugged into a 50 (ohm) 50/250μH Line Impedance Stabilization Network (LISN). The test area and set-up are in accordance with ANSI C63.4-1992, sections 5, 6, and 7. The AC power supply to the LISN was fed into the shielded room via an appropriate broadband EMI filter.

See Section 2.15 for pictures of the test setup.

After the equipment under test was set-up in the shielded room and connected to the LISN, the RF sampling port of the LISN was cabled to a 10dB attenuator-limiter, and then to the EMI receiver. The EMCO LISN used has the facility to terminate the unused port with a 50Ω (ohm) load when switched to either L1 (line) or L2 (neutral). The appropriate frequency range and bandwidths were entered into the HP 8546A EMI receiver, and measurements were made. The test object cables and position were varied to find the maximum signal levels. Final readings were then taken and recorded. The test procedure guidelines used are found in ANSI C63.4-1992: Sections 7 and 11 including Annex E1 and E2.

The limits for conducted emissions for this test object are found in Title 47CFR, FCC Part 15.207 (b) for an intentional radiator. The levels of these limits are 250μV (48dBμV) from 450 kHz to 30 MHz.

2.13 Test Equipment Utilized for Radiated Emissions Test

A list of the test equipment and antennas used for the tests can be found in Section 2.17, which includes the calibration information as well as the equipment description. All equipment is calibrated and used according to the user manuals supplied by the manufacturer. All antenna calibrations were performed at a N.I.S.T traceable site, and the resultant correction factors were entered into the Hewlett Packard 8546A EMI receiver software database. The connecting cables used were also measured for loss using a calibrated signal generator and the HP 8546A EMI receiver. The resulting loss factors were entered into the HP 8546A database. This allowed for automatic changes in the antenna correction factor, as well as cable loss or other corrections, to be added to the EMI receiver display while taking measurements. Thus, the resulting data taken from the HP 8546A is an actual reading and can be entered into the database as a corrected meter reading. The HP 8546A EMI receiver was operated with a bandwidth of 120 kHz when receiving signals below 1 GHz, and with a bandwidth of 1 MHz when receiving signals above 1 GHz, in accordance with CISPR 16. Both the peak and Quasi-peak detector functions were used.

For measurements in the upper microwave region, a HP 84125C microwave measurement system was leased from Hewlett Packard Corporation. This system includes the Spectrum analyzer, preamps and integrated horn antennas, and is supplied with a current calibration as supplied by the manufacturer facility. Copies of this certification can be supplied if requested. Being that this instrument is an integrated system, all antenna factors, cable factors, and preamp gain factors are stored and recalled when initially calibrated and configured for use. Data appearing on the screen and measured during emissions testing is then presented as corrected readings. During emissions testing, signals where significant levels were noted were measured using the 1 MHz IF bandwidth, and a 10 or 100 Hz video bandwidth, resulting in an average measurement mode of the analyzer. Signal levels were also inspected using the 100 kHz bandwidth and compared to the maximum radiated signal in a 100 kHz bandwidth of the fundamental modulated carrier for the three channels tested.

2.4 INTRODUCTION

On May 6th-8th , and June 25th of 1998, a series of Radiated Emissions tests were performed on two sample models of the T. T. I. Model RCB, a spread spectrum transceiver module, designed for point-to-point wireless high speed data transfer.. These tests were performed using the test procedures outlined in ANSI C63.4-1992 for intentional radiators, and in accordance with the requirements set forth in FCC Part 15.247 for a periodic transmitter. Tests were also performed as outlined in ANSI C63.4-1992 for non-intentional radiators, in order to verify compliance with the limits set forth in part 15.109 for and to allow verification of emissions for the digital section of the product. These tests were performed by Kenneth L. Boston, PE, of L. S. Compliance, Inc. and witnessed by Dragan Zivkovik of T. T. I.

2.5 PURPOSE

The above mentioned tests were performed in order to determine the compliance of the TTI Wireless RCB S. S. transceiver product with limits contained in various provisions of Title 47 CFR, FCC Part 15, including:

15.207	15.247b	15.247e
15.205	15.247c	15.109
15.247a2	15.247d	

All radiated emissions tests were performed to measure the emissions in the frequency bands described by the above sections, and to determine whether said emissions are below the limits established by the above sections. These tests were performed in accordance with the procedure described in the American National Standard for methods of measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (ANSI C63.4-1992). Another document used as reference for the EMI receiver specification was the International Special Committee on Radio Interference (CISPR) number 16-1 (1993).

2.6 Power Output Test Performed

For the 15.247b measurement, the output of the RCB transceiver module was connected via a short jumper cable created only for this measurement, into the input of the HP 8546A EMI receiver. The unit was configured to run in a continuous transmit mode, with a repeating data package providing the appropriate modulation. The HP receiver was set to a 1 MHz Bandwidth, and the transmit signal was then stored, with the peak signal level stored. This power level was collected for all six channels and can be seen in the chart presented below.

CHANNEL	CENTER FREQ	LIMIT	MEASURED POWER	MARGIN
1	2412 MHz	30 dBm	14.26 dBm	15.74 dB
2	2422 MHz	30 dBm	14.82 dBm	15.18 dB
3	2432 MHz	30 dBm	15.05 dBm	14.95 dB
4	2442 MHz	30 dBm	15.08 dBm	14.92 dB
5	2452 MHz	30 dBm	15.05 dBm	14.95 dB
6	2462 MHz	30 dBm	14.81 dBm	15.19 dB

2.8 Occupied Bandwidth Measurements

The 6 dB bandwidth found in 15.247.a.2 is a minimum of 500 kHz. The test sample was setup in the 3 meter Semi-anechoic chamber in accordance with the configuration described below, in section 7.11. Direct measurement of the transmitted signal , taken from a position 1 meter in front of the transmitting antenna, was then used to determine the signal bandwidth. For each of the representative channels, refer to the graphs found in Appendix C, on page 37 through page 39. From this data, the bandwidth of channel 1, which is the closest data to the specification limit, is 7.15 MHz, which is above the minimum of 500 kHz.

CHANNEL	CENTER FREQ	MEASURED 6 DB BW	MINIMUM LIMIT
1	2412 MHz	7.15 MHz	0.5 MHz
3	2432 MHz	7.25 MHz	0.5 MHz
6	2462 MHz	7.25 MHz	0.5 MHz

2.9 Power Spectral Density

In accordance with FCC part 15.247(d), the peak power spectral density should not exceed +8 dBm in any 3 kHz band. This measurement was performed along with the conducted power output readings performed as described in section 7.6. The peak output frequency for each representative frequency was scanned, with a narrow bandwidth, and reduced sweep. The resultant density can be determined by inspection of the graphs found in Appendix C, pages 40 through 42, and was found to be no greater than –5.9 dBm, which is under the allowable limit by 13.9 dB.

CHANNEL	CENTER FREQ	MEASURED P	ATTEN.	CORRECTED	SPEC	MARGIN
1	2412	-18.67dBm	10.0dB	-8.67dBm	+8.0dBm	16.67dB
3	2432	-16.58dBm	10.0dB	-6.58dBm	+8.0dBm	14.58dB
6	2462	-15.88dBm	10.0dB	-5.88dBm	+8.0dBm	13.88dB

2.10 Processing Gain

A full description of this measurement can be found in Appendix D, wherein the processing gain of the system was determined by using the CW jamming margin method. This test was performed within a screened room located on the L.S. Compliance facility, by Brian Petted, of L.S. Research, which is colocated with L. S. Compliance in Cedarburg.

FCC ID: LXX-11

2.11 Radiated Emissions Test Setup

The test sample was operated within the 3 meter Semi-Anechoic, FCC listed chamber located at L.S. Compliance in Cedarburg, WI. The sample was mounted on its supplied metal tripod, which was centered on the flush-mounted 2m diameter metal turntable. The test sample was operated on its own [new] internal power supply. The test sample was configured to run in a continuous transmit mode during the 15.247 and 15.205 measurements. The sample was also set to run in a T.D.D. mode with 1 second on and 1 second off transmit times in order to inspect the level of TDD spurs transmitted. One test sample was set to operate on either channel 1 (2412mhz), channel 3 (2432MHz) or channel 6 (2462MHz) while being tested as an intentional radiator, in order to determine compliance within a frequency range of 2400-2483.5 MHz, as dictated by FCC part 15.31m

The system was also mounted on the 80 CM high wooden table, centered on the turntable for measurement of spurious signals emanating from the system during both receive and transmit modes.

Please refer to Section 2.15 for pictures of the test setup.

2.12 Radiated Emission Test Procedure

The fundamental and spurious (harmonic) emissions of the transmitter were tested for compliance to Title 47 CFR, FCC Part 15.247c limits for Direct Sequence Spread Sprectrum systems, and the 15.205 general limits, within the restriced bands. For the calculations used to determine the 1 meter limits, see Appendix A. The test sample was tested from the lowest frequency generated by the transmitter to the 10th harmonic of the fundamental frequency generated by the device. The appropriate limits were also observed where any spurious signals were located within any of the restricted bands as described in Part 15.205a. These frequencies, and their associated limits, are referenced in Section 2.14. The sample was mounted on the supplied metal tripod and placed in the 3 Meter chamber and the antenna mast was placed such that the antenna was either 1 meter or 3 meters from the test object. A biconical antenna was used to measure emissions from 30 to 200 MHz, a log periodic was used to measure emissions from 200 to 1000 MHz, and a double ridged waveguide horn was used to measure emissions above 1 GHz. The test object was programmed to operate in continuous transmit, and the resultant signals were maximized by rotating the turntable 360 degrees, and by raising and lowering the antenna between 1 and 4 meters. The test object was also given several different orientations to determine the maximum signal levels, using both horizontal and vertical antenna polarities. Emissions above 1 GHz were also measured at a 1 meter separation, using the HP 84125C Microwave Measurement system.

No significant emissions were found aside from the transmitter fundamental and some spurious signals. The unit was scanned for emissions in both transmit and receive modes, over the range 30 to 26000 MHz to establish compliance with Part 15.247c and 15.205 for the system. Also, the scans were performed to evaluate the digital controller section of the product, which is subject to verification as a Class A digital device. The same procedures as detailed for the transmitter tests described above were used to perform these measurements. The results of the system measurements are found in Appendix B, with graphs of the signature scans found in Appendix C.

FCC ID: LXX-11

Manufacturer: T.T.I. Wireless
Model: RCB
Serial Number(s): 14363, 14364

2.14 - Restricted Bands affecting this product

3 Meter limits

Frequency (MHz)	Limit (μV)	Limit (dB/μV/m)
960-1240	500	54.0
1300-1427	500	54.0
1435-1626.5	500	54.0
1645.5-1646.5	500	54.0
1660-1710	500	54.0
1718.8-1722.2	500	54.0
2200-2300	500	54.0
2310-2390	500	54.0
2483.5-2500	500	54.0
2655-2900	500	54.0
3260-3267	500	54.0
3332-3339	500	54.0
3345.8-3358	500	54.0
3600-4400	500	54.0
4500-5150	500	54.0
5350-5460	500	54.0
7250-7750	500	54.0
8025-8500	500	54.0
9000-9200	500	54.0
9300-9500	500	54.0
10600-12700	500	54.0
13250-13400	500	54.0
14470-14500	500	54.0
15350-16200	500	54.0
17700-21400	500	54.0
22010-23120	500	54.0
23600-24000	500	54.0

2.15 – Photos taken during testing

2.16 Summary of Results and Conclusions

Based on the procedures outlined in this report, and the test results included in appendices B and C, it can be determined that the T.T.I. Wireless model RCB does "meet" the emission requirements of Title 47 CFR, FCC Part 15 Subpart C for an intentional radiator.

The enclosed test results pertain to the samples of the test item listed, and only for the tests performed on the data sheets. Any subsequent modification or changes to the test items could invalidate the data contained herein, and could therefore invalidate the findings of this report.

FCC ID: LXX-11

2.17 - Test Equipment

Asset #	Manufacturer	Model #	Serial #	Description	Due Date
AA960003	EMCO	3121C	786	Dipole Set Antenna	7/14/98
AA960004	EMCO	3146	9512-4276	Log Periodic Antenna	9/9/98
AA960005	EMCO	3110B	9601/2280	Biconical Antenna	9/9/98
AA960007	EMCO	3115	99111-4198	Double Ridged Guide/Horn Antenna	9/9/98
EE960004	EMCO	2090	9607-1164	Mast/Ttable Controller	I.O
EE960013	HP	8546A	3617A00320	Receiver RF Section W/Display and RF filter section	7/30/98
EE960014	HP	85460A	3448A00296	Receiver RF Section Preselector	7/30/98

Manufacturer	Model	Serial	Description	Calibrated on:
Hewlett Packard	84125C	3643A00026	Microwave EMI Test System	12 October 1997

FCC ID: LXX-11

APPENDIX A:

SAMPLE CALCULATIONS

FCC ID: LXX-11

Manufacturer: T.T.I. Wireless
Model: RCB
Serial Number(s): 14363, 14364

Calculation of Radiated Emissions limits for FCC Part 15.209 (above 1 GHz)

The following table depicts the Class B limits for an unintentional radiator: Limits established at a measurement distance of 3 meters and limits corrected for a 1 meter measurement distance which are extrapolated from the 3 meter limit.

Frequency (MHz)	3m limit (dB μV/m)	1m limit (dB μV/m)
960 MHz up	54	63.54

- The 1 meter limits were calculated by adding a factor of 9.54 dB, derived from:

$20\log_{10}(3/1) = 9.54$ dB uV/m

3m limit = 10m limit + factor

= 54 dB μV/m + 9.54 dB μV/m

=63.54 dB μV/m

FCC ID: LXX-11

APPENDIX B:

DATA CHARTS

FCC ID: LXX-11

Measurement of Electromagnetic Radiated Emission within 3 Meter FCC Listed Chamber

Frequency Range inspected: 30 to 1000 MHz

Date of Test:	May 6, 8 ,1998	Manufacturer:	T.T.I.Wireless
Location:	L. S. Compliance, Inc.	Model No.:	RCB
	W66 N220 Commerce Court		
	Cedarburg, WI 53012		
Specifications:	47CFR FCC Part 15.109 class A	Serial No.:	14363
Distance:	3 meters	Configuration:	Rx on Channel 6, worst case
Equipment:	HP 8546A EMI Receiver	Detector(s) Used:	Quasi-peak
	EMCO 3146A Log Periodic		
	EMCO 3110B Biconical		

The following table depicts the level of significant spurious emissions found:

Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	EMI Meter Reading (dB μV/m)	15.109 Limit (dB μV/m)	Margin (dB)
32.5	Vert	1.0	133	41.1	49.54	8.44
41.28	Vert	1.0	133	38.4	49.54	11.14
78.7	Vert	1.4	0	39.6	49.54	9.94
176.5	Horiz	1.0	144	37.7	53.98	16.28
177	Horiz	1.0	144	38.3	53.98	15.68
180	Horiz	1.0	144	38.6	53.98	15.38
200	Horiz	1.0	161	39.3	53.98	14.68
203	Horiz	1.0	161	40.0	53.98	13.98
213.6	Horiz	1.0	160	47.1	53.98	6.7
213.6	Vert	1.0	125	40.3	53.98	13.68
280	Vert	1.0	55	48.5	56.9	8.4
280	Horiz	1.0	295	48.1	56.9	8.8
290	Vert	1.45	165	49.5	56.9	7.4
290	Horiz	1.7	137	48.3	56.9	8.6
310	Vert	1.5	170	49.9	56.9	7.0
320	Vert	1.5	164	49.0	56.9	7.9
320	Horiz	1.7	232	46.3	56.9	10.6
330	Horiz	1.7	290	47.0	56.9	9.9
396	Vert	1.0	230	45.5	56.9	11.4
397.5	Horiz	1.0	47	46.6	56.9	10.3
480	Horiz	1.0	233	42.9	56.9	14.0
480	Vert	1.4	182	42.6	56.9	14.3

FCC ID: LXX-11

Measurement of Electromagnetic Radiated Emission within 3 Meter FCC Listed Chamber

Frequency Range inspected: 1 to 26 GHz

Date of Test:	May 6, 8, June 25, 1998	Manufacturer:	T. T. I. Wireless
Location:	L.S. Compliance, Inc.	Model No.:	RCB
	W66 N220 Commerce Court		
	Cedarburg, WI 53012		
Specifications:	47CFR, FCC Part 15.247(c), 15.205	Serial No.:	14363
Distance:	1 meter	Configuration:	Tx on Ch 1, 3, or 6
Equipment:	HP 8546A EMI Receiver HP 84125C microwave EMI system	Detector(s) Used:	Average
	EMCO 3115 Double Ridged Waveguide		Unless noted as Peak

The following table depicts the level of significant spurious and harmonic emissions found:

Emissions radiating from the system are defined by height and azimuth on the turntable.

Emissions radiating via the mesh antenna are described as being inspected on boresite of antenna.

Frequency (GHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	EMI Meter Reading (dB μV/m)	Channel (dB)	15.205 Limit (dB μV/m)	Margin (dB)
4.264	H	1.0	160	42.17	1	63.54	21.37
12.064	V	1.0	Boresite	38.05	1	63.54	25.49
14.472	V	1.0	Boresite	39.24	1	63.54	24.30
19.296	V	1.0	Boresite	36.42	1	63.54	27.08
4.304	H	1.0	230	40.5	3	63.54	23.04
12.160	H	1.0	Boresite	38.62	3	63.54	24.82
14.592	H	1.0	Boresite	38.65	3	63.54	24.89
19.456	V	1.0	Boresite	36.17	3	63.54	27.37
4.364	H	1.0	150	42.33	6	63.54	21.21
4.364	V	1.0	30	45.67	6	63.54	17.87
12.310	V	1.0	Boresite	36.94	6	63.54	26.60
19.696	V	1.0	Boresite	36.75	6	63.54	26.79
22.158	V	1.0	Boresite	37.83	6	63.54	25.71
2.3852	V	1.0	Boresite	56.70	1	63.54	6.84
2.3780	V	1.0	Boresite	78.86 peak	1	83.54	4.68
2.4921	V	1.0	Boresite	57.40	6	63.54	5.14
2.3762	V	1.0	Boresite	52.60	6	63.54	10.94
2.4921	V	1.0	Boresite	66.03 peak	6	83.54	17.51

FCC ID: LXX-11

Measurement of Electromagnetic Radiated Emission within 3 Meter FCC Listed Chamber

Frequency Range inspected: 1000 to 26000 MHz

Date of Test:	May 6,8, June 25, 1998	Manufacturer:	T.T.I Wireless
Location:	L. S. Compliance, Inc.	Model No.:	RCB
	W66 N220 Commerce Court		
	Cedarburg, WI 53012		
Specifications:	Title 47CFR, FCC Part 15.247 (C)	Serial No.:	14363
Distance:	1 meter	Configuration:	Tx on channel 1, 3, and 6
Equipment:	HP 8546A EMI Receiver	Detector(s) Used:	Peak, Average
	HP 84125C microwave EMI system		1 MHz bandwidth
	EMCO 3115 Double Ridged Waveguide		100 kHz Bandwidth
	EMCO 3146A Log Periodic		
	EMCO 3110B Biconical		

All other Harmonics and Spurious signals not reported within restricted bands

No emissions within 20 dB of the minus 20 dBc specification could be found

FCC ID: LXX-11

Measurement of Conducted Emissions within 8' X 10' FCC Listed Shielded Room.

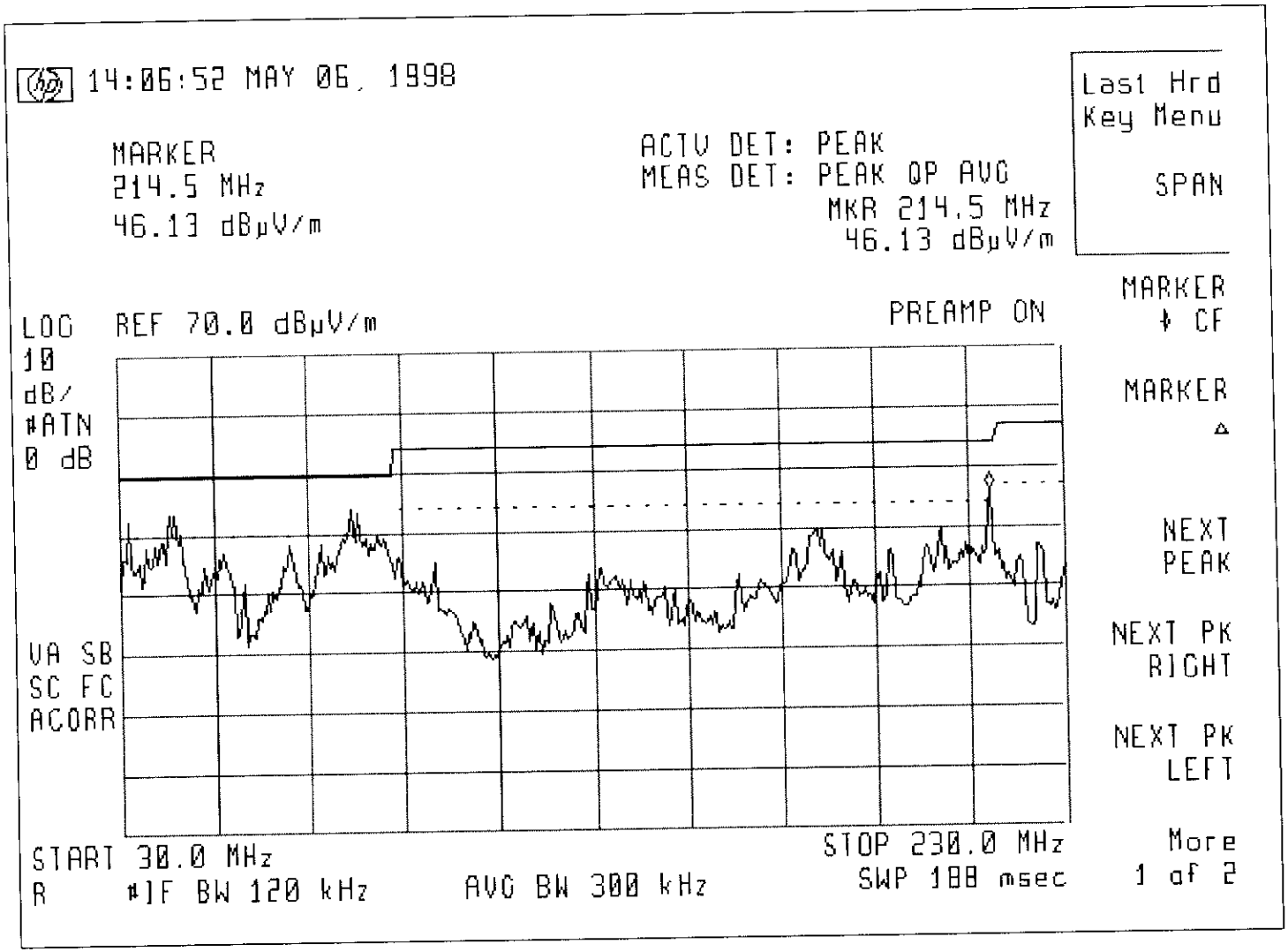
Date of Test:	May 6,8, June 25, 1998	Manufacturer:	T.T.I. Wireless
Location:	L. S. Compliance, Inc.	Model No.:	RCB
	W66 N220 Commerce Court		
	Cedarburg, WI 53012		
Specifications:	Title 47CFR, FCC Part 15 Subpart C	Serial No.:	14363
Distance:	40 cm to vert. G.P.	Configuration:	Channel 3, Rx and Tx
Equipment:	HP 85460A, 85462A EMI Receiver	Detector(s) Used:	Quasi-Peak
	EMCO 3810/2NM LISN		
	HP 11947A Limiter		
Lab Conditions:	Temp.: 72° F	Humidity:50%	

The following table depicts the level of significant spurious emissions found:

Frequency (MHz)	Line	EMI Meter Reading (dB μV)	FCC 15.207 Limit (dB μV)	Margin (dB)
1.32	L1	36.9	48	11.1
1.46	L1	36.4	48	11.6
1.55	L1	35.9	48	12.1
1.79	L1	36.3	48	11.7
24.03	L1	38.8	48	9.2
26.58	L1	37.2	48	10.8
26.72	L1	37.6	48	10.4
0.72	L2	39.2	48	8.8
0.85	L2	37.7	48	10.3
1.32	L2	39.6	48	8.4
1.92	L2	35.0	48	13.0
2.03	L2	37.1	48	10.9
2.39	L2	36.9	48	11.1
16.47	L2	36.4	48	11.6
24.97	L2	36.0	48	12.0
25.18	L2	38.2	48	9.8
25.46	L2	36.2	48	11.8
25.76	L2	36.8	48	11.2
26.24	L2	39.1	48	8.9
26.58	L2	40.1	48	7.9
26.72	L2	40.0	48	8.0
27.14	L2	40.7	48	7.3

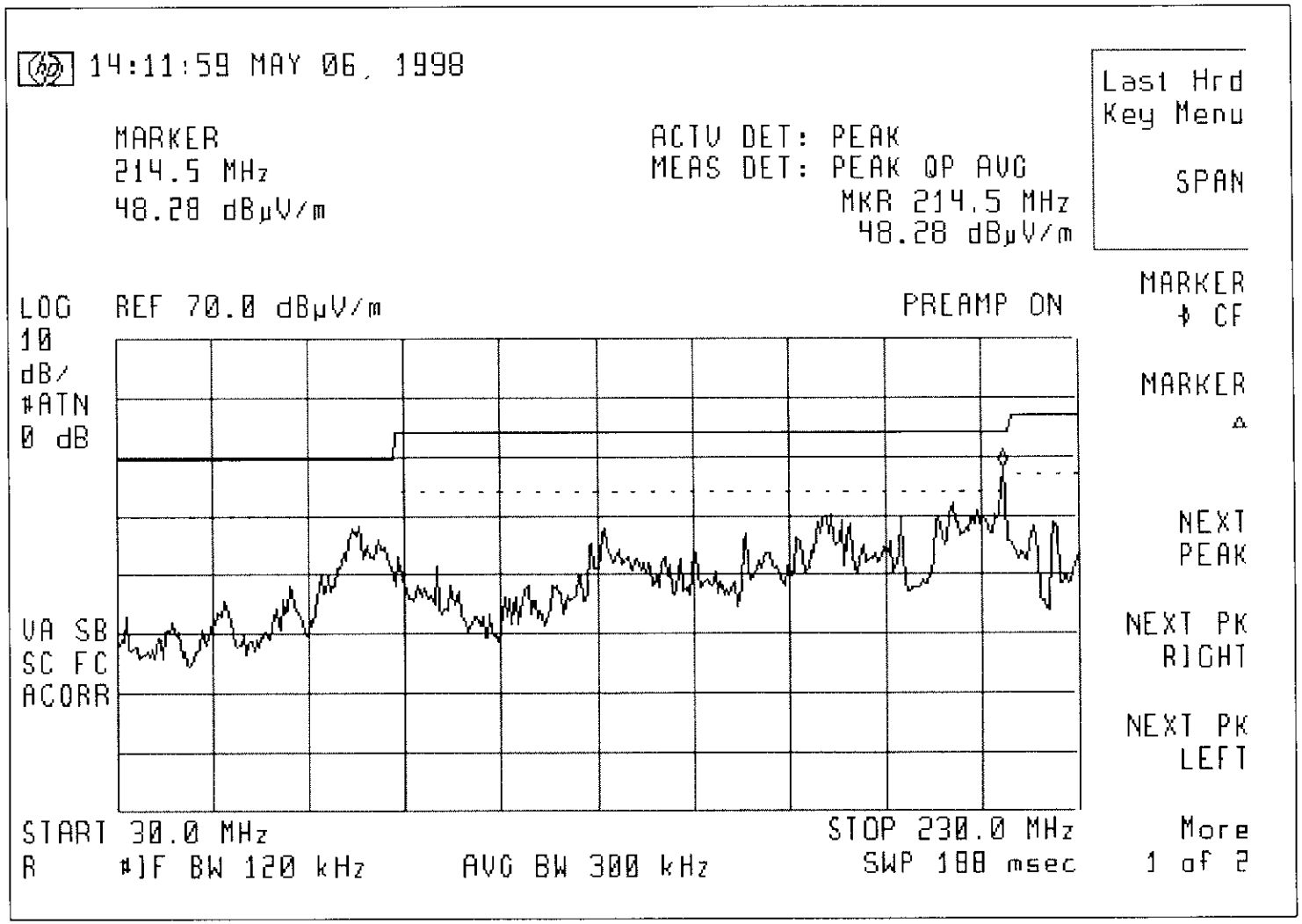
FCC ID : LXX-11

Channel 6 Rx Transceiver, emissions 30-230 MHz, vertical polarity



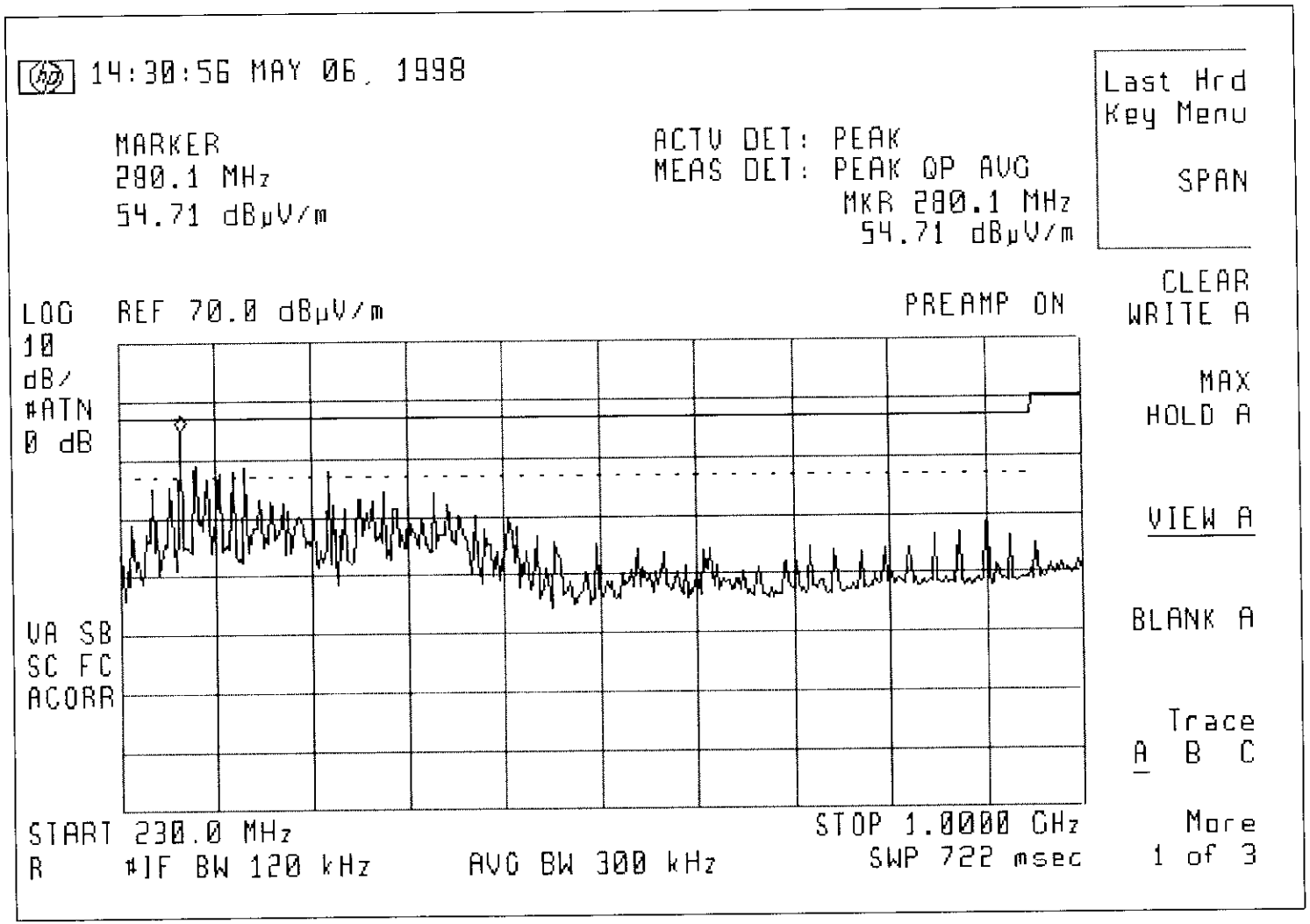
FCC ID : LXX-11

Channel 6 Rx Transceiver, emissions 30-230 MHz, horizontal polarity



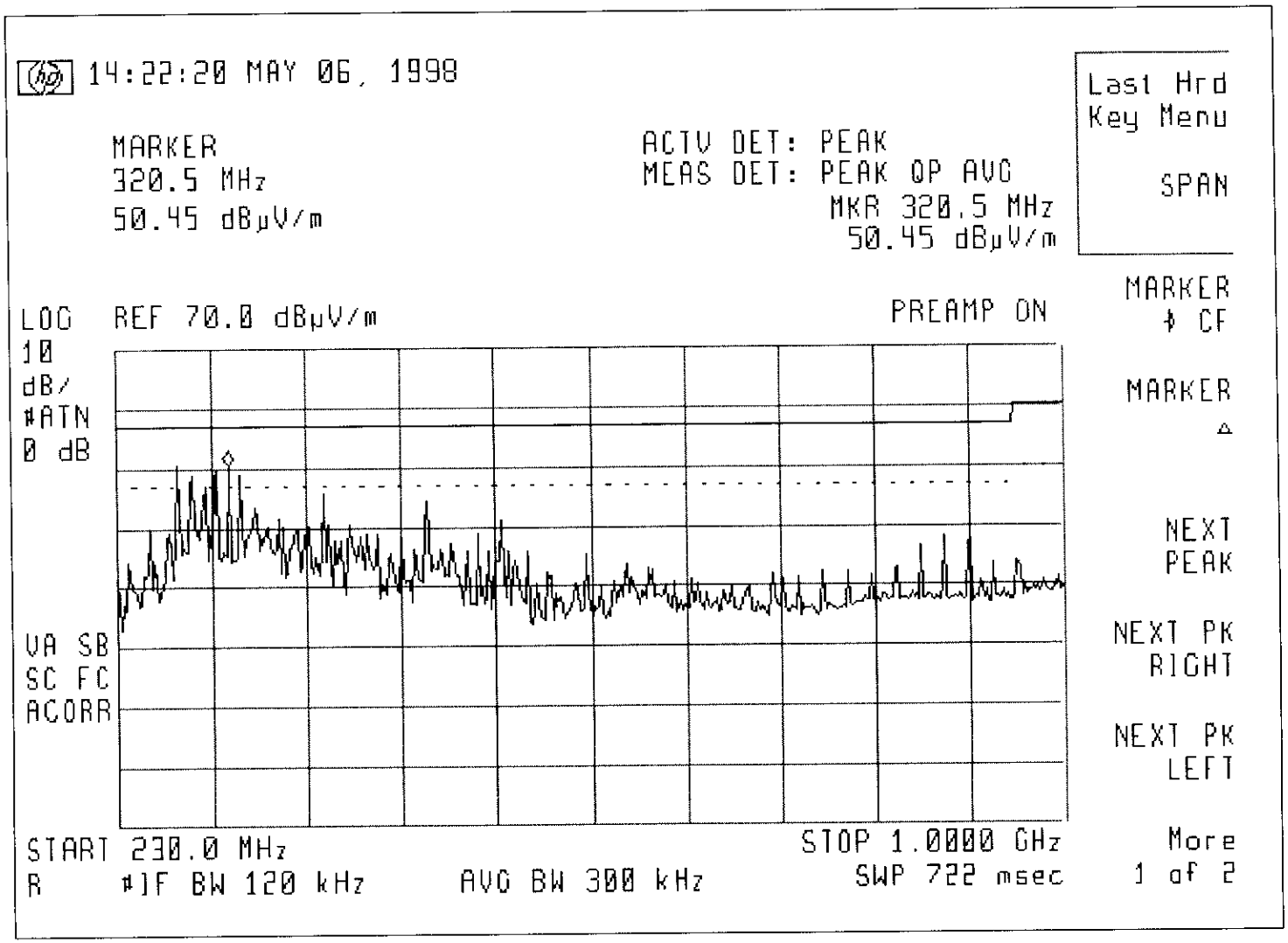
FCC ID : LXX-11

Channel 6 Rx Transceiver, emissions below1 GHz, horizontal polarity



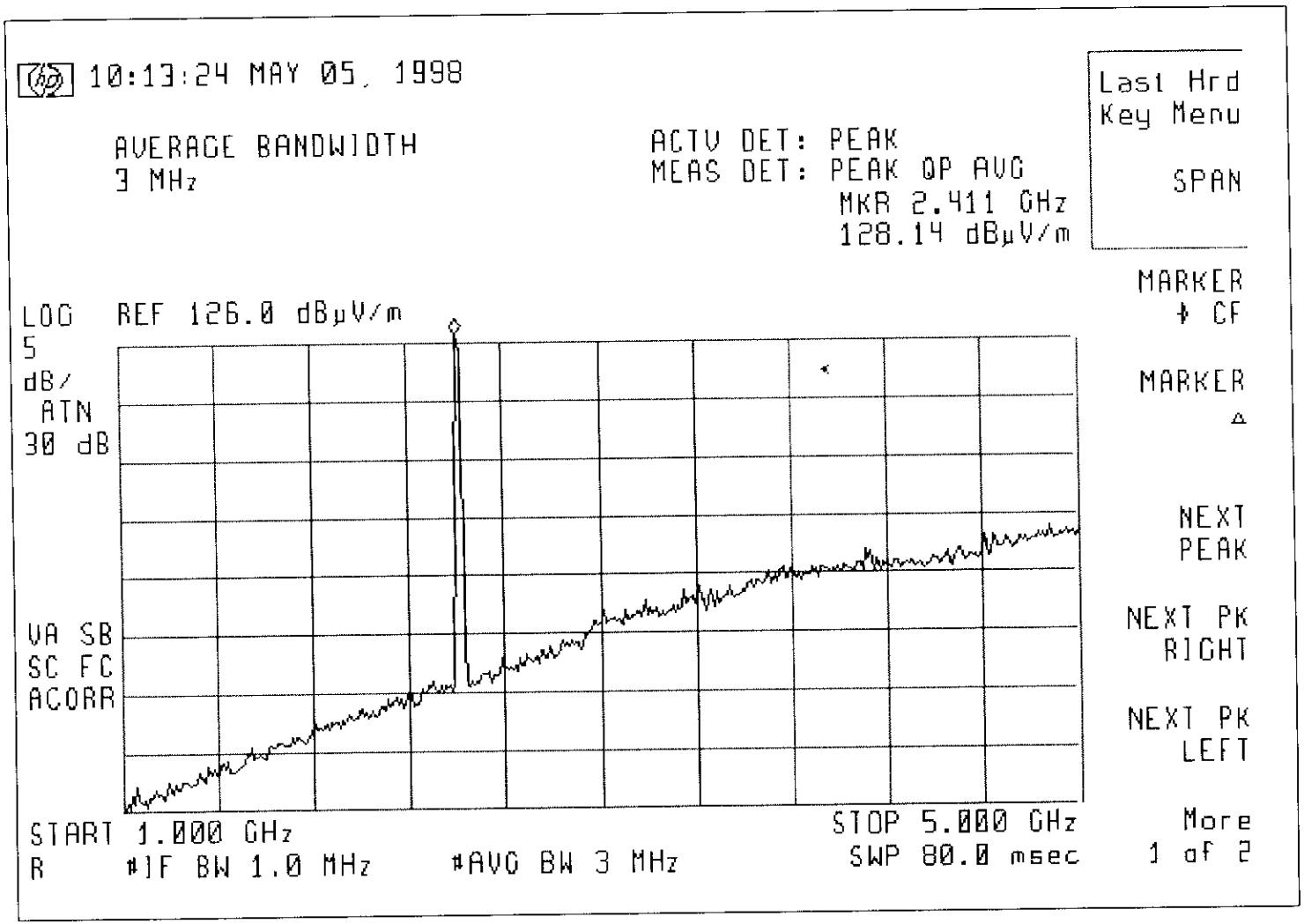
FCC ID : LXX-11

Channel 6 Rx Transceiver, emissions below1 GHz, Vertical polarity



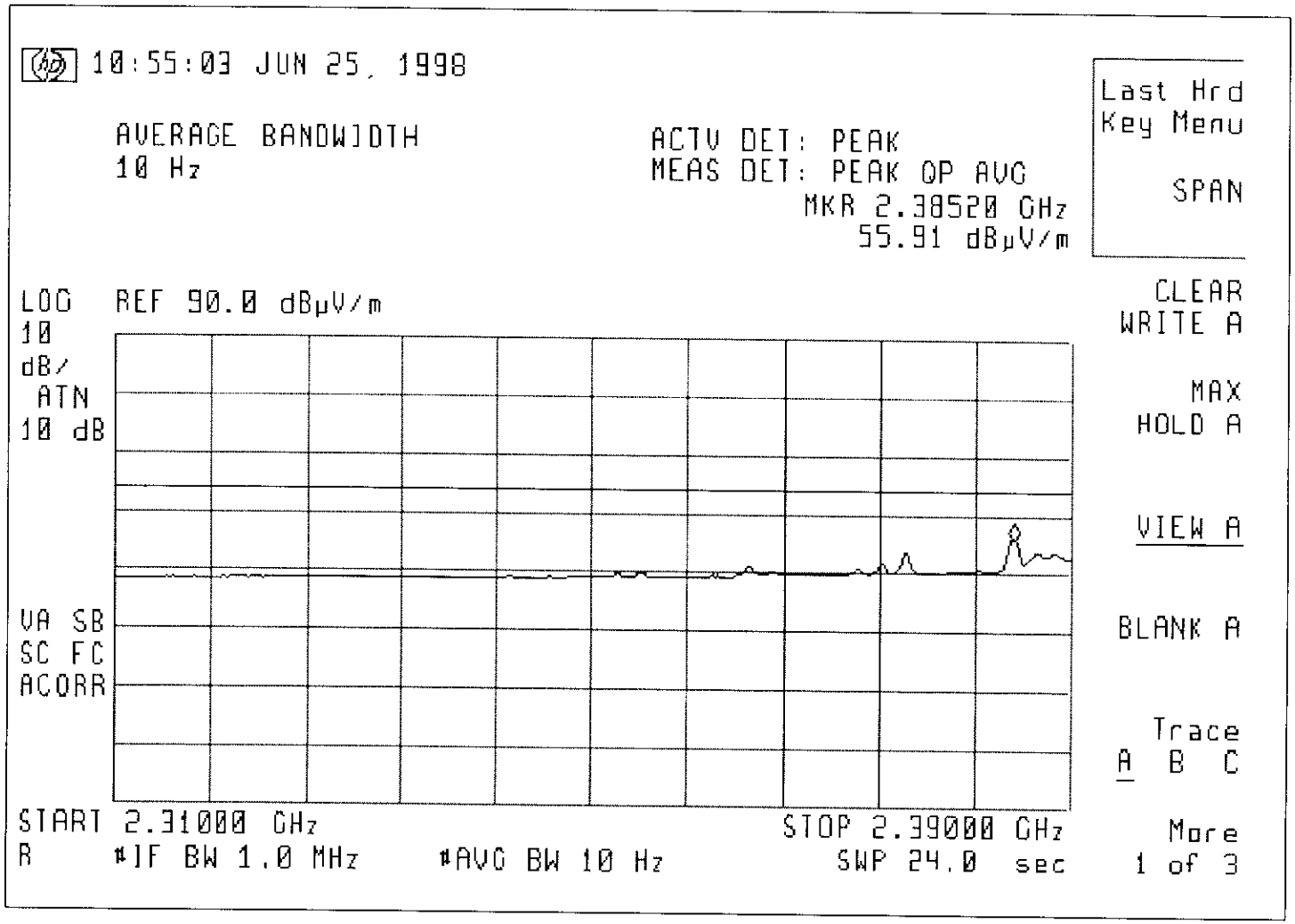
FCC ID : LXX-11

Channel 1 Transceiver, Tx mode, emissions 1 to 5 GHz, vertical Polarity



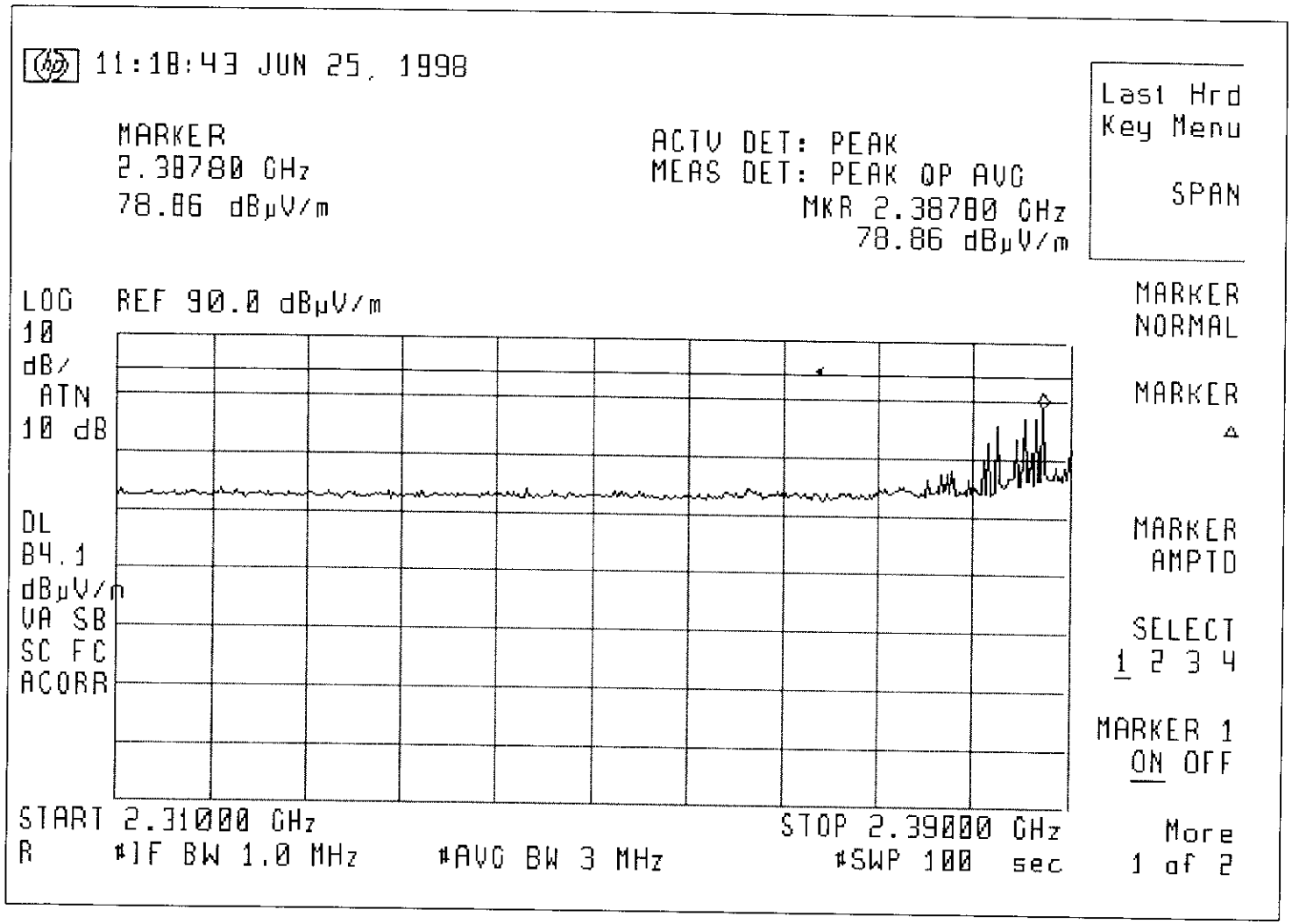
FCC ID : LXX-11

Channel 1 TX, emissions within adjacent restricted band, during continuous operation, Vertical polarity



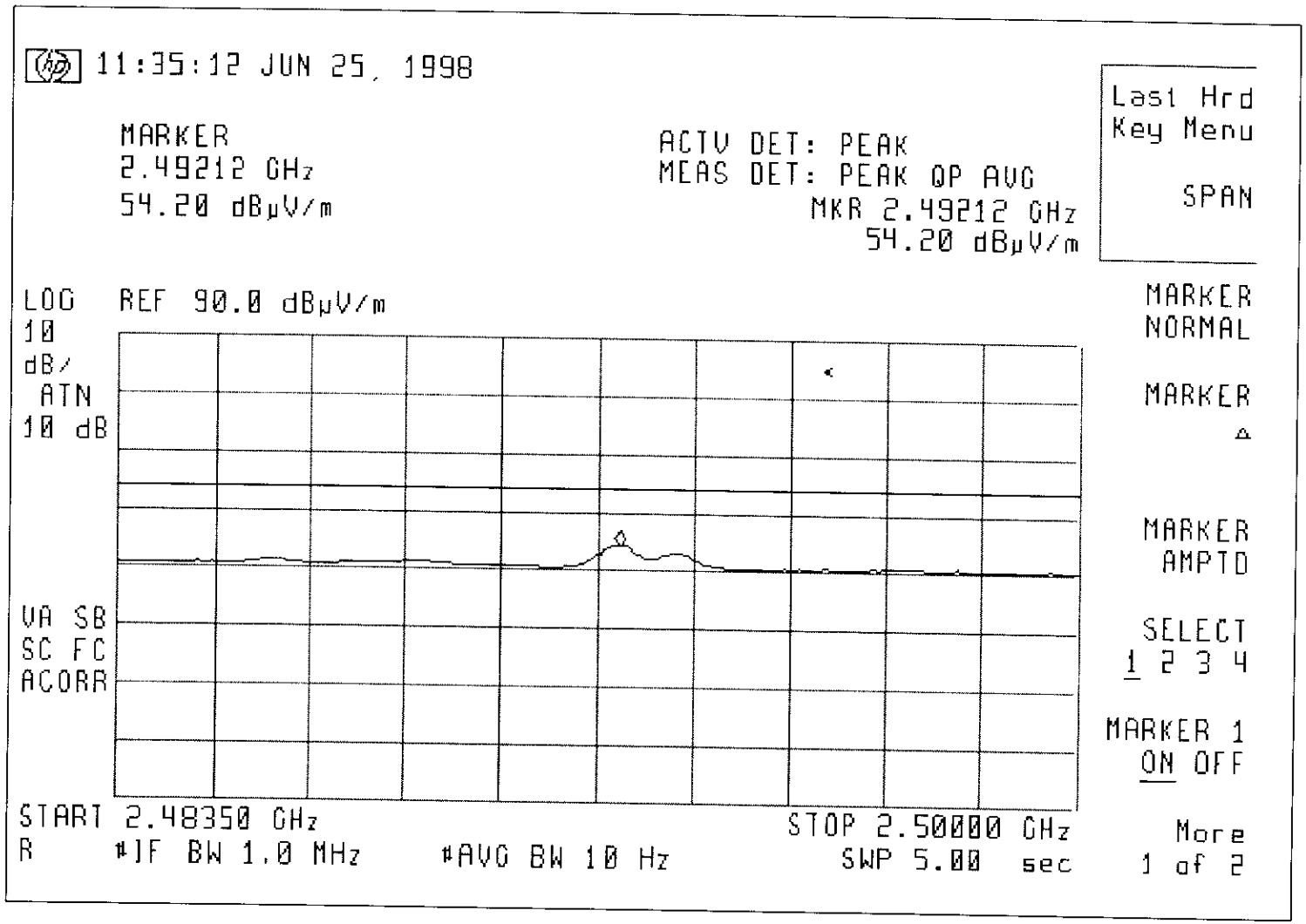
FCC ID : LXX-11

Channel 1 TX, emissions within adjacent restricted band, during TDD operation, Vertical Polarity



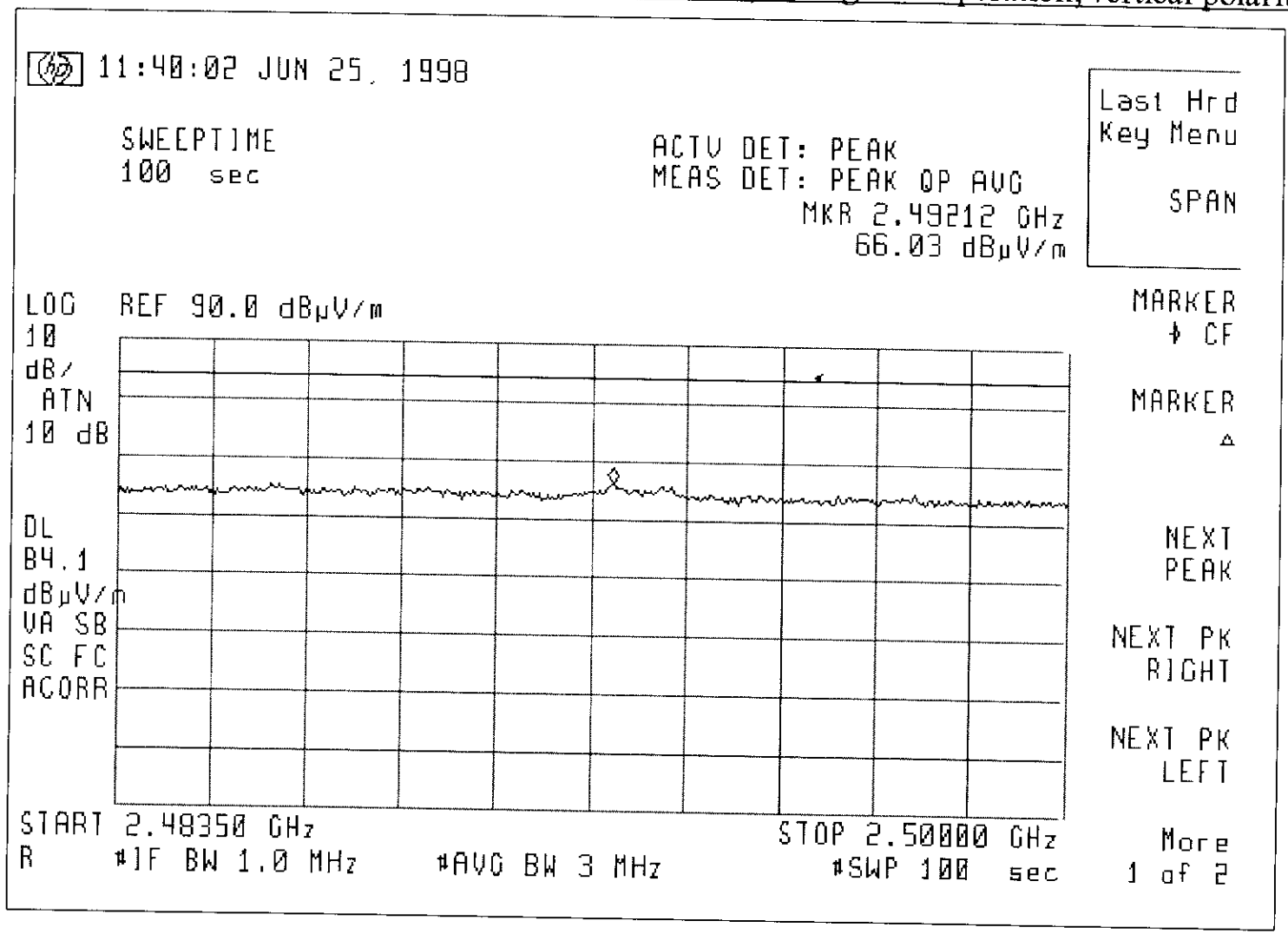
FCC ID : LXX-11

Channel 6 TX, emissions within adjacent restricted band, during continuous operation, Vertical Polarity



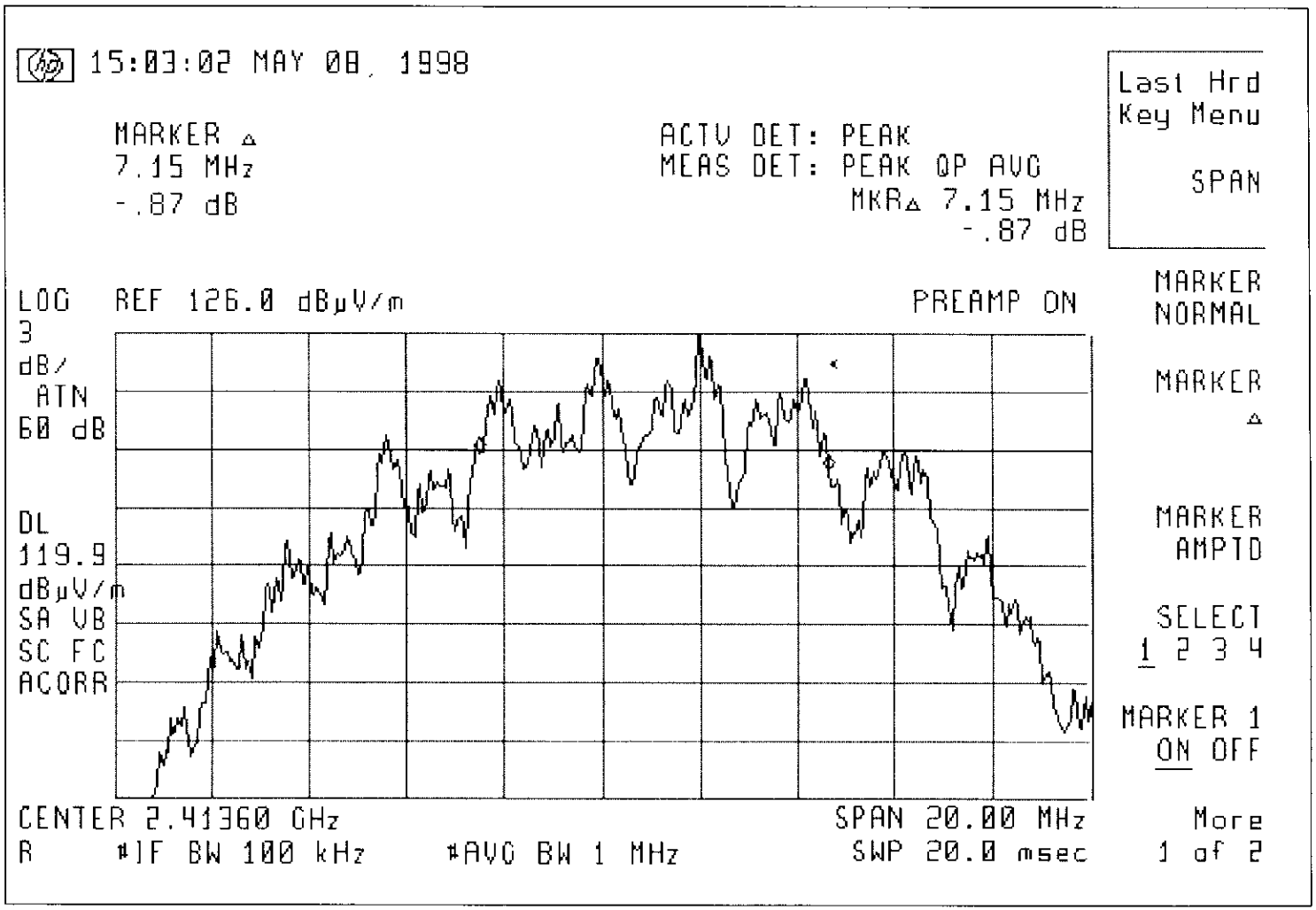
FCC ID : LXX-11

Channel 6 TX, emissions within adjacent restricted band, during TDD operation, vertical polarity



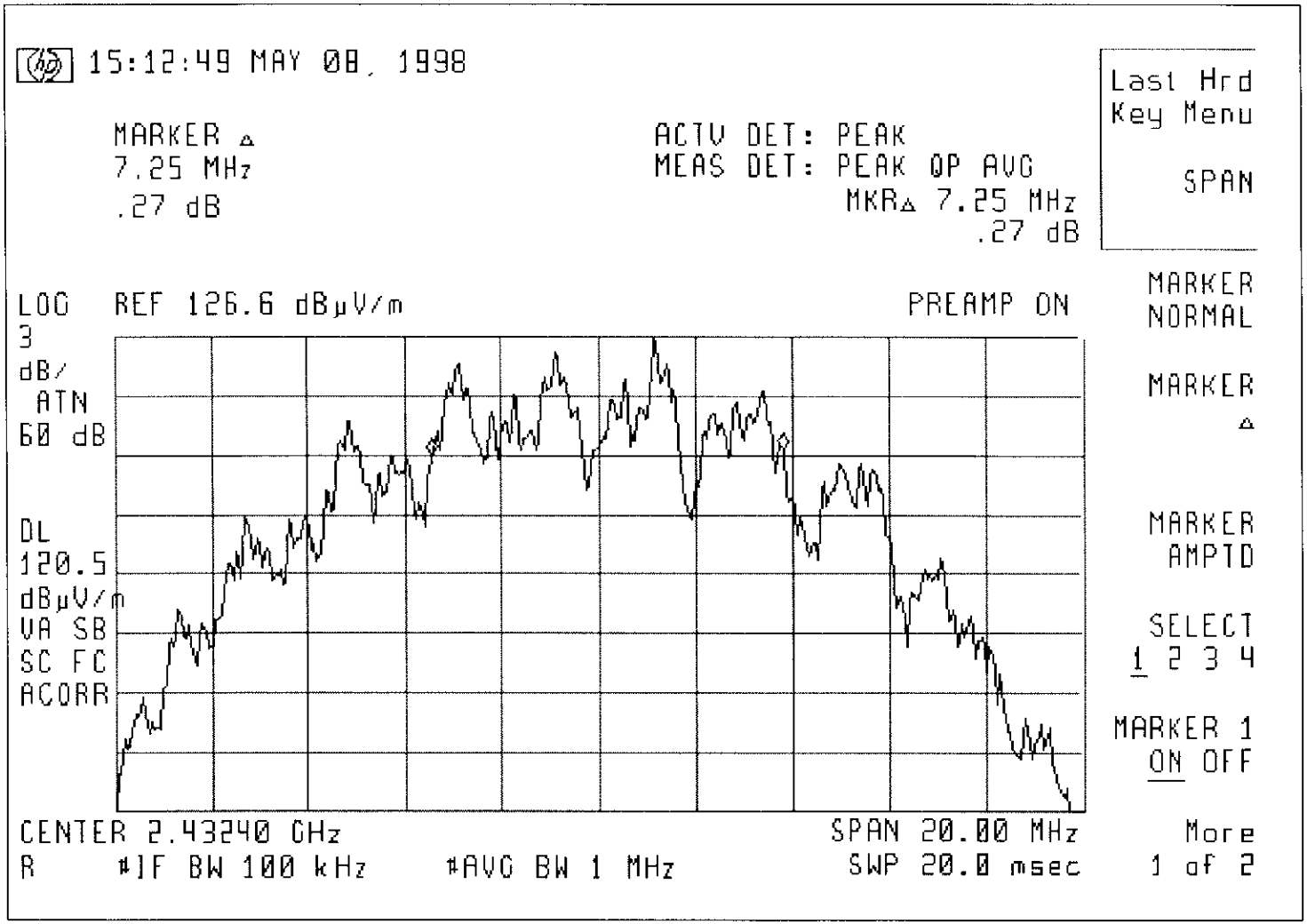
FCC ID : LXX-11

Channel 1 TX, 6dB occupied bandwidth



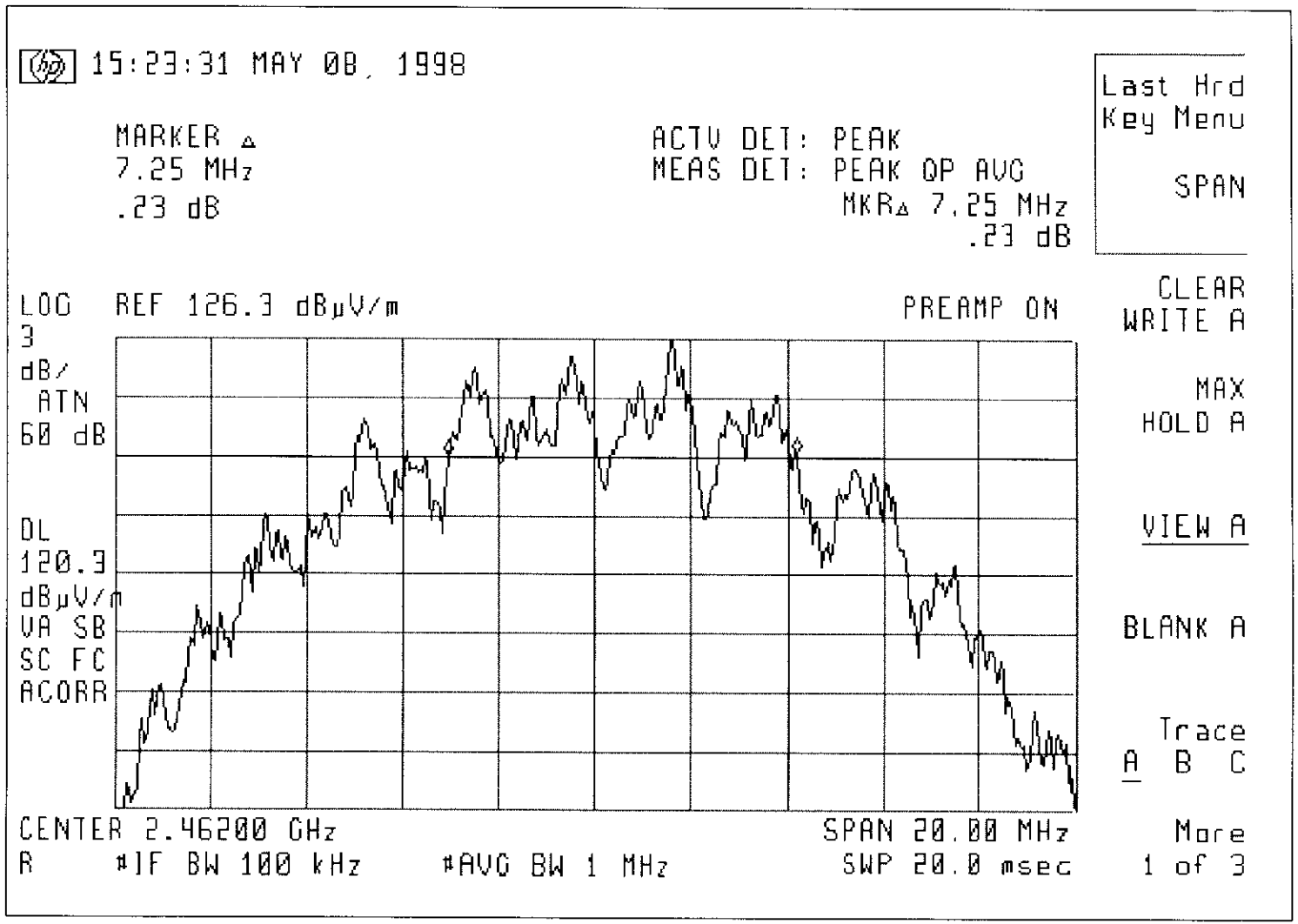
FCC ID : LXX-11

Channel 3 TX, 6dB occupied bandwidth



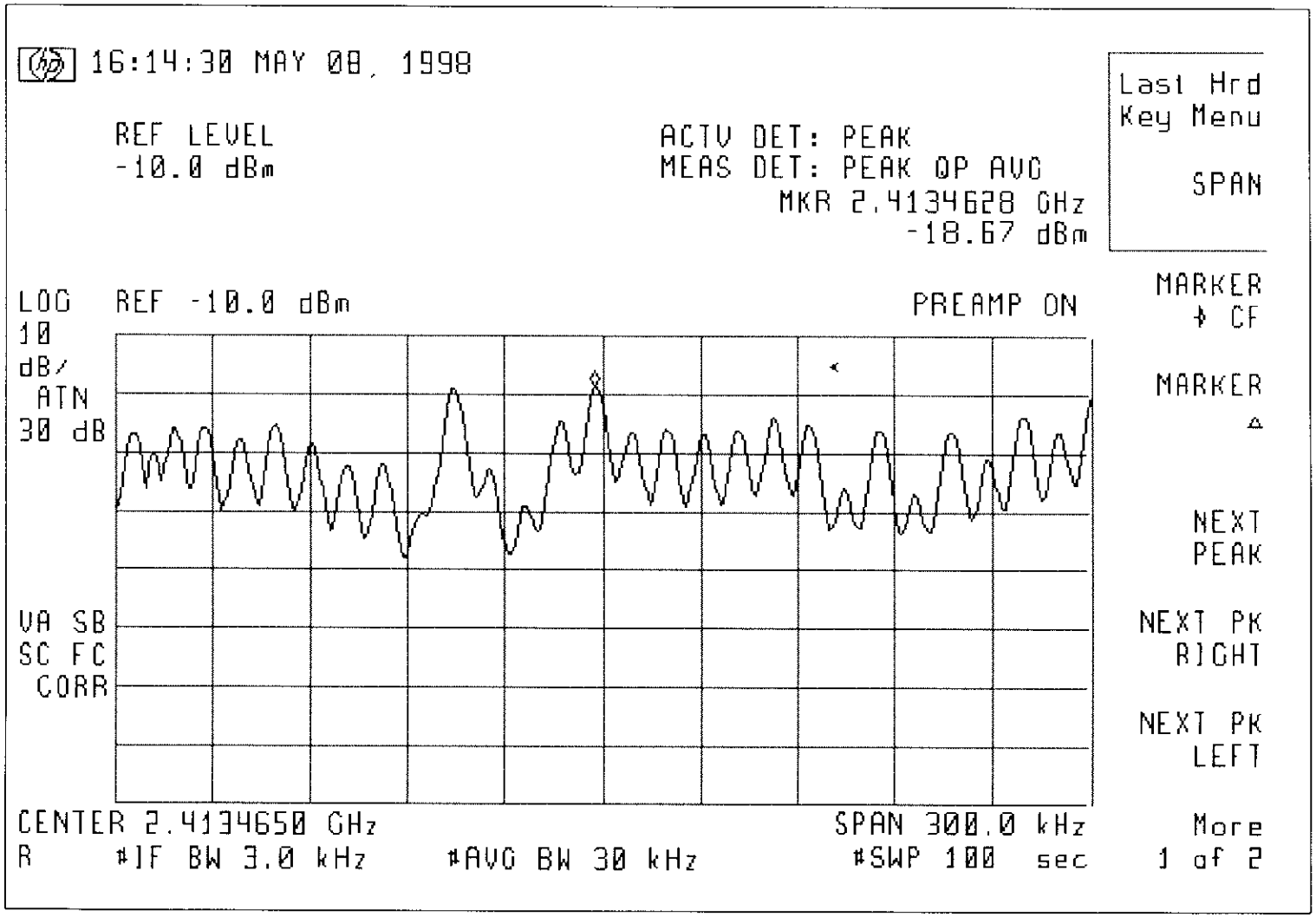
FCC ID : LXX-11

Channel 6 TX, 6dB occupied bandwidth



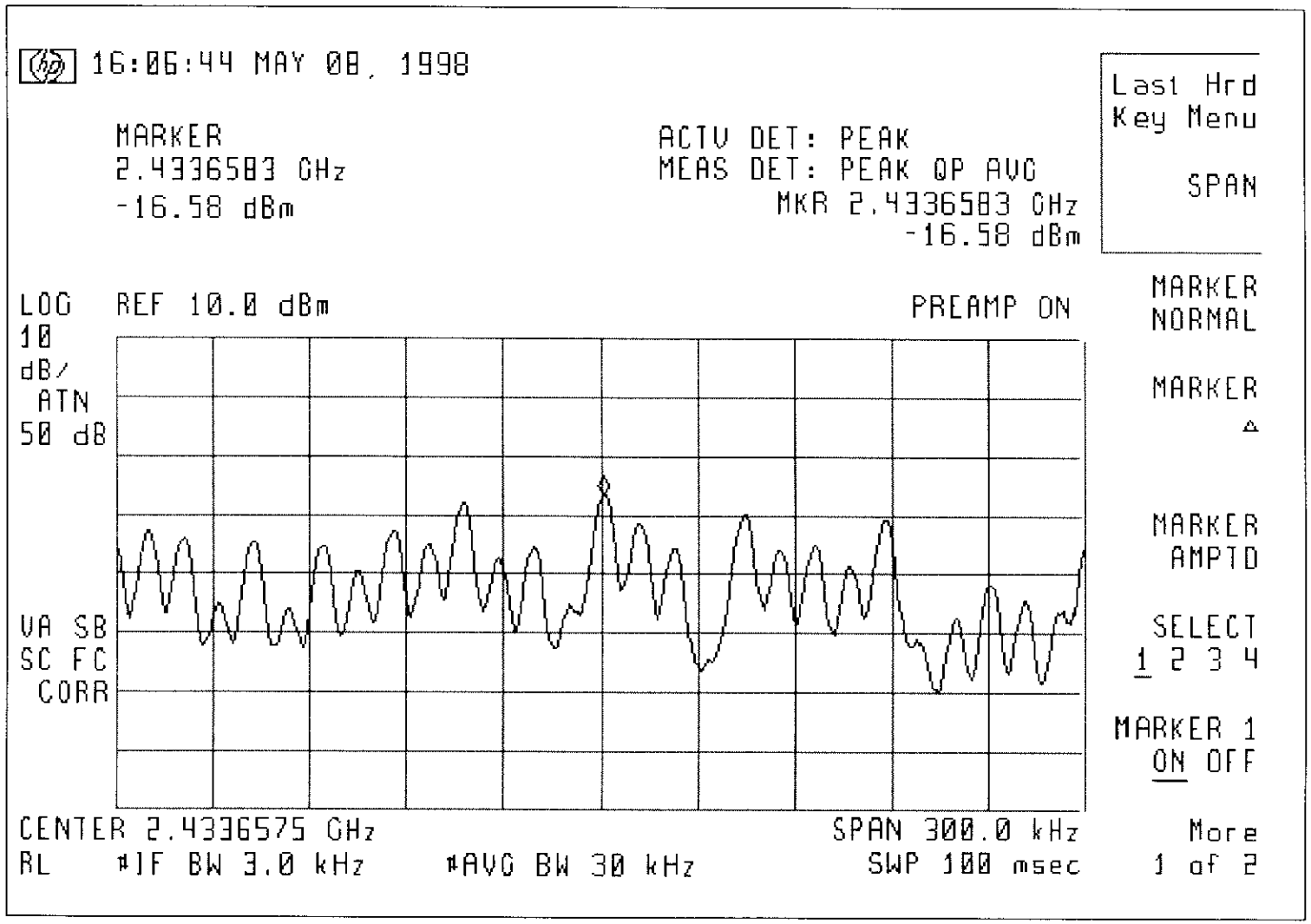
FCC ID : LXX-11

3 Kilohertz Spectral Density; channel 1



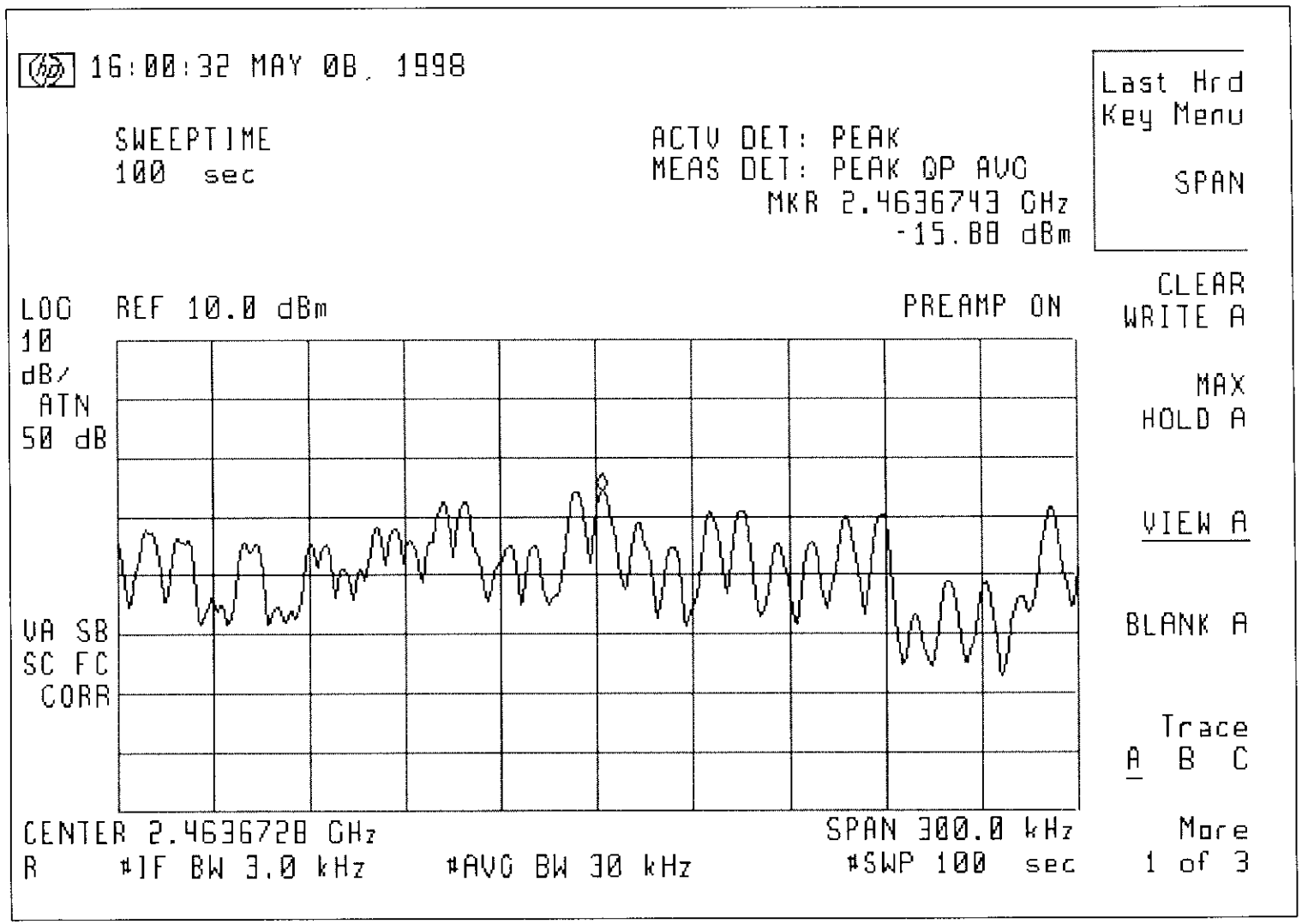
FCC ID : LXX-11

3 Kilohertz Spectral Density; channel 3



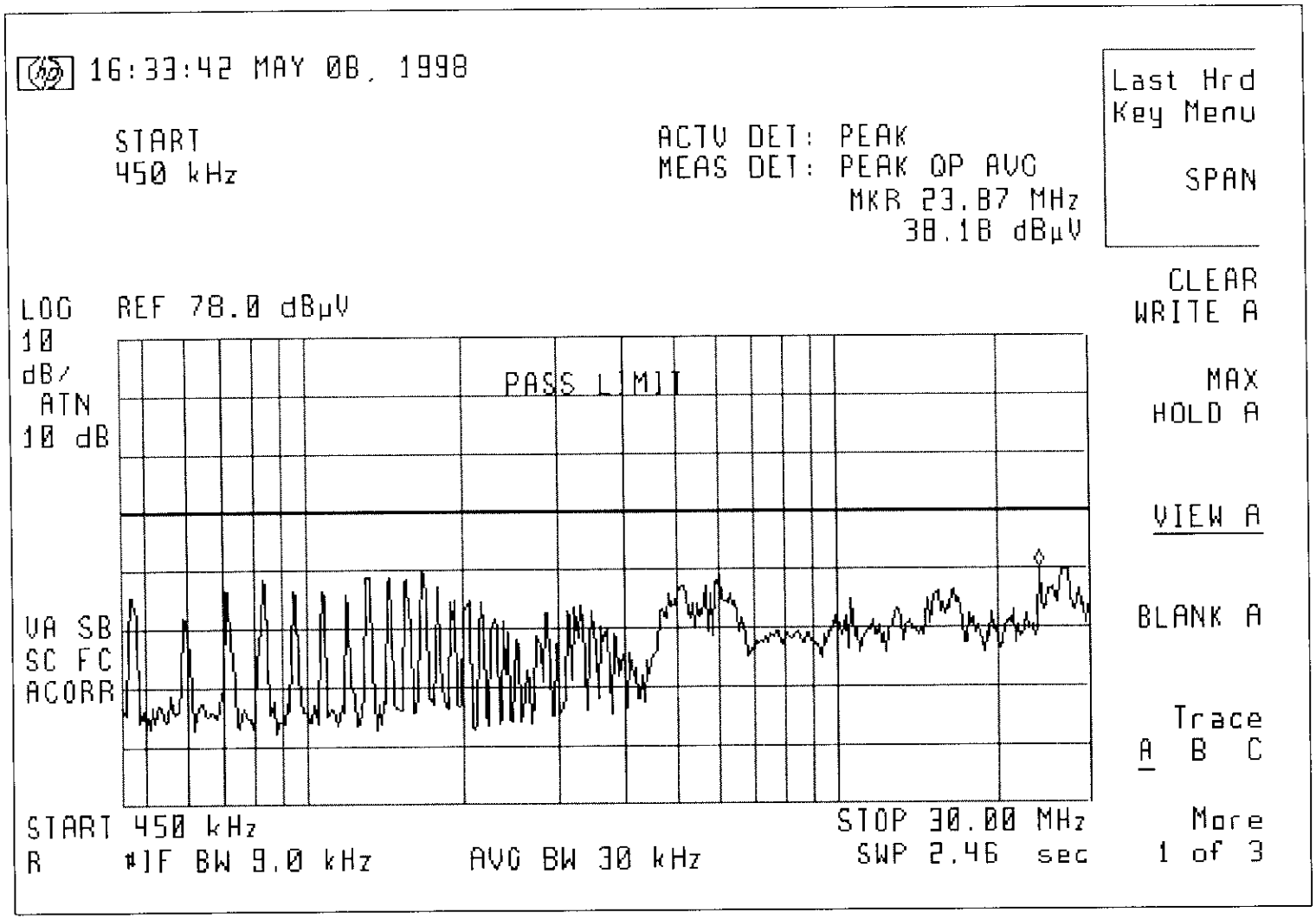
FCC ID : LXX-11

3 Kilohertz Spectral Density; channel 6



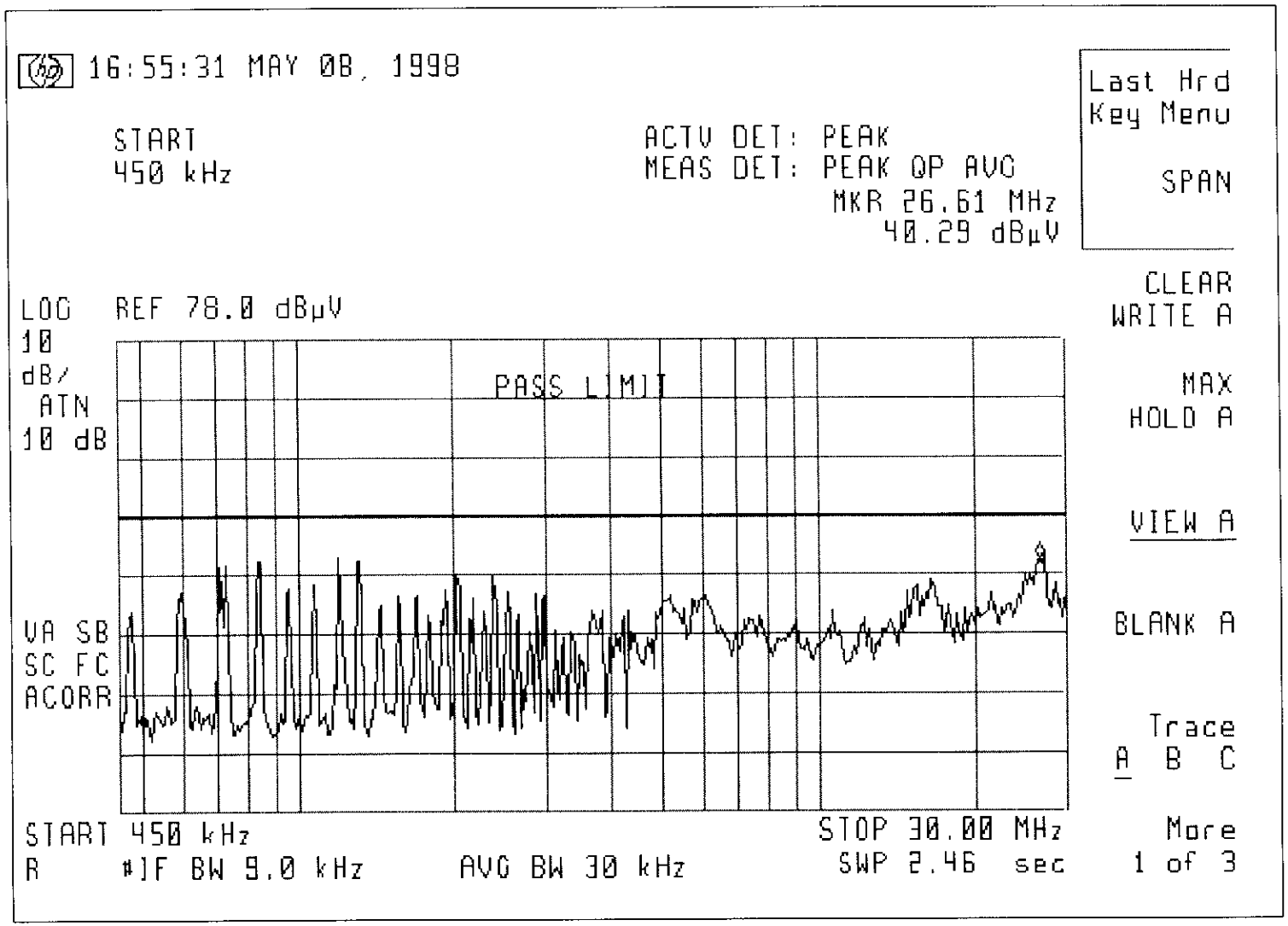
FCC ID : LXX-11

Conducted Emissions, Line 1, Channel 1 TX



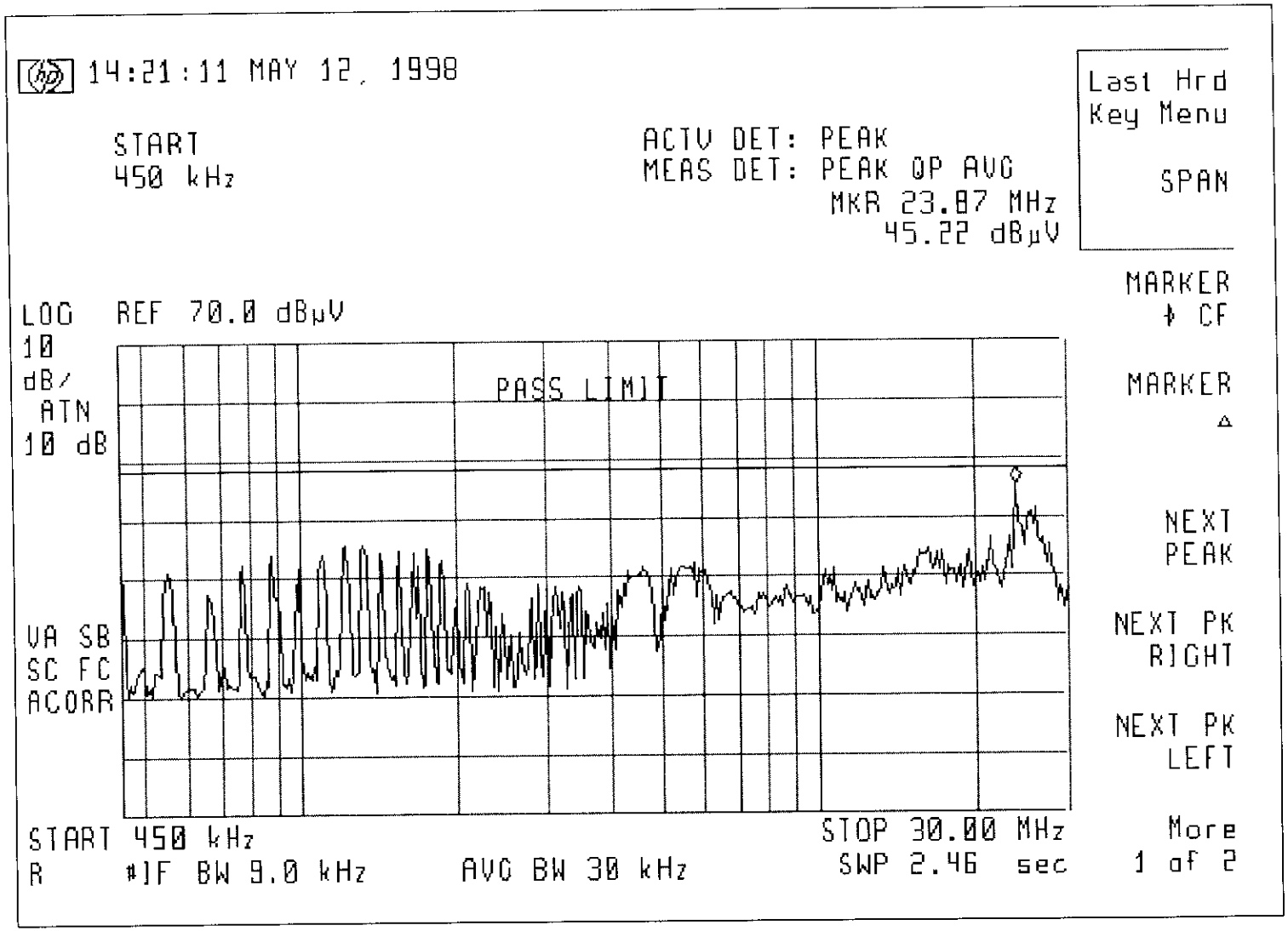
FCC ID : LXX-11

Conducted Emissions, Line 2, Channel 1 TX



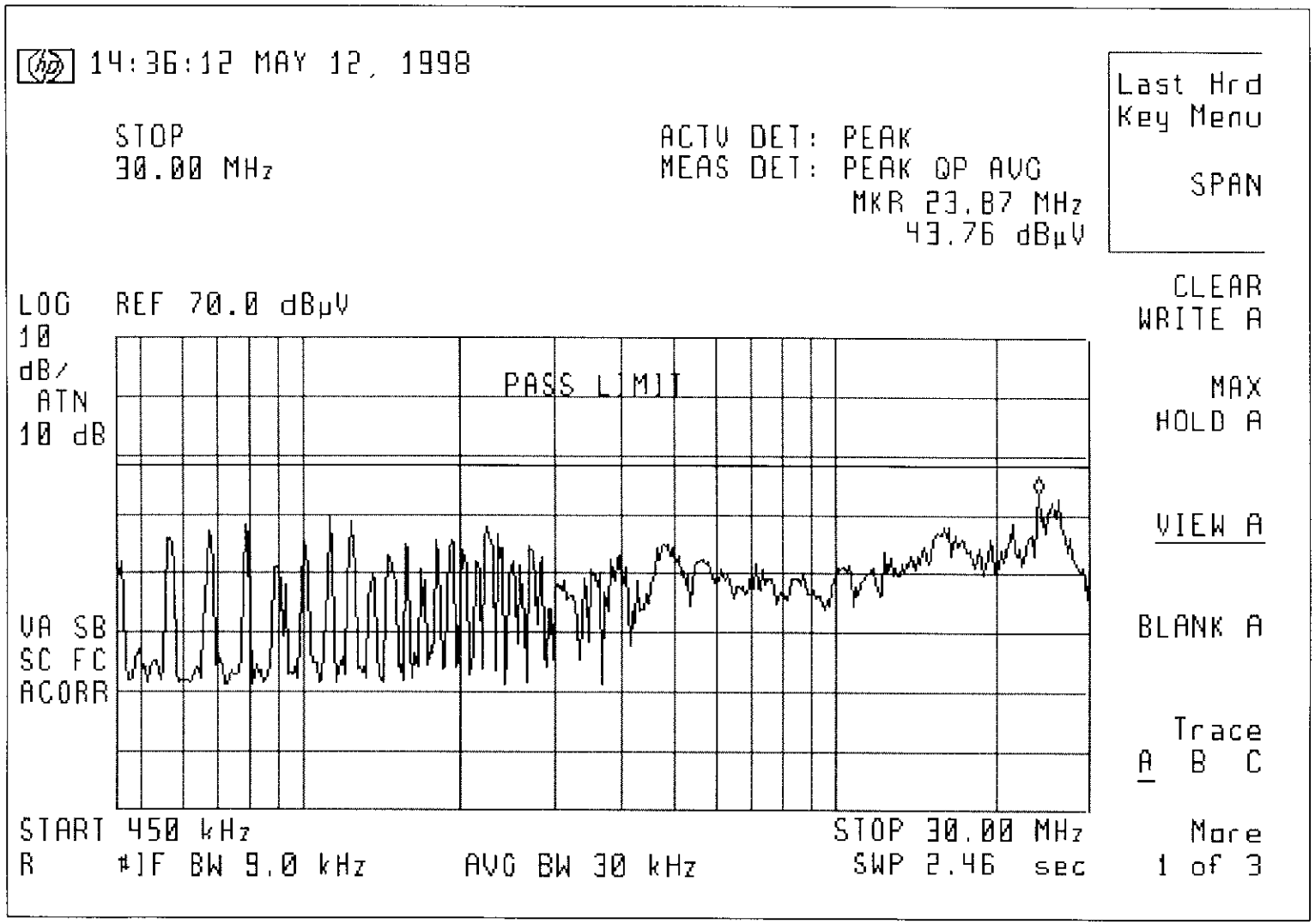
FCC ID : LXX-11

Conducted Emissions, Line 1, Channel 3 Rx



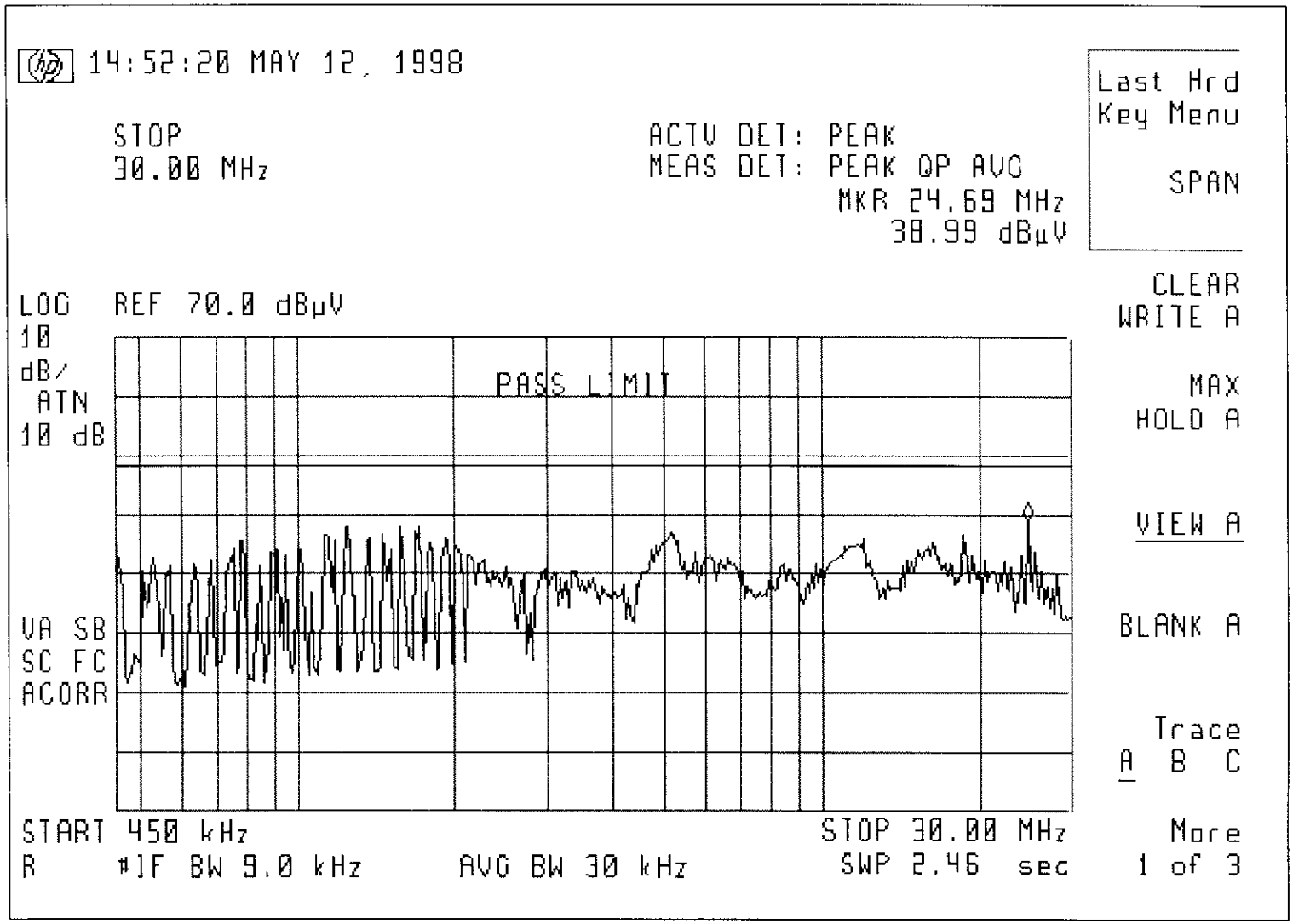
FCC ID : LXX-11

Conducted Emissions, Line 2, Channel 3 Rx



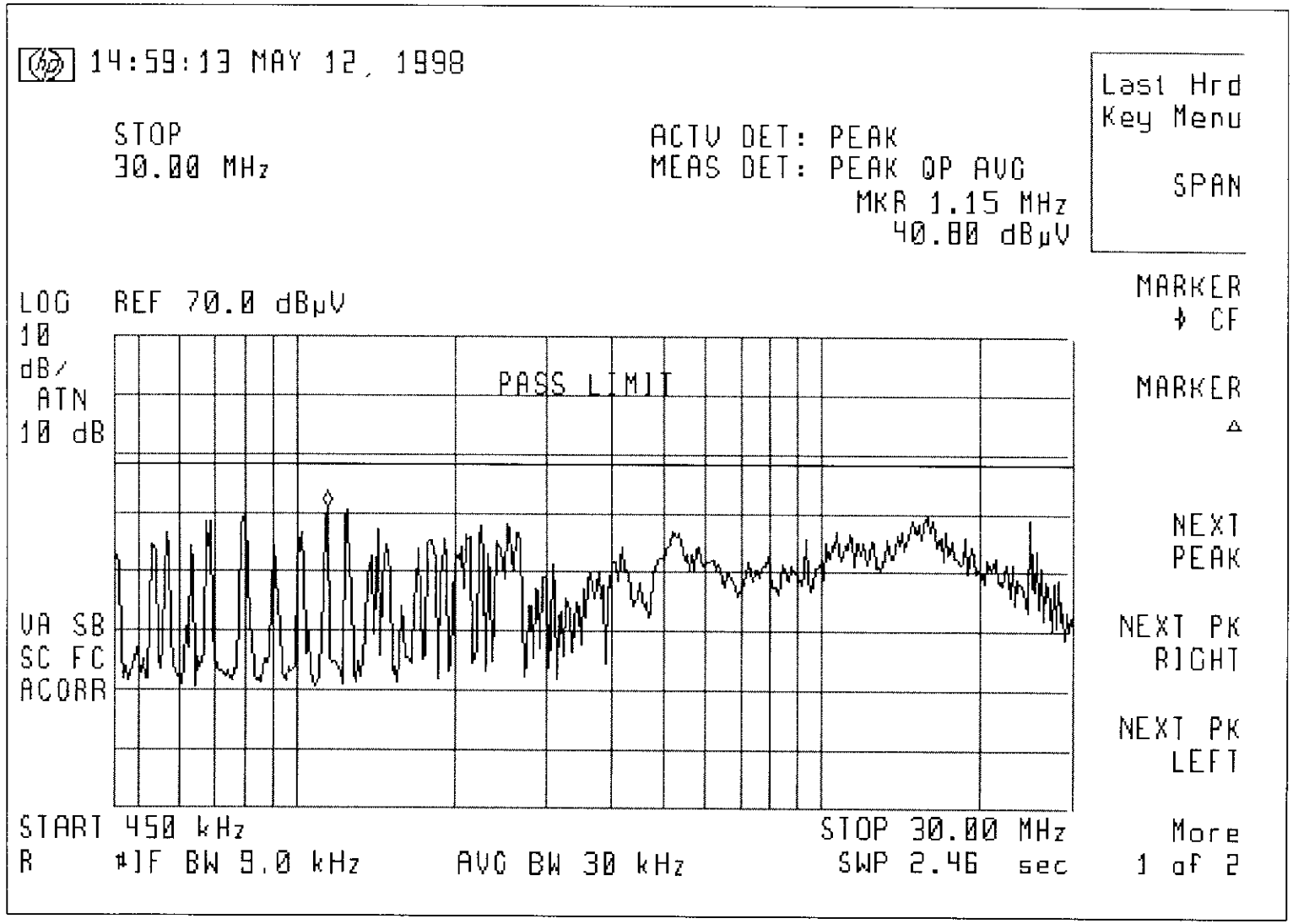
FCC ID : LXX-11

Conducted Emissions, Line 1, Channel 3 TX, TDD mode



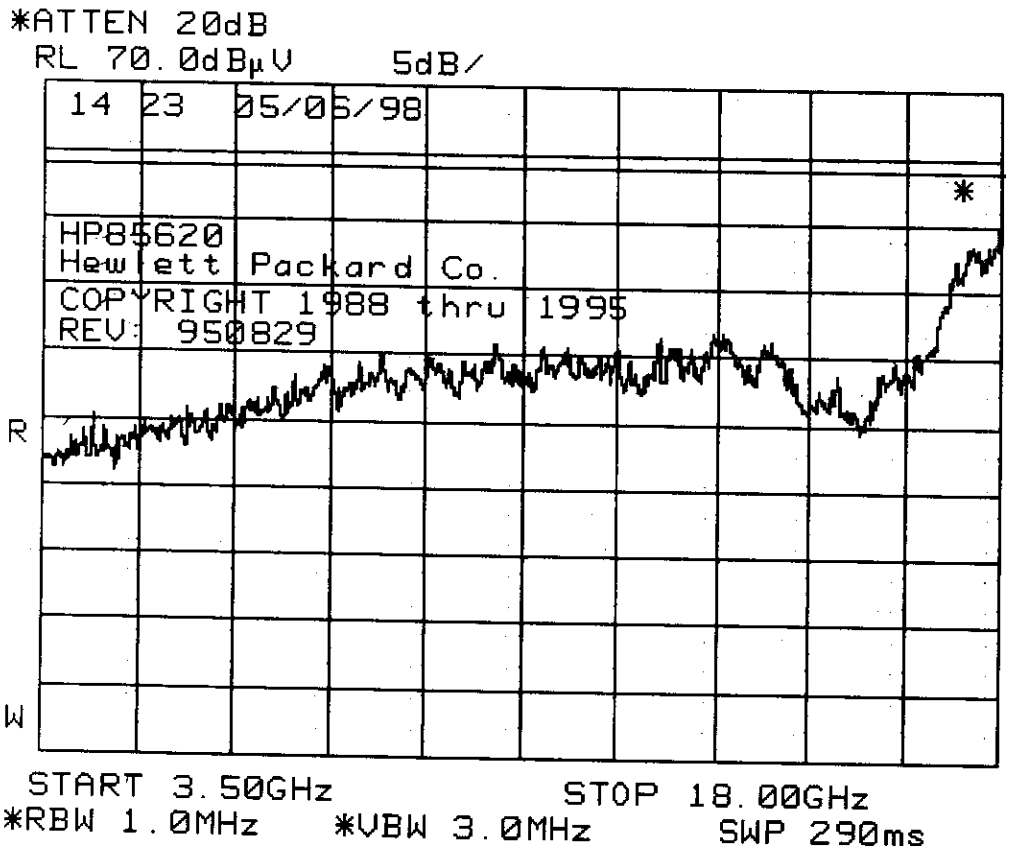
FCC ID : LXX-11

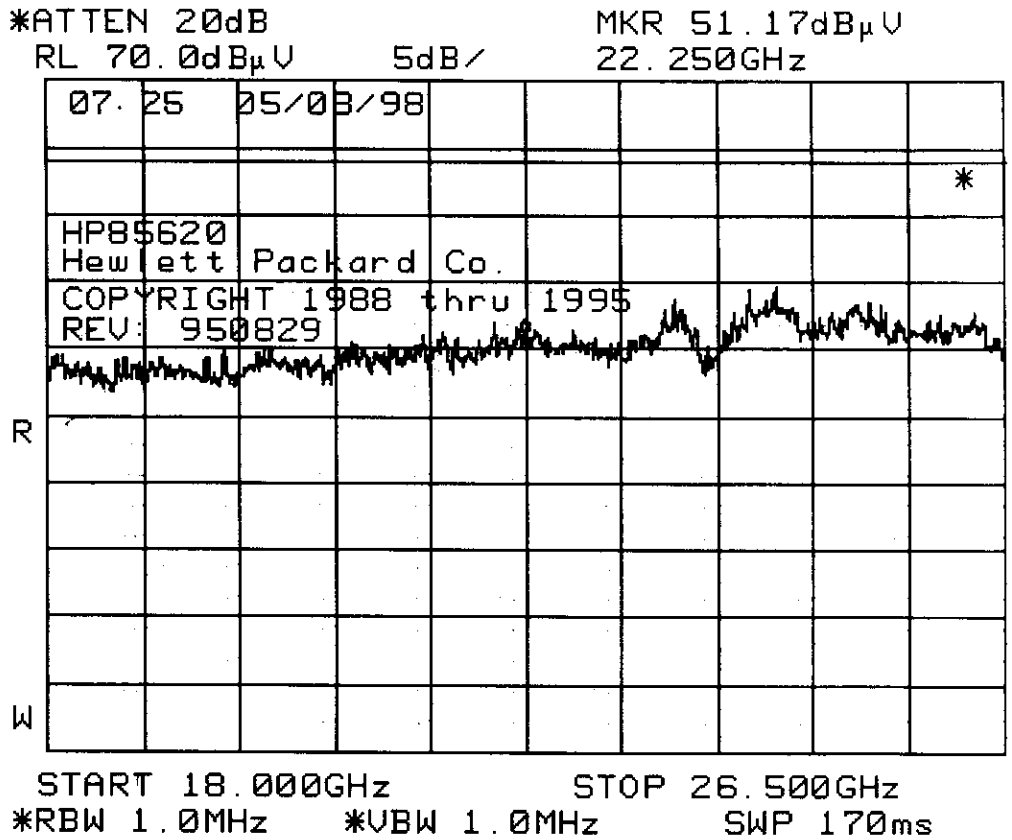
Conducted Emissions, Line 1, Channel 3 TX, TDD Mode



FCC ID : LXX-11

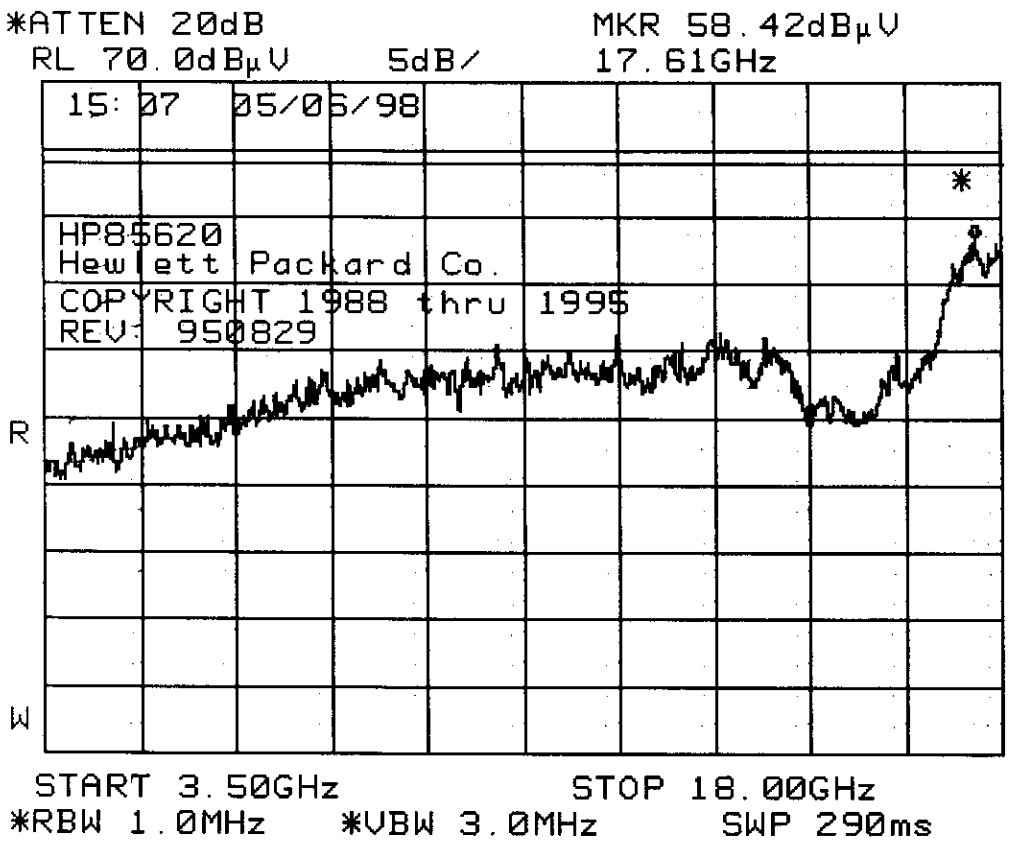
Channel 1 Emissions, second harmonic and above, measured on boresite at 1 meter.

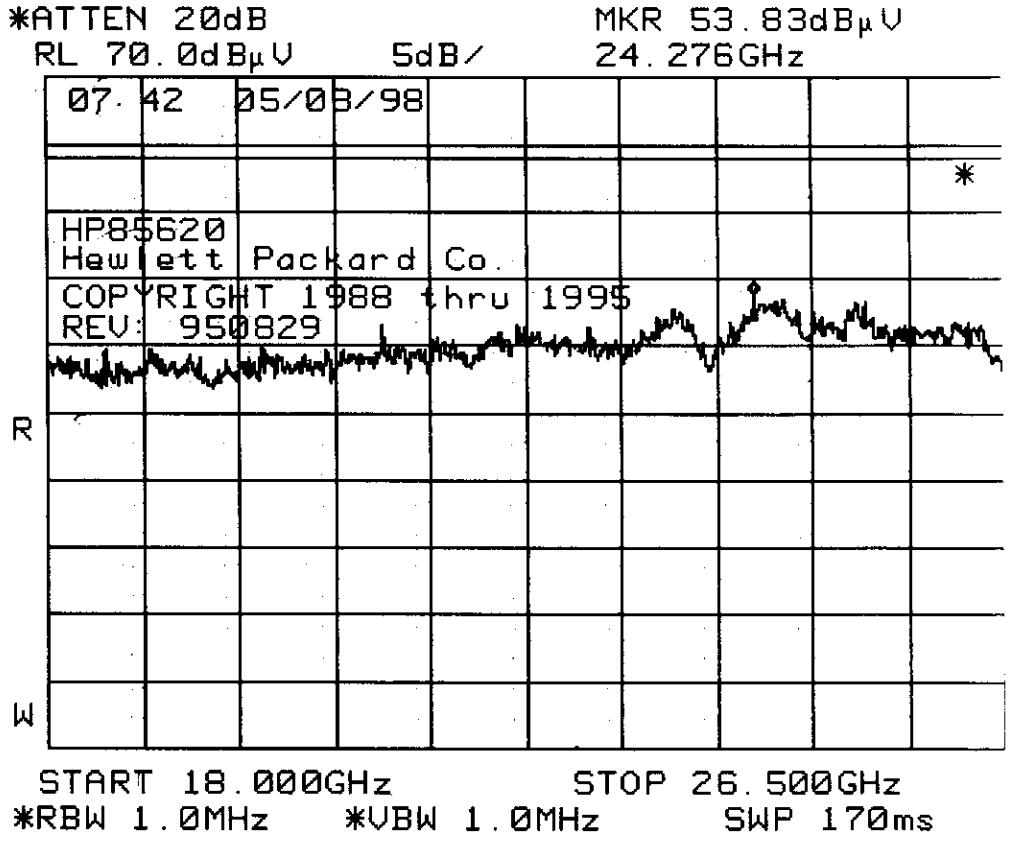




FCC ID : LXX-11

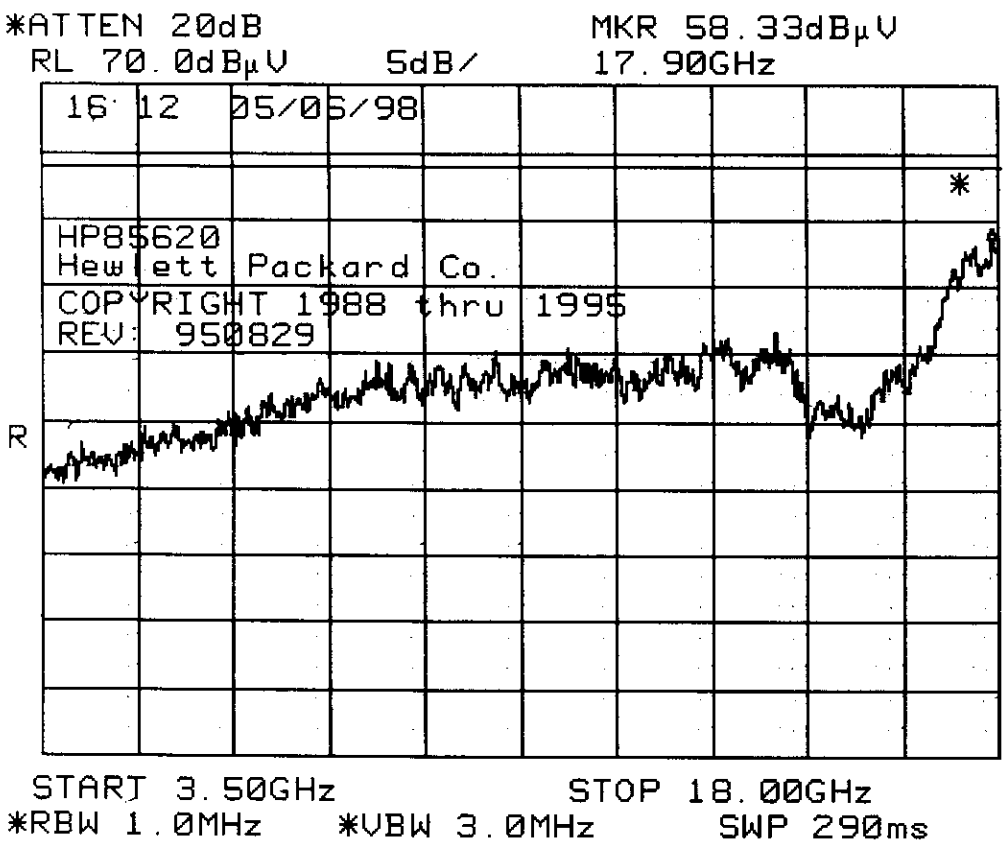
Channel 3 Emissions, second harmonic and above, measured on boresite at 1 meter.

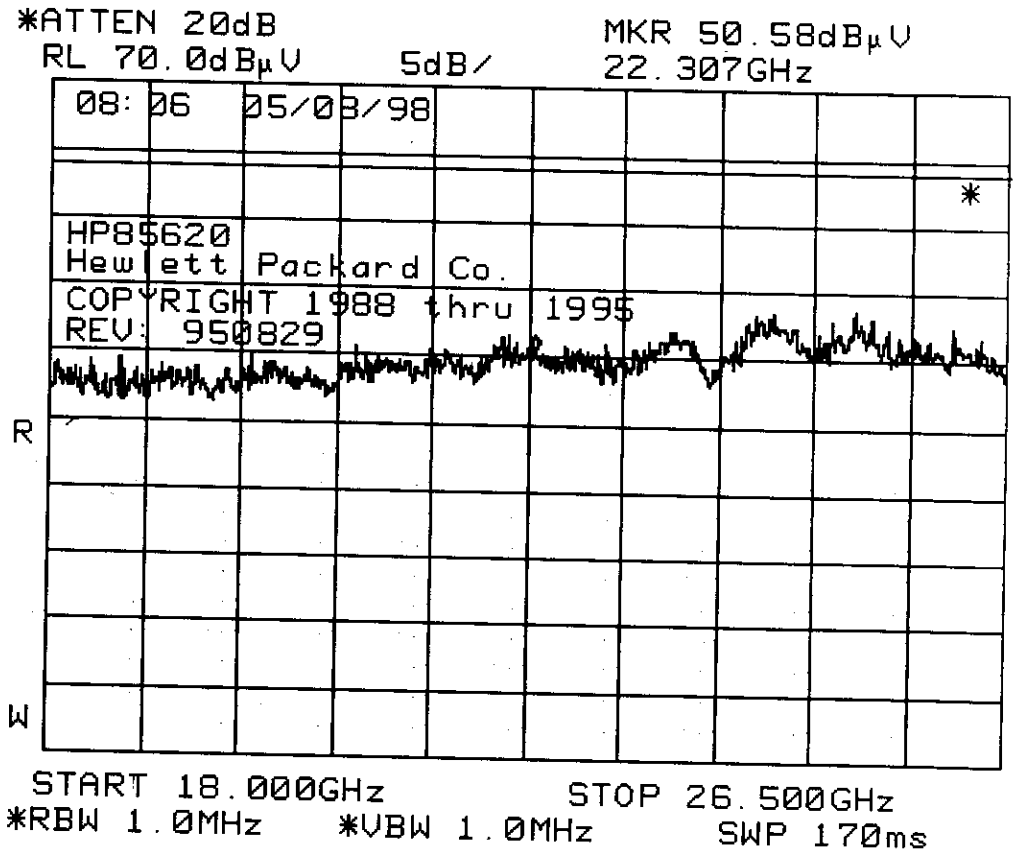




FCC ID : LXX-11

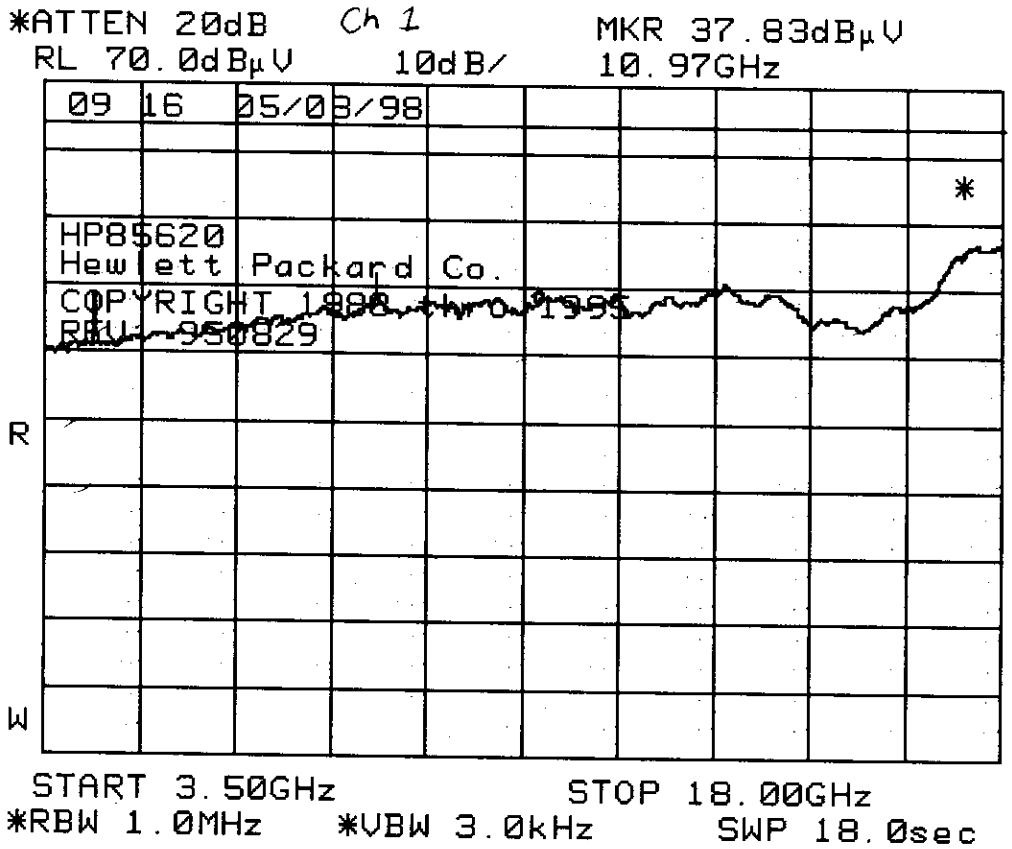
Channel 6 Emissions, second harmonic and above, measured on boresite at 1 meter.





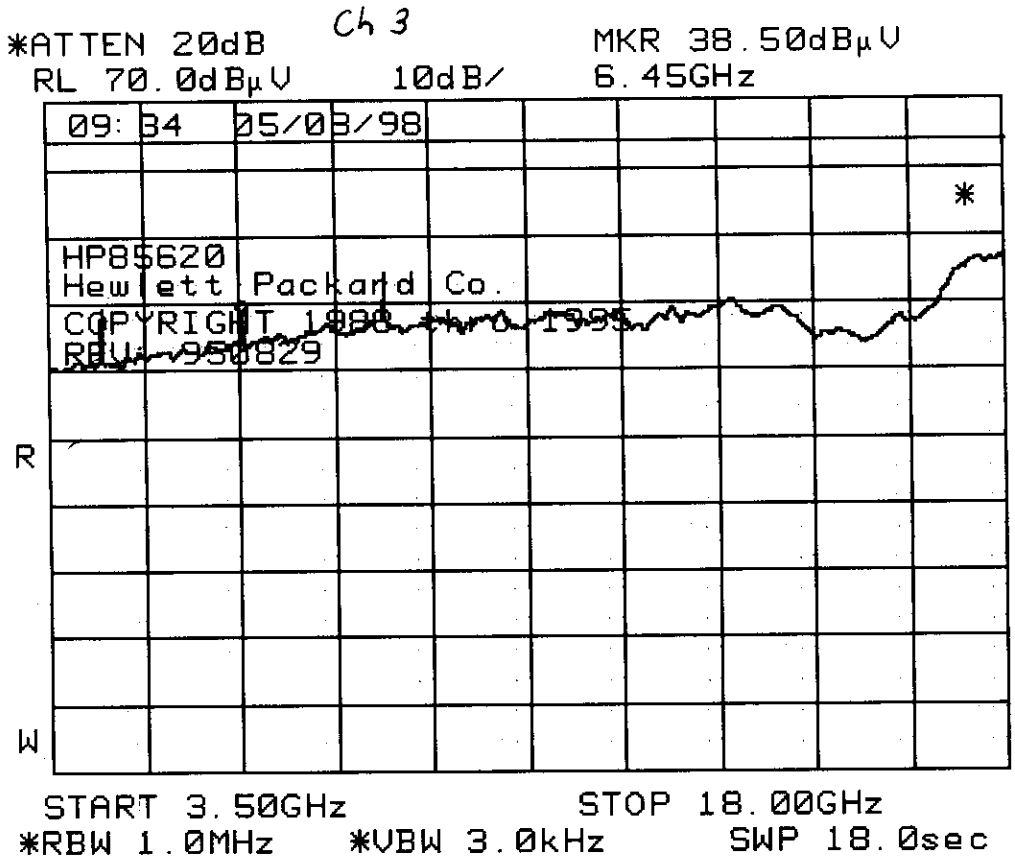
FCC ID : LXX-11

Channel 1 Emissions, second harmonic and above, measured from the system perimeter at 1 meter.



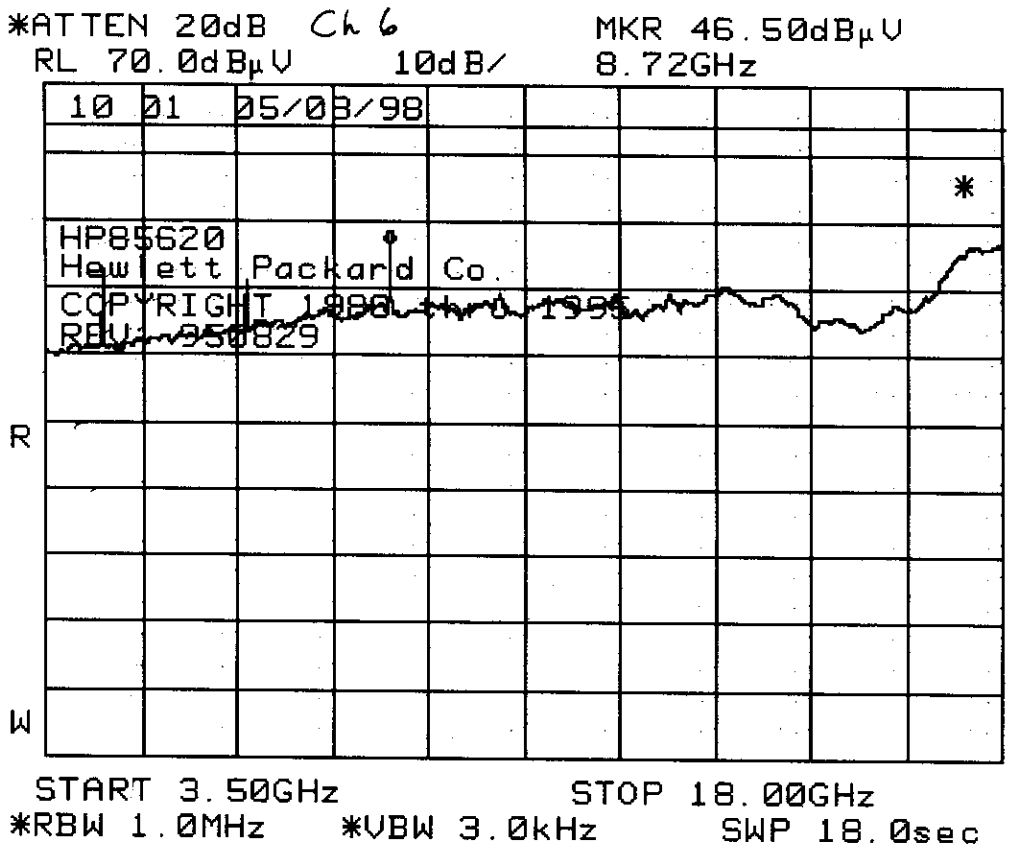
FCC ID : LXX-11

Channel 3 Emissions, second harmonic and above, measured from the system perimeter at 1 meter.



FCC ID : LXX-11

Channel 6 Emissions, second harmonic and above, measured from the system perimeter at 1 meter.



APPENDIX D:

FCC 15.247(e) Jamming Margin Test

PROJECT:	TTI Wireless Jamming Margin Test
COMPANY CONTACTS:	Pete Bonk , President Dragan Zivkovic, Director of Engineering 17830 Englewood Dr. #1 Cleveland, OH 44130 Phone (440)-243-9033 FAX: (440)-243-9045
L.S. RESEARCH CONTACTS:	Brian Petted, Vice President,.Engineering Bill Steinike, Business Manager Phone: (414) 375-4400 FAX: (414) 375-4248 R&D FAX: (414)-375-6731
FILE:	TTI_JM.doc

1.0 Scope

This report presents the test procedure, test configuration and test data associated with a FCC Part 15.247 (e) Jamming Margin test for the indirect measurement of processing gain.

2.0 Applicable Reference Documents.

[1] "Operation within the bands 902-928 MHz, 2400-2483.5, and 5725-5850 MHz" Title 47 Part 15 section 247 (e) Code of Federal Regulations. (47 CFR 15.247).

[2] "Report and Order: Amendment of Parts 2 and 15 of the Commission's Rules Regarding Spread Spectrum Transmitters. Appendix C: 'Guidance on Measurements for Direct Sequence Spread Spectrum Systems" FCC 97-114. ET Docket No. 96-8, RM-8435, RM-8608, RM-8609.

[3] "The Treatment of Uncertainty in EMC Measurements" NAMAS, NIS 81 Edition 1, May 1994. NAMAS Executive, National Physical Laboratory, Teddington Middlesex, TW11 0LW, England.

[4] " HFA3860 Direct Sequence Spread Spectrum Baseband Processor" Harris Corporation Semiconductor Sector Preliminary Data Sheet, Melbourne FL, June 1997.

[5] " M-ary Orthogonal Keying BER Curve", Communication from Harris Corporation to L.S. Research, Inc.

3.0 Test Background and Procedure.

According to FCC regulations [1], a direct sequence spread spectrum system must have a processing gain, G_p of at least 10 dB. Compliance to this requirement can be shown by demonstrating a relative bit-error-ratio (BER) performance improvement (and corresponding signal to noise ratio per symbol improvement of at least 10 dB) between the case where spread spectrum processes (coding, modulation) are engaged relative to the processes being bypassed. In some practical systems, the spread spectrum processing cannot simply be bypassed. In these cases, the processing gain can be indirectly measured by a jamming margin test [2].

The processing gain is related to the jamming margin as follows [2]:

$$G_p = BER_{REFERENCE} \leftrightarrow \left(\frac{S}{N}\right)_{output} + \left(\frac{J}{S}\right) + L_{system}$$

Where $BER_{REFERENCE}$ is the reference bit error ratio with its corresponding, theoretical output signal to noise ratio per symbol, $(S/N)_{output}$, (J/S) is the jamming margin (jamming signal power relative to desired signal power), and L_{system} are the system implementation losses.

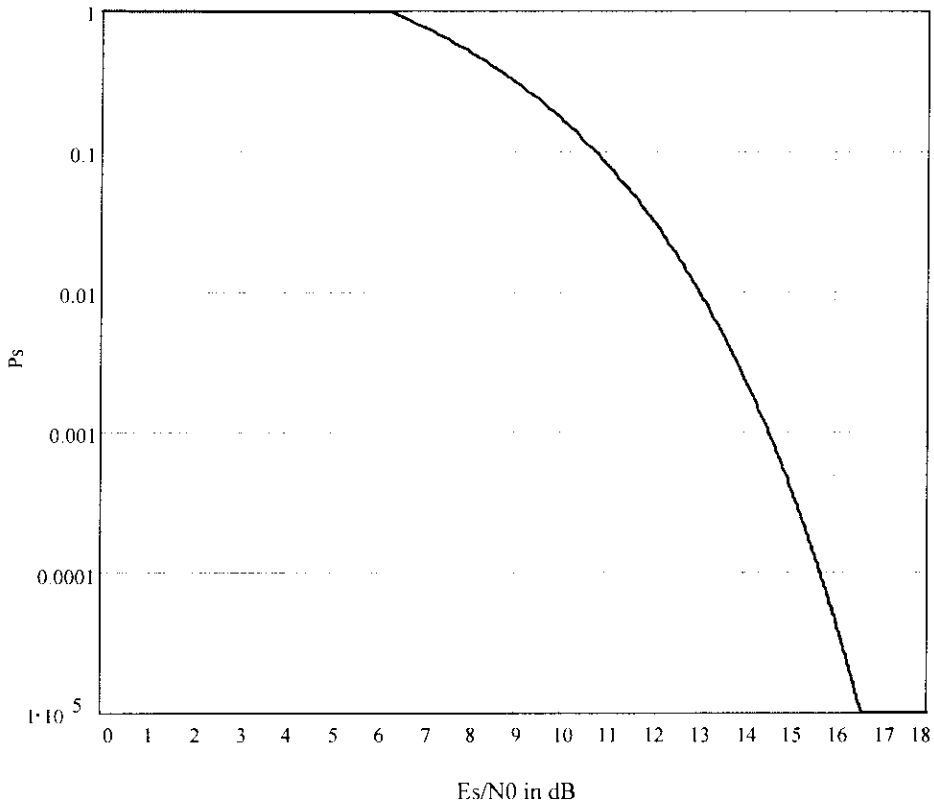
The maximum allowable system implementation loss is 2 dB.

The HFA3860 direct sequence spread spectrum baseband processor uses M-ary Bi-Orthogonal Keying. The BER performance curve is given by [5]:

" The probability of error for generalized M-ary Orthogonal signaling using coherent demodulation is given by:

$$P_e = 1 - P_{c1} = 1 - \frac{1}{\sqrt{2\pi}} \int_{-\frac{S_{01}}{N_0}}^{\infty} \left[2\left(1 - Q\left\{ z + \sqrt{2\,\frac{E_b}{\eta}} \right\}\right) \right]^{\frac{M}{2}-1} \exp\left\{ -\frac{z^2}{2} \right\} dz$$

This integral cannot be solved in closed form, and numerical integration must be used. This is done in a MATHCAD environment and is displayed in graphical format for M=2, 4, 8, and 16." (Shown on next page for M=16).



M=16 QMBOK Es/No

The reference BER is specified as $1 \bullet 10^{-5}$. The corresponding Es/No (signal to noise ratio per symbol) is 16.6 dB. The Es/No required to achieve the desired BER with maximum system implementation losses is 18.6 dB. The minimum processing gain is again, 10 dB, therefore:

$$G_p = \left(\frac{E_s}{N_o}\right)_{output} + \left(\frac{J}{S}\right) + L_{system} = 16.6\,dB + 2.0\,dB + \left(\frac{J}{S}\right) \geq 10dB$$

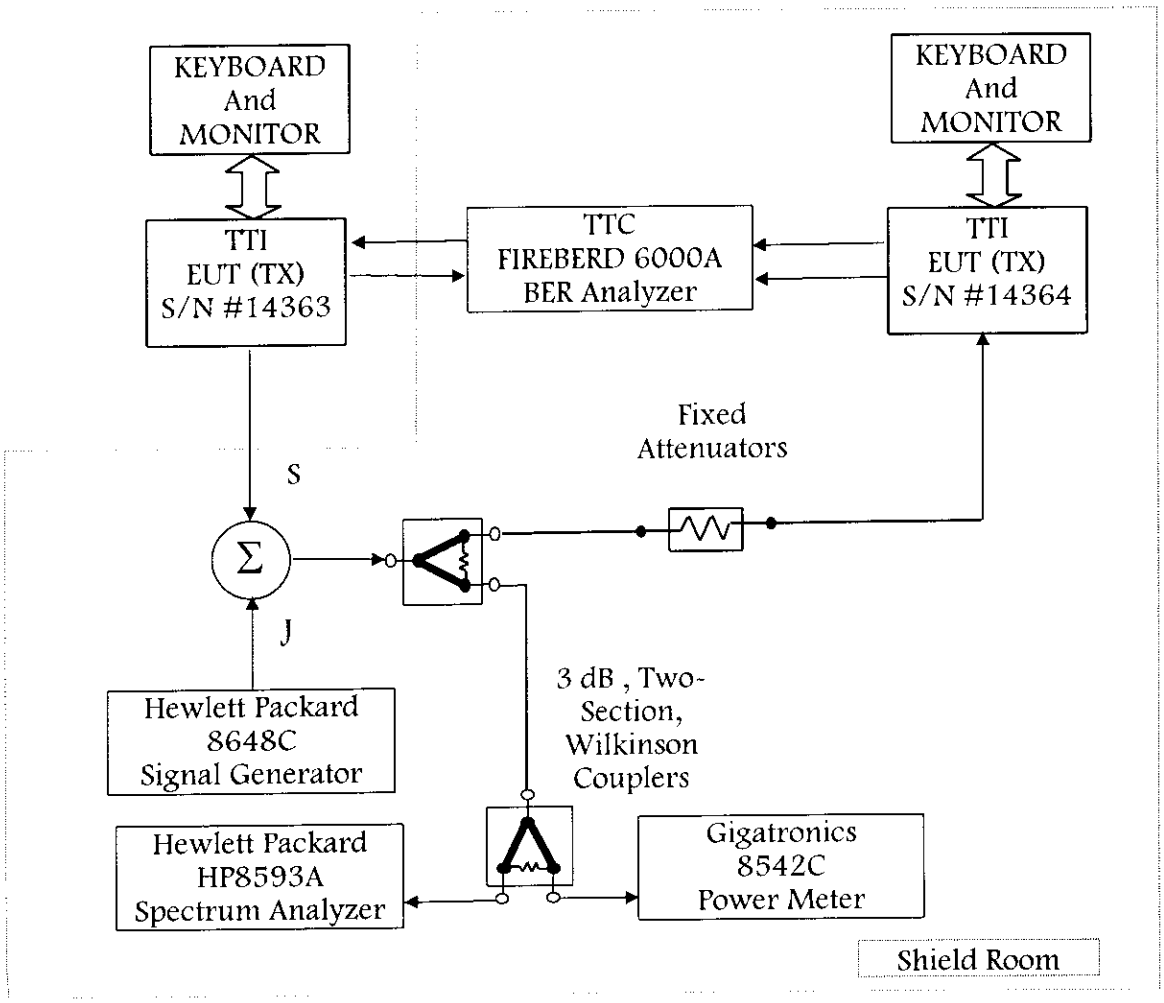
$$G_p = 18.6\ dB\ + \left(\frac{J}{S}\right) \geq 10dB$$

The minimum jammer to signal ratio is as follows:

$$\left(\frac{J}{S}\right) \geq -8.6\ dB$$

4.0 Test Configuration: CW Jamming Margin (15.247) (e)

4.1 Basic Test Block Diagram



4.2 Test Procedure

4.2.1 Obtain the simplex link shown. Perform all independent instrumentation calibrations prior to this procedure. Set operating power levels using fixed and variable attenuators in system to meet the following objectives:

1. Signal Power at receiver approximately -60 dBm (above thermal sensitivity such that thermal noise does not cause bit errors).

2. Signal Power at power meter between -20 and -40 dBm for optimal linearity.

3. Use spectrum analyzer to monitor test.

4. Ensure that CW Jammer generator RF output is disabled and measure the power at the power meter port using the power meter. This is the relative signal power, S_r.

5. Disable Transmitter, and set CW Jammer generator RF output frequency equal to the carrier frequency and enable generator output. Set reference CW Jammer power level at power meter port equal to S_r (0 dB J/S reference level). Note the power level setting on the generator, this is the reference CW Jammer power setting, J_r.

6. Disable CW Jammer, re-establish link. BER test set should be operating error-free.

7. Enable CW Jammer at a low power level and gradually increase the CW Jammer power until the BER test set indicates the reference BER level ($1 \bullet 10^{-5}$) or greater. Note nominal Jammer power setting, J_n.

8. The maximum Jamming signal level is limited such that the link is not degraded to the point where re-acquisition is necessary. This was necessary to allow the test to be automated and to be independent of the E.U.T. If the jammer power level were allowed to exceed the threshold in which the link is lost in the equipment, the test would be interrupted. The maximum jamming level is above the level necessary to detect the minimum processing gain.

4.2.2 This test is repeated for a fixed signal carrier frequency and for uniform steps in frequency increments of 50 kHz across the receiver passband with the CW Jammer. In this case, the receiver passband is ±9.5 MHz. The procedure can be illustrated as follows:

For offset frequency - 9.5 MHz to carrier frequency + 9.5 MHz , Step 50 kHz.
Begin at minimum Jammer Power
Do:
Increase Jammer Power Setting by 1dB.
Until:
Average BER is greater or equal to reference BER.
Record Indicated Nominal Jammer Level setting.
Next offset frequency.

4.2.3 The nominal Jammer Level settings are tabulated versus offset frequency. The J/S ratio and the processing gain are then calculated as follows:

$$\left(\frac{J}{S}\right) = \left[\left(J_r - J_n\right)\right]$$

If $J_n = J_r$ then:

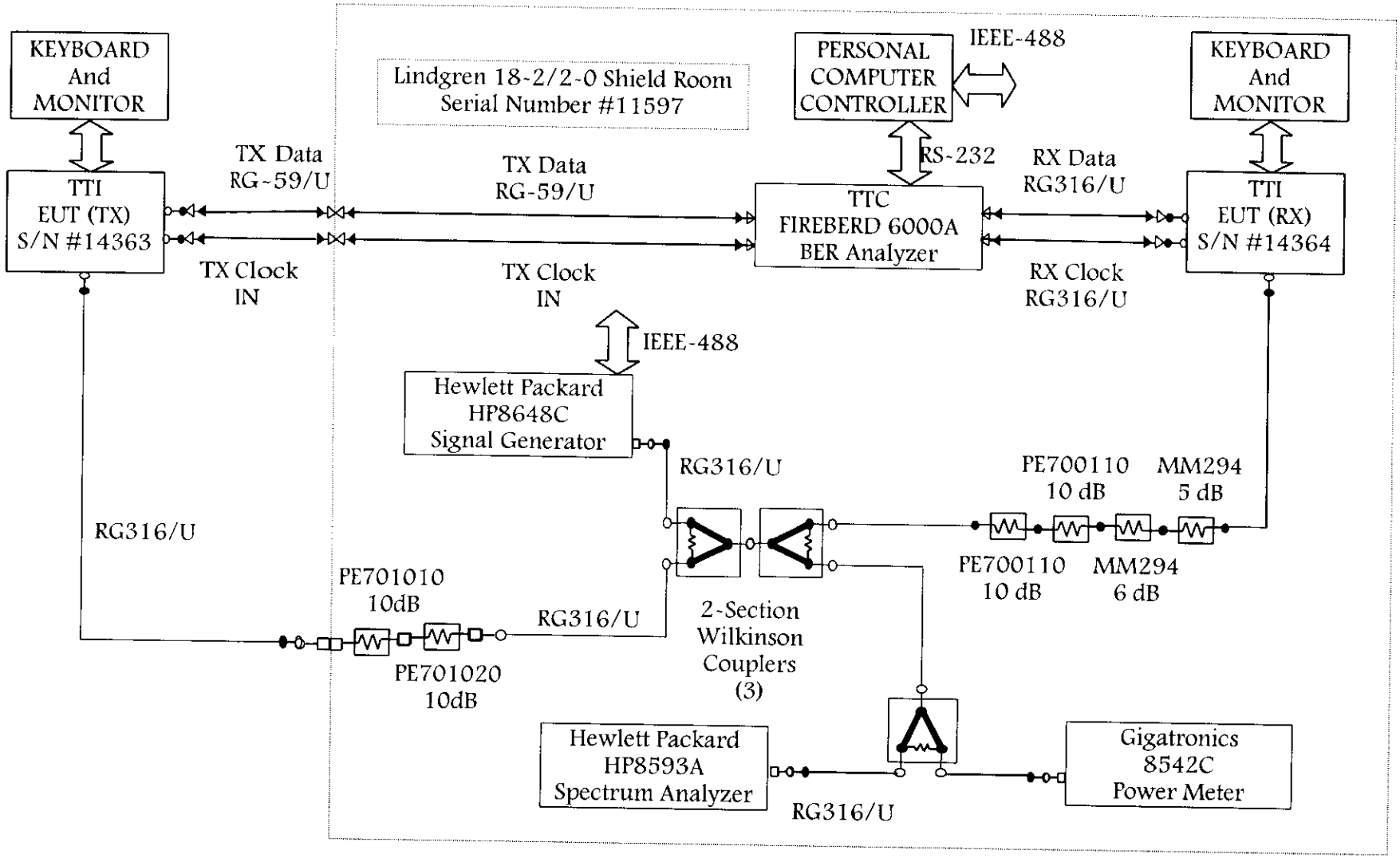
$$\left(\frac{J}{S}\right) = 0dB$$

is the reference Jammer Power Level.

4.2.4 The processing gain then is determined using the J/S ratio:

$$G_p = 18.6\ dB + \left(\frac{J}{S}\right)$$

4.3 Test Electrical Configuration:



4.4 Measurement Equipment List

Equipment	LSR Serial No.	Serial Number	Calibration
HP8596E Spectrum Analyzer	CC00130C	3205A00103	Initial Only
Gigatronics 8542C Power Meter	EE960005	1831450	2/14/97
Gigatronics 86301A Sensor	-	1830164	3/5/98
TTC Fireberd 6000 BER Test Set Test Interval 10^7 Pattern: 2^23-1 External TX input	CC00164C	10016	11/29/96
HP 8648C Signal Generator.	CC00129C	34119400344	6/16/94
Wilkinson Power Couplers (3)	-	2400-1,-2,-3	HP8753E

4.5 Measurement Uncertainties for Absolute Measurements

The measurement uncertainties are determined by the methods specified in NAMAS NIS 81, Edition 1, May 1994, "The Treatment of Uncertainty in EMC Measurements".

Equipment	Specified Characteristic	Probability Density	Specified Uncertainty
HP8596E Spectrum Analyzer	Reference Level	Uniform	±0.3 dB +0.01 • dB from -20 dBm
HP8596E Spectrum Analyzer	Calibrator Output	Uniform	±0.4 dB
HP8596E Spectrum Analyzer	Absolute Amplitude Calibration Uncertainty	Uniform	±0.15 dB
Gigatronics 86301A Sensor	Power Calibration Factor	Uniform	1.33 %
Wilkinson Couplers 2400-2500 MHz	Amplitude Imbalance	Uniform	±0.1 dB
HP 8648C	Output Power	Uniform	±2.0 dB

HP Spectrum Analyzer Total Uncertainty (-60 dBm level):

Perform Root-Sum-Square of three uncertainties to find total uncertainty for a 95% confidence level:

Uniform uncertainties specify the probability density interval ±a. The variance of the uniform density is a/3.

Sum the uncorrelated variances to find the total variance:

Total variance = [(0.3 dB +0.01 • 40 dB)/3 +(0.4)/3+(0.15)/3] = 1.25/3 = 0.416

The uncertainty for a 95% confidence interval is 1.96 times the standard deviation:

Total Uncertainty = ±1.96 • √0.416 = 1.96 • 0.644 = ±1.26 dB

Gigatronics Power Sensor Power Calibration Factor Uncertainty:

Probable error in Power sensor: ±1.33% , ±10 log10 (1.0133) = ±0.0574 dB
Variance = 0.0574/3 =0.01913
Total uncertainty = ±1.96 • √0.01913 = ±0.27 dB

Signal Generator Output Power Uncertainty:

Level Accuracy = ±2.0 dB
Variance = 2.0/3 =0.667
Total uncertainty = ±1.96 • √0.667 = ±1.6 dB

To check the power setting accuracy, the output of the HP8648 C was varied at 2432 MHz over expected power level range and the power was measured at the output of the summing coupler. The power was measured with the Gigatronics Power meter.

Power Setting (dBm)	Coupler Output Power (dBm)	Ideal Output Power (dBm)	Error (dB)
-17.5	-30.3	-30.3	0
-18.5	-31.3	-31.3	0
-19.5	-32.3	-32.3	0
-20.5	-33.2	-33.3	-0.1
-21.5	-34.2	-34.3	-0.1
-22.5	-35.2	-35.3	-0.1
-23.5	-36.1	-36.3	-0.2
-24.5	-37.1	-37.3	-0.2
-25.5	-38	-38.3	-0.3
-26.5	-39.4	-39.3	0.1
-27.5	-40.4	-40.3	0.1
-28.5	-41.5	-41.3	0.2
-29.5	-42.5	-42.3	0.2
-30.5	-43.5	-43.3	0.2
-31.5	-44.6	-44.3	0.3
-32.5	-45.6	-45.3	0.3
-33.5	-46.7	-46.3	0.4
-34.5	-47.8	-47.3	0.5
-35.5	-48.9	-48.3	0.6
-36.5	-49.9	-49.3	0.6
-37.5	-50.5	-50.3	0.2
-38.5	-50.9	-51.3	-0.4
-39.5	-51.4	-52.3	-0.9

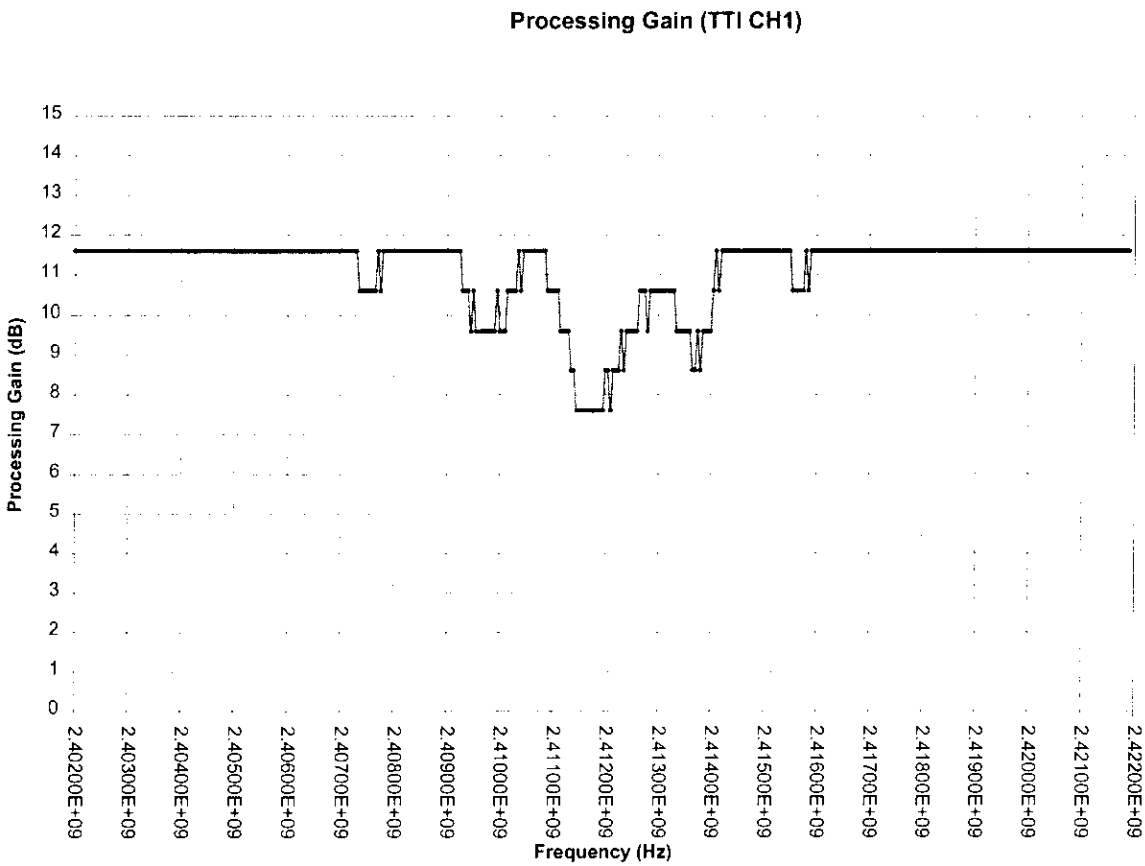
5.0 CW Jamming Margin Test Data

The numerical data is presented in graphical form here. Processing gain versus CW frequency for Channels 1,3, and 6 are presented. The measured relative signal power, reference jamming level, and reference jamming level setting are shown below for each channel:

	Channel 1 2412 MHz	Channel 3 2432 MHz	Channel 6 2462 MHz
Relative Signal Power , Sr	-33.7 dBm	-29.5 dBm	-32.5 dBm
Reference Jamming Level	-33.9 dBm	-29.8 dBm	-32.6 dBm
Reference Jamming Level Setting, Jr	-21 dBm	-17.5 dBm	-20 dBm

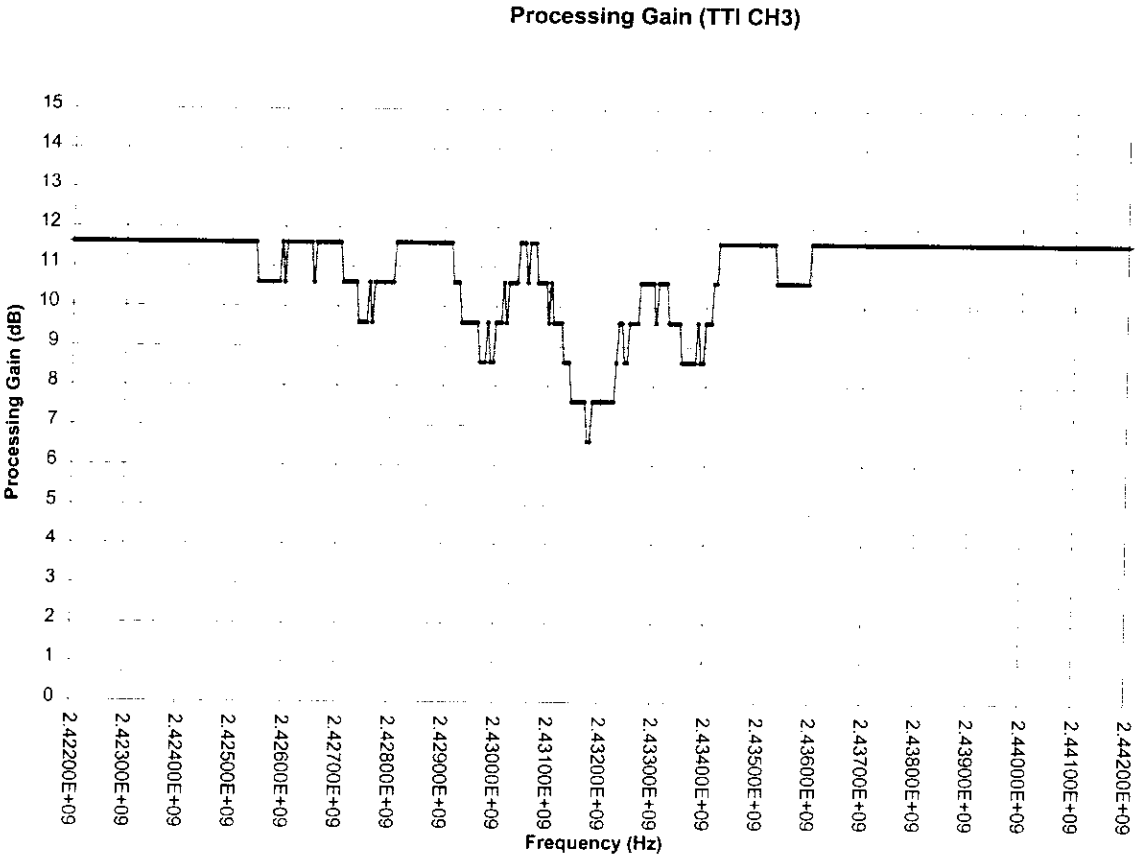
5.1 CW Jamming Test Data for Channel 1

The processing gain versus frequency offset from the carrier is presented below. The Jamming Margin test procedure [3] allows the worst 20% of the points to be discarded. The minimum processing gain is the minimum of the remaining points. The minimum of remaining points can be determined by calculating the upper bound of the 20th percentile of processing gain data. This number will be listed with the data and it represents the final compliance quantity.



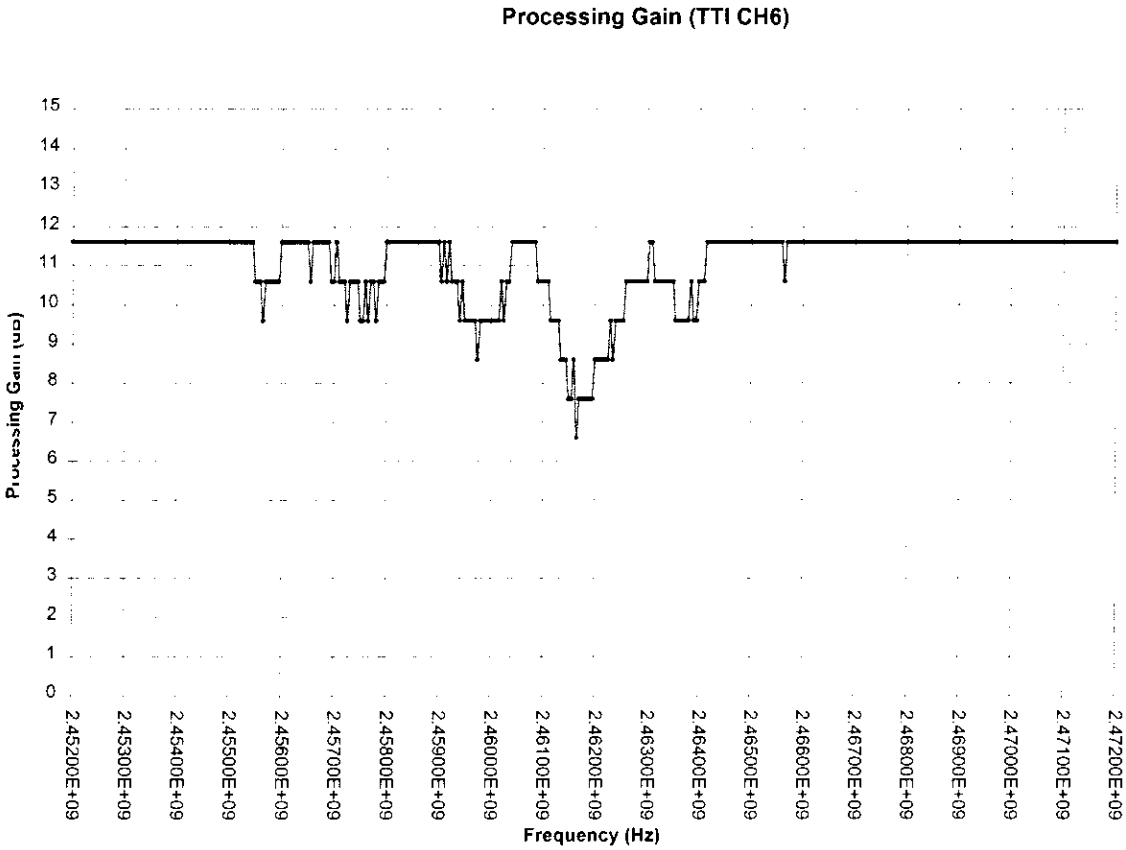
The minimum processing gain with 20% worst points removed is 10.6 dB.

5.2 CW Jamming Test Data for Channel 3



The minimum processing gain with 20% worst points removed is 10.6 dB.

5.3 CW Jamming Test Data for Channel 6:



The minimum processing gain with 20% worst points removed is 10.6 dB.

6.0 Analysis of Test Data

The main conclusions associated with this set of tests are as follows:

1. The system passes the CW jamming margin test on Channel 1.
2. The system passes the CW jamming margin test on Channel 3.
3. The system passes the CW jamming margin test on Channel 6.

The tabular data used to prepare the graphs and conclusions found in this report are stored at the offices of L.S.Compliance, and are available for inspection if deemed necessary. The computer program used to control the test equipment automatically (in HP VEE) is also available for inspection, if deemed necessary.

FEDERAL COMMUNICATIONS COMMISSION
Equipment Authorization Division, Applications Processing Branch
7435 Oakland Mills Road, Columbia, MD 21046
Telephone: (301) 362-3000, Facsimile: (301) 344-2050

QUICK FAX OfficeMax -3025

Date:	# Of Pages:
To: Errol Chang	From: Pete Bonk
Co./Dept.	Co./Dept.
Fax: 301-344-2050	Fax: 9045
Phone: 301 362 3000	Phone: 440 243 9087
Note:	E-Mail: pbonk@aflink.com

0 445

r at the above extension.

Applicant: Transformation Techniques Inc

The items indicated below must be submitted before processing can continue on the above referenced application. Failure to provide the requested information within 60 days may result in application dismissal pursuant to Section 2.917(c) and forfeiture of the filing fee pursuant to Section 1.1108.

1. What is the gain of those antennas that will be sold with the system.

2. Please state the theoretical processing gain of the system and indicate how it was determined.

FAXED Replies to this letter MUST contain the Reference Number: 4504

Mr Chang

Pls see attached material.
I have updated the original document I sent you.
Thx

Peter Bonk

11-6-98

Reference Number 4504

FCC ID LXX11

Explanation of how the device works

The device is a spread spectrum radio transceiver used to transmit and receive data at rates up to 11 million bits per second (MBPS). The device includes the 2.4GHZ ISM Band radio module and an antenna assembly consisting of a lightning arrestor, a minimum of 50' of RG8 cable, and parabolic antenna.

The Gain on the parabolic antenna is 24dbi.

Detailed Description of the Intended Use

The device will be used by commercial establishments to transmit data between fixed locations for purposes of connecting Local Area Networks (LAN)'s, Private Branch Exchange (PBX) telephone systems, video cameras, and other devices that can be made to produce a data stream compatible with this device. The device will accomplish this transmission by transmitting a spread spectrum signal in the 2.4 to 2.483 GHZ ISM band under Part 15 of the FCC rules at data rates up to but not exceeding 11 MBPS. Under these rules users will be able to install the device for the purposes of establishing communications between the fixed points involved without having to file for a license or coordinate with other users. It is anticipated that the robust communications established using spread spectrum will provide sufficient separation from other users nearby.

It is intended that commercial establishments including schools, hospitals, manufacturers, and offices will use the product to establish communications between their private locations including internet access, LAN, voice, or video communications.

The device will be used in a point to point mode or in point to multipoint with two parabolic antennas pointing back to the main parabolic antenna.

The theoretical processing gain on the radio module is 10.6db and was determined using the CW jamming test method. The details for this method are attached and are included in the lab test report from L.S. Compliance.

FCC ID: LXX-11

2.11 RADIATED EMISSIONS TEST SETUP

The test sample was operated within the 3 meter Semi-Anechoic, FCC listed chamber located at L.S. Compliance in Cedarburg, WI. The sample was mounted on its supplied metal tripod, which was centered on the flush-mounted 2m diameter metal turntable. The test sample was operated on its own [new] internal power supply. The test sample was configured to run in a continuous transmit mode during the 15.247 and 15.205 measurements. The sample was also set to run in a T.D.D. mode with 1 second on and 1 second off transmit times in order to inspect the level of TDD spurs transmitted. One test sample was set to operate on either channel 1 (2412mhz), channel 3 (2432MHz) or channel 6 (2462MHz) while being tested as an intentional radiator, in order to determine compliance within a frequency range of 2400-2483.5 MHz, as dictated by FCC part 15.31m

The system was also mounted on the 80 CM high wooden table, centered on the turntable for measurement of spurious signals emanating from the system during both receive and transmit modes.

Please refer to Section 2.15 for pictures of the test setup.

2.12 Radiated Emission Test Procedure

The fundamental and spurious (harmonic) emissions of the transmitter were tested for compliance to Title 47 CFR, FCC Part 15.247c limits for Direct Sequence Spread Sprectrum systems, and the 15.205 general limits, within the restriced bands. For the calculations used to determine the 1 meter limits, see Appendix A. The test sample was tested from the lowest frequency generated by the transmitter to the 10th harmonic of the fundamental frequency generated by the device. The appropriate limits were also observed where any spurious signals were located within any of the restricted bands as described in Part 15.205a. These frequencies, and their associated limits, are referenced in Section 2.14. The sample was mounted on the supplied metal tripod and placed in the 3 Meter chamber and the antenna mast was placed such that the antenna was either 1 meter or 3 meters from the test object. A biconical antenna was used to measure emissions from 30 to 200 MHz, a log periodic was used to measure emissions from 200 to 1000 MHz, and a double ridged waveguide horn was used to measure emissions above 1 GHz. The test object was programmed to operate in continuous transmit, and the resultant signals were maximized by rotating the turntable 360 degrees, and by raising and lowering the antenna between 1 and 4 meters. The test object was also given several different orientations to determine the maximum signal levels, using both horizontal and vertical antenna polarities. Emissions above 1 GHz were also measured at a 1 meter separation, using the HP 84125C Microwave Measurement system.

No significant emissions were found aside from the transmitter fundamental and some spurious signals. The unit was scanned for emissions in both transmit and receive modes, over the range 30 to 26000 MHz to establish compliance with Part 15.247c and 15.205 for the system. Also, the scans were performed to evaluate the digital controller section of the product, which is subject to verification as a Class A digital device. The same procedures as detailed for the transmitter tests described above were used to perform these measurements. The results of the system measurements are found in Appendix B, with graphs of the signature scans found in Appendix C.

2.13 Test Equipment Utilized for Radiated Emissions Test

A list of the test equipment and antennas used for the tests can be found in Section 2.17, which includes the calibration information as well as the equipment description. All equipment is calibrated and used according to the user manuals supplied by the manufacturer. All antenna calibrations were performed at a N.I.S.T traceable site, and the resultant correction factors were entered into the Hewlett Packard 8546A EMI receiver software database. The connecting cables used were also measured for loss using a calibrated signal generator and the HP 8546A EMI receiver. The resulting loss factors were entered into the HP 8546A database. This allowed for automatic changes in the antenna correction factor, as well as cable loss or other corrections, to be added to the EMI receiver display while taking measurements. Thus, the resulting data taken from the HP 8546A is an actual reading and can be entered into the database as a corrected meter reading. The HP 8546A EMI receiver was operated with a bandwidth of 120 kHz when receiving signals below 1 GHz, and with a bandwidth of 1 MHz when receiving signals above 1 GHz, in accordance with CISPR 16. Both the peak and Quasi-peak detector functions were used.

For measurements in the upper microwave region, a HP 84125C microwave measurement system was leased from Hewlett Packard Corporation. This system includes the Spectrum analyzer, preamps and integrated horn antennas, and is supplied with a current calibration as supplied by the manufacturer facility. Copies of this certification can be supplied if requested. Being that this instrument is an integrated system, all antenna factors, cable factors, and preamp gain factors are stored and recalled when initially calibrated and configured for use. Data appearing on the screen and measured during emissions testing is then presented as corrected readings. During emissions testing, signals where significant levels were noted were measured using the 1 MHz IF bandwidth, and a 10 or 100 Hz video bandwidth, resulting in an average measurement mode of the analyzer. Signal levels were also inspected using the 100 kHz bandwidth and compared to the maximum radiated signal in a 100 kHz bandwidth of the fundamental modulated carrier for the three channels tested.

FCC ID: LXX-11

Manufacturer: T.T.I. Wireless
Model: RCB
Serial Number(s): 14363, 14364

2.14 - Restricted Bands affecting this product

3 Meter limits

Frequency (MHz)	Limit (μV)	Limit (dB/μV/m)
960-1240	500	54.0
1300-1427	500	54.0
1435-1626.5	500	54.0
1645.5-1646.5	500	54.0
1660-1710	500	54.0
1718.8-1722.2	500	54.0
2200-2300	500	54.0
2310-2390	500	54.0
2483.5-2500	500	54.0
2655-2900	500	54.0
3260-3267	500	54.0
3332-3339	500	54.0
3345.8-3358	500	54.0
3600-4400	500	54.0
4500-5150	500	54.0
5350-5460	500	54.0
7250-7750	500	54.0
8025-8500	500	54.0
9000-9200	500	54.0
9300-9500	500	54.0
10600-12700	500	54.0
13250-13400	500	54.0
14470-14500	500	54.0
15350-16200	500	54.0
17700-21400	500	54.0
22010-23120	500	54.0
23600-24000	500	54.0

2.15 – Photos taken during testing

2.16 SUMMARY OF RESULTS AND CONCLUSIONS

Based on the procedures outlined in this report, and the test results included in appendices B and C, it can be determined that the T.T.I. Wireless model RCB does "meet" the emission requirements of Title 47 CFR, FCC Part 15 Subpart C for an intentional radiator.

The enclosed test results pertain to the samples of the test item listed, and only for the tests performed on the data sheets. Any subsequent modification or changes to the test items could invalidate the data contained herein, and could therefore invalidate the findings of this report.

FCC ID: LXX-11

2.17 - Test Equipment

AA960003	EMCO	3121C	786	Dipole Set Antenna	7/14/98
AA960004	EMCO	3146	9512-4276	Log Periodic Antenna	9/9/98
AA960005	EMCO	3110B	9601/2280	Biconical Antenna	9/9/98
AA960007	EMCO	3115	99111-4198	Double Ridged Guide/Horn Antenna	9/9/98
EE960004	EMCO	2090	9607-1164	Mast/Table Controller	I.O
EE960013	HP	8546A	3617A00320	Receiver RF Section W/Display and RF filter section	7/30/98
EE960014	HP	85460A	3448A00296	Receiver RF Section Preselector	7/30/98

Manufacturer	Model	Serial	Description	Calibrated on:
Hewlett Packard	84125C	3643A00026	Microwave EMI Test System	12 October 1997

APPENDIX A:

SAMPLE CALCULATIONS

FCC ID: LXX-11

Manufacturer: T.T.I. Wireless
Model: RCB
Serial Number(s): 14363, 14364

Calculation of Radiated Emissions limits for FCC Part 15.209 (above 1 GHz)

The following table depicts the Class B limits for an unintentional radiator: Limits established at a measurement distance of 3 meters and limits corrected for a 1 meter measurement distance which are extrapolated from the 3 meter limit.

960 MHz up	54	63.54

- The 1 meter limits were calculated by adding a factor of 9.54 dB, derived from:

$20\log_{10}(3/1) = 9.54$ dB uV/m

3m limit = 10m limit + factor

= 54 dB μV/m + 9.54 dB μV/m

=63.54 dB μV/m

APPENDIX B:

DATA CHARTS

FCC ID: LXX-11

Measurement of Electromagnetic Radiated Emission within 3 Meter FCC Listed Chamber

Frequency Range inspected: 30 to 1000 MHz

Date of Test: May 6, 8 ,1998
Location: L. S. Compliance, Inc.
W66 N220 Commerce Court
Cedarburg, WI 53012
Specifications: 47CFR FCC Part 15.109 class A
Distance: 3 meters
Equipment: HP 8546A EMI Receiver

EMCO 3146A Log Periodic
EMCO 3110B Biconical

Manufacturer: T.T.I.Wireless
Model No.: RCB

Serial No.: 14363
Configuration: Rx on Channel 6, worst case
Detector(s) Used: Quasi-peak

The following table depicts the level of significant spurious emissions found:

Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	EMI Meter Reading (dB µV/m)	15.109 Limit (dB µV/m)	Margin (dB)
32.5	Vert	1.0	133	41.1	49.54	8.44
41.28	Vert	1.0	133	38.4	49.54	11.14
78.7	Vert	1.4	0	39.6	49.54	9.94
176.5	Horiz	1.0	144	37.7	53.98	16.28
177	Horiz	1.0	144	38.3	53.98	15.68
180	Horiz	1.0	144	38.6	53.98	15.38
200	Horiz	1.0	161	39.3	53.98	14.68
203	Horiz	1.0	161	40.0	53.98	13.98
213.6	Horiz	1.0	160	47.1	53.98	6.7
213.6	Vert	1.0	125	40.3	53.98	13.68
280	Vert	1.0	55	48.5	56.9	8.4
280	Horiz	1.0	295	48.1	56.9	8.8
290	Vert	1.45	165	49.5	56.9	7.4
290	Horiz	1.7	137	48.3	56.9	8.6
310	Vert	1.5	170	49.9	56.9	7.0
320	Vert	1.5	164	49.0	56.9	7.9
320	Horiz	1.7	232	46.3	56.9	10.6
330	Horiz	1.7	290	47.0	56.9	9.9
396	Vert	1.0	230	45.5	56.9	11.4
397.5	Horiz	1.0	47	46.6	56.9	10.3
480	Horiz	1.0	233	42.9	56.9	14.0
480	Vert	1.4	182	42.6	56.9	14.3

FCC ID: LXX-11

Measurement of Electromagnetic Radiated Emission within 3 Meter FCC Listed Chamber

Frequency Range Inspected: 1 to 26 GHz

Date of Test:	May 6, 8, June 25, 1998	Manufacturer:	T. T. I. Wireless
Location:	L.S. Compliance, Inc. W66 N220 Commerce Court Cedarburg, WI 53012	Model No.:	RCB
Specifications:	47CFR, FCC Part 15.247(c), 15.205	Serial No.:	14363
Distance:	1 meter	Configuration:	Tx on Ch 1, 3, or 6
Equipment:	HP 8546A EMI Receiver HP 84125C microwave EMI system EMCO 3115 Double Ridged Waveguide	Detector(s) Used:	Average Unless noted as Peak

The following table depicts the level of significant spurious and harmonic emissions found:

Emissions radiating from the system are defined by height and azimuth on the turntable.

Emissions radiating via the mesh antenna are described as being inspected on boresite of antenna.

Frequency (GHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	EMI Meter Reading (dB µV/m)	Channel (dB)	15.205 Limit (dB µV/m)	Margin (dB)
4.264	H	1.0	160	42.17	1	63.54	21.37
12.064	V	1.0	Boresite	38.05	1	63.54	25.49
14.472	V	1.0	Boresite	39.24	1	63.54	24.30
19.296	V	1.0	Boresite	36.42	1	63.54	27.08
4.304	H	1.0	230	40.5	3	63.54	23.04
12.160	H	1.0	Boresite	38.62	3	63.54	24.82
14.592	H	1.0	Boresite	38.65	3	63.54	24.89
19.456	V	1.0	Boresite	36.17	3	63.54	27.37
4.364	H	1.0	150	42.33	6	63.54	21.21
4.364	V	1.0	30	45.67	6	63.54	17.87
12.310	V	1.0	Boresite	36.94	6	63.54	26.60
19.696	V	1.0	Boresite	36.75	6	63.54	26.79
22.158	V	1.0	Boresite	37.83	6	63.54	25.71
2.3852	V	1.0	Boresite	56.70	1	63.54	6.84
2.3780	V	1.0	Boresite	78.86 peak	1	83.54	4.68
2.4921	V	1.0	Boresite	57.40	6	63.54	5.14
2.3762	V	1.0	Boresite	52.60	6	63.54	10.94
2.4921	V	1.0	Boresite	66.03 peak	6	83.54	17.51

FCC ID: LXX-11

Measurement of Electromagnetic Radiated Emission within 3 Meter FCC Listed Chamber

Frequency Range inspected: 1000 to 26000 MHz

Date of Test:	May 6,8, June 25, 1998	Manufacturer:	T.T.I Wireless
Location:	L. S. Compliance, Inc.	Model No.:	RCB
	W66 N220 Commerce Court		
	Cedarburg, WI 53012		
Specifications:	Title 47CFR, FCC Part 15.247 (C)	Serial No.:	14363
Distance:	1 meter	Configuration:	Tx on channel 1, 3, and 6
Equipment:	HP 8546A EMI Receiver	Detector(s) Used:	Peak, Average
	HP 84125C microwave EMI system		1 MHz bandwidth
	EMCO 3115 Double Ridged Waveguide		100 kHz Bandwidth
	EMCO 3146A Log Periodic		
	EMCO 3110B Biconical		

All other Harmonics and Spurious signals not reported within restricted bands

No emissions within 20 dB of the minus 20 dBc specification could be found

FCC ID: LXX-11

Measurement of Conducted Emissions within 8' X 10' FCC Listed Shielded Room.

Date of Test:	May 6,8, June 25, 1998	Manufacturer:	T.T.I. Wireless
Location:	L. S. Compliance, Inc.	Model No.:	RCB
	W66 N220 Commerce Court		
	Cedarburg, WI 53012		
Specifications:	Title 47CFR, FCC Part 15 Subpart C	Serial No.:	14363
Distance:	40 cm to vert. G.P.	Configuration:	Channel 3, Rx and Tx
Equipment:	HP 85460A, 85462A EMI Receiver	Detector(s) Used:	Quasi-Peak
	EMCO 3810/2NM LISN		
	HP 11947A Limiter		
Lab Conditions:	Temp.: 72° F / Humidity:50%		

The following table depicts the level of significant spurious emissions found:

Frequency (MHz)	Line	EMI Meter Reading (dB μV)	FCC 15.207 Limit (dB μV)	Margin (dB)
1.32	L1	36.9	48	11.1
1.46	L1	36.4	48	11.6
1.55	L1	35.9	48	12.1
1.79	L1	36.3	48	11.7
24.03	L1	38.8	48	9.2
26.58	L1	37.2	48	10.8
26.72	L1	37.6	48	10.4
0.72	L2	39.2	48	8.8
0.85	L2	37.7	48	10.3
1.32	L2	39.6	48	8.4
1.92	L2	35.0	48	13.0
2.03	L2	37.1	48	10.9
2.39	L2	36.9	48	11.1
16.47	L2	36.4	48	11.6
24.97	L2	36.0	48	12.0
25.18	L2	38.2	48	9.8
25.46	L2	36.2	48	11.8
25.76	L2	36.8	48	11.2
26.24	L2	39.1	48	8.9
26.58	L2	40.1	48	7.9
26.72	L2	40.0	48	8.0
27.14	L2	40.7	48	7.3

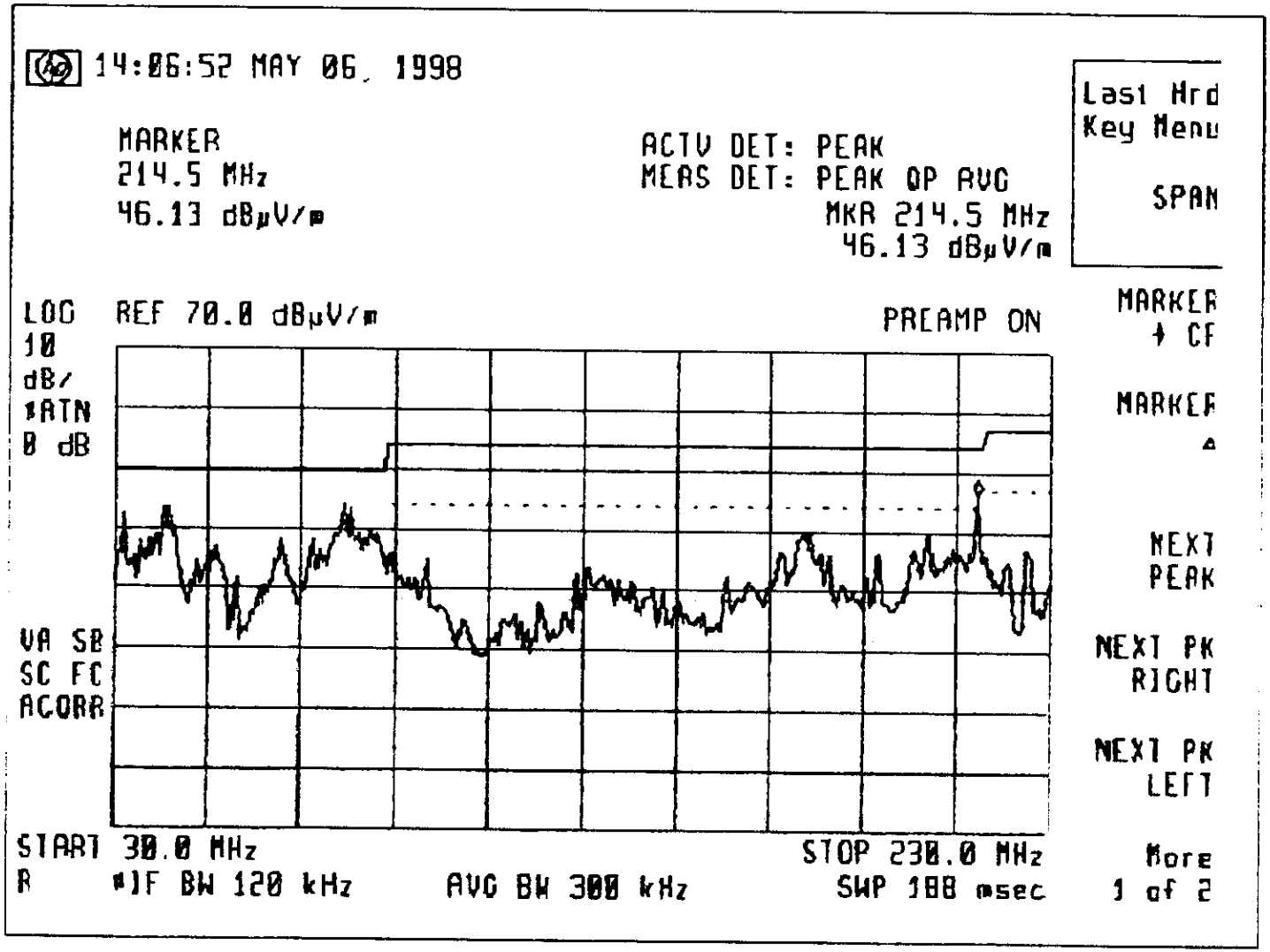
FCC ID: LXX-11

APPENDIX C:

GRAPHS

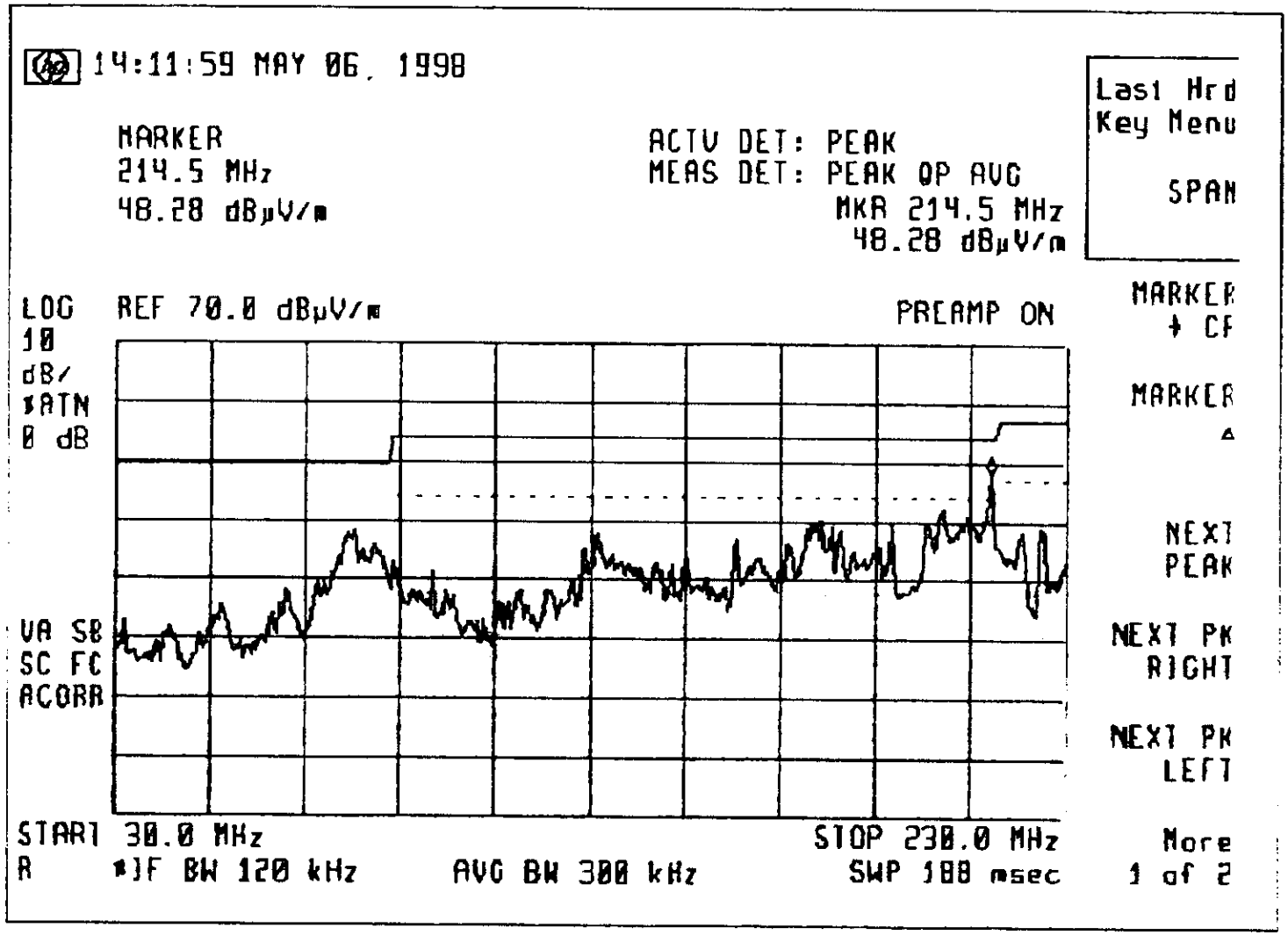
FCC ID : LXX-11

Channel 6 Rx Transceiver, emissions 30-230 MHz, vertical polarity



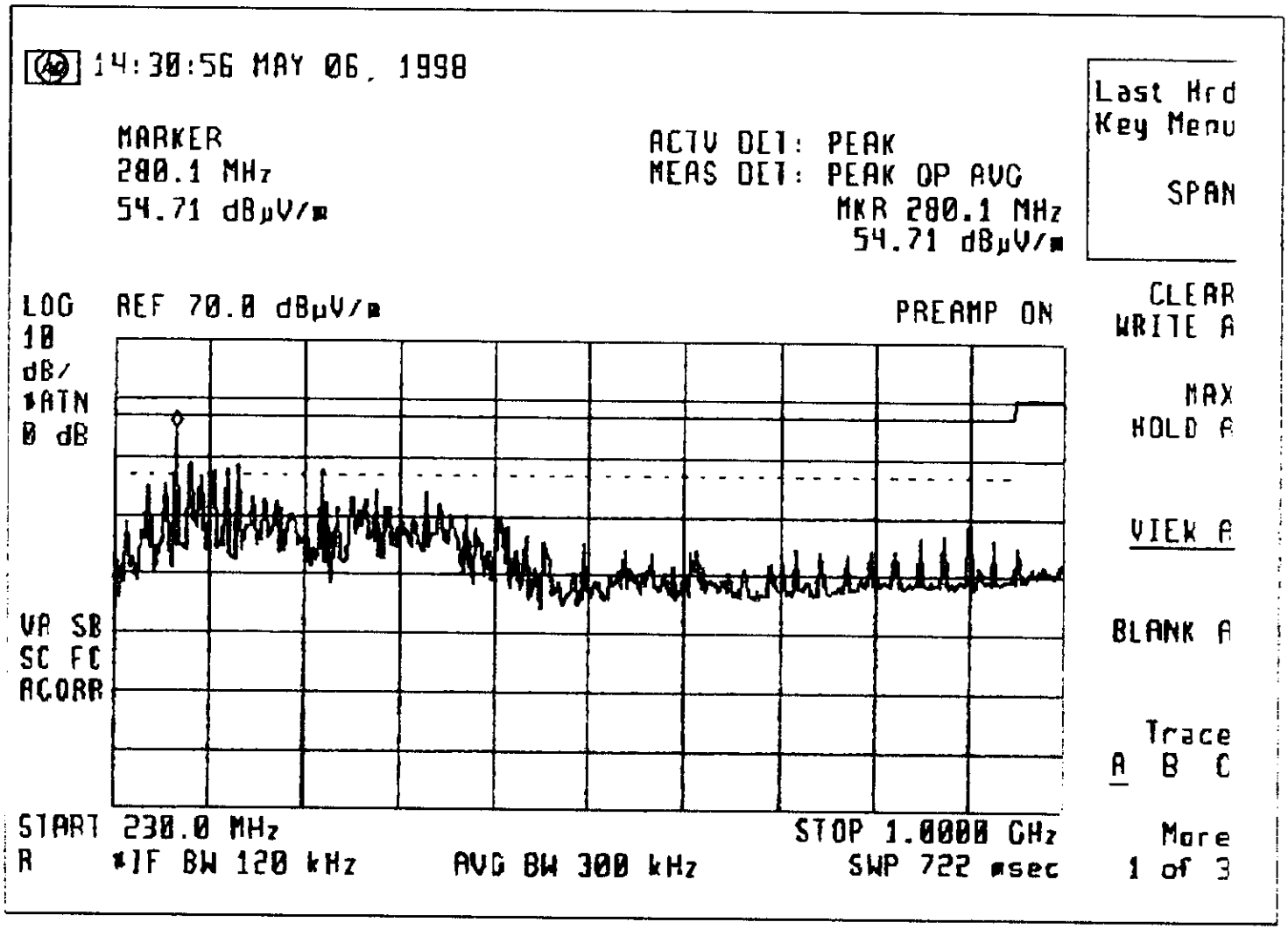
FCC ID : LXX-11

Channel 6 Rx Transceiver, emissions 30-230 MHz, horizontal polarity



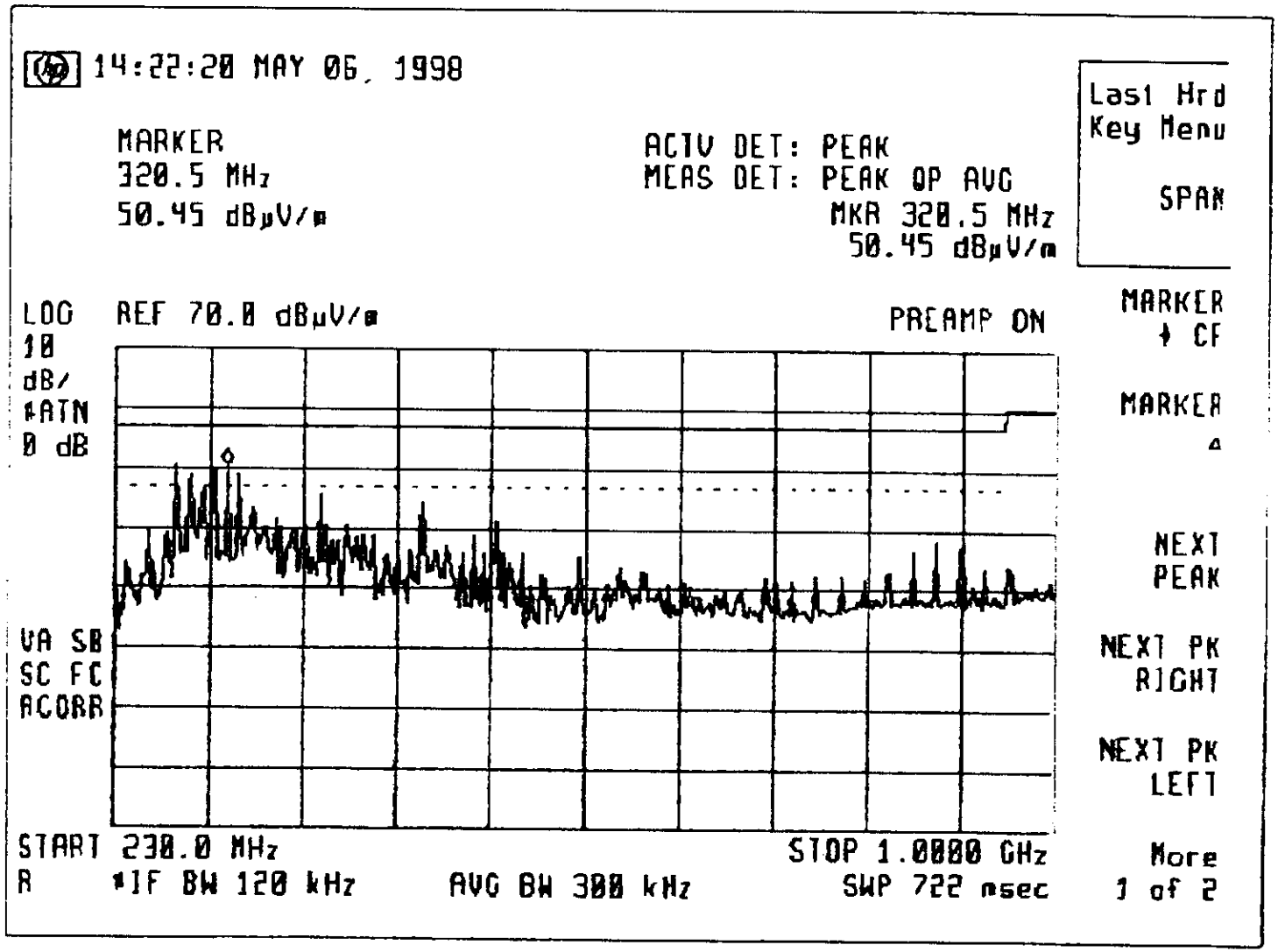
FCC ID : LXX-11

Channel 6 Rx Transceiver, emissions below1 GHz, horizontal polarity



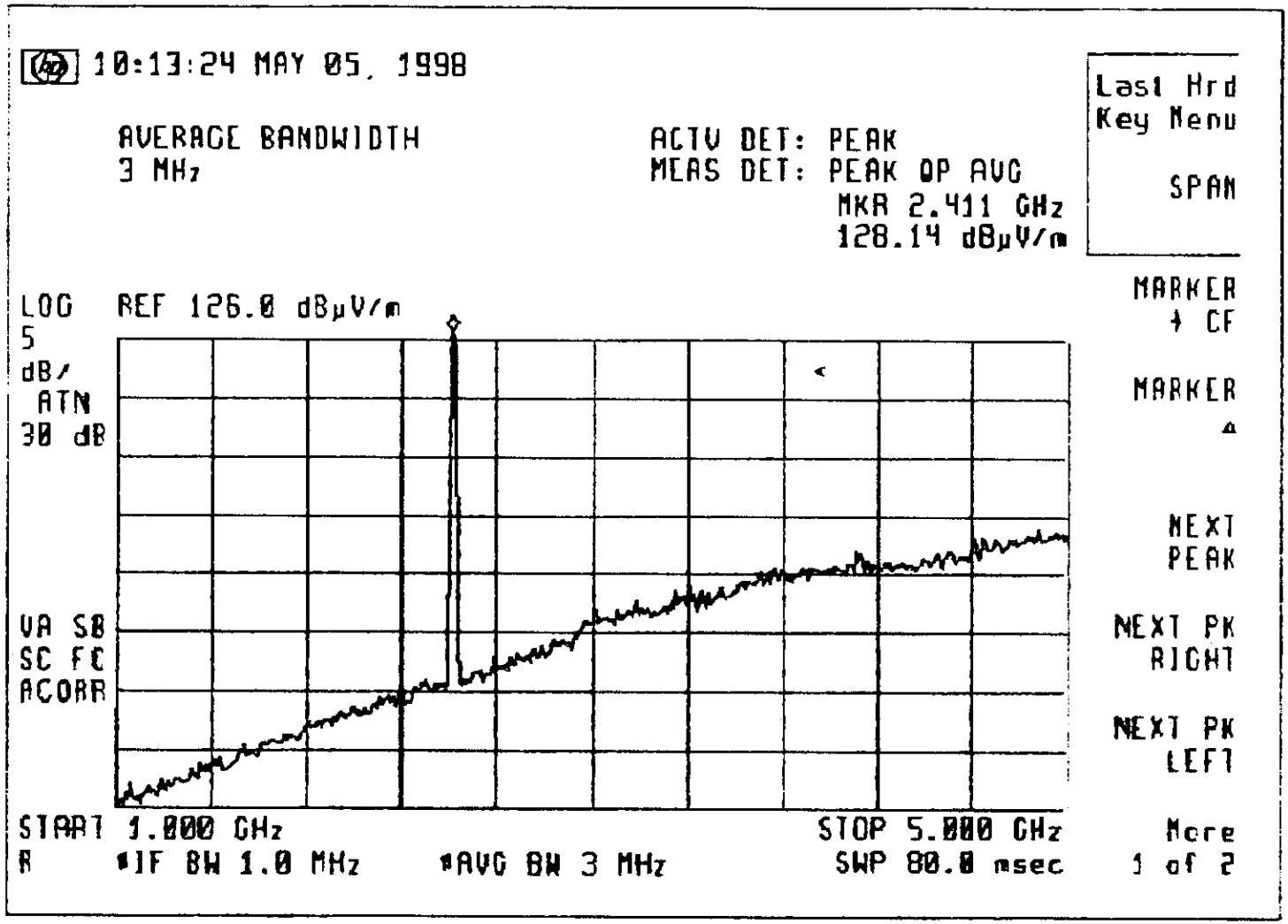
FCC ID : LXX-11

Channel 6 Rx Transceiver, emissions below1 GHz, Vertical polarity



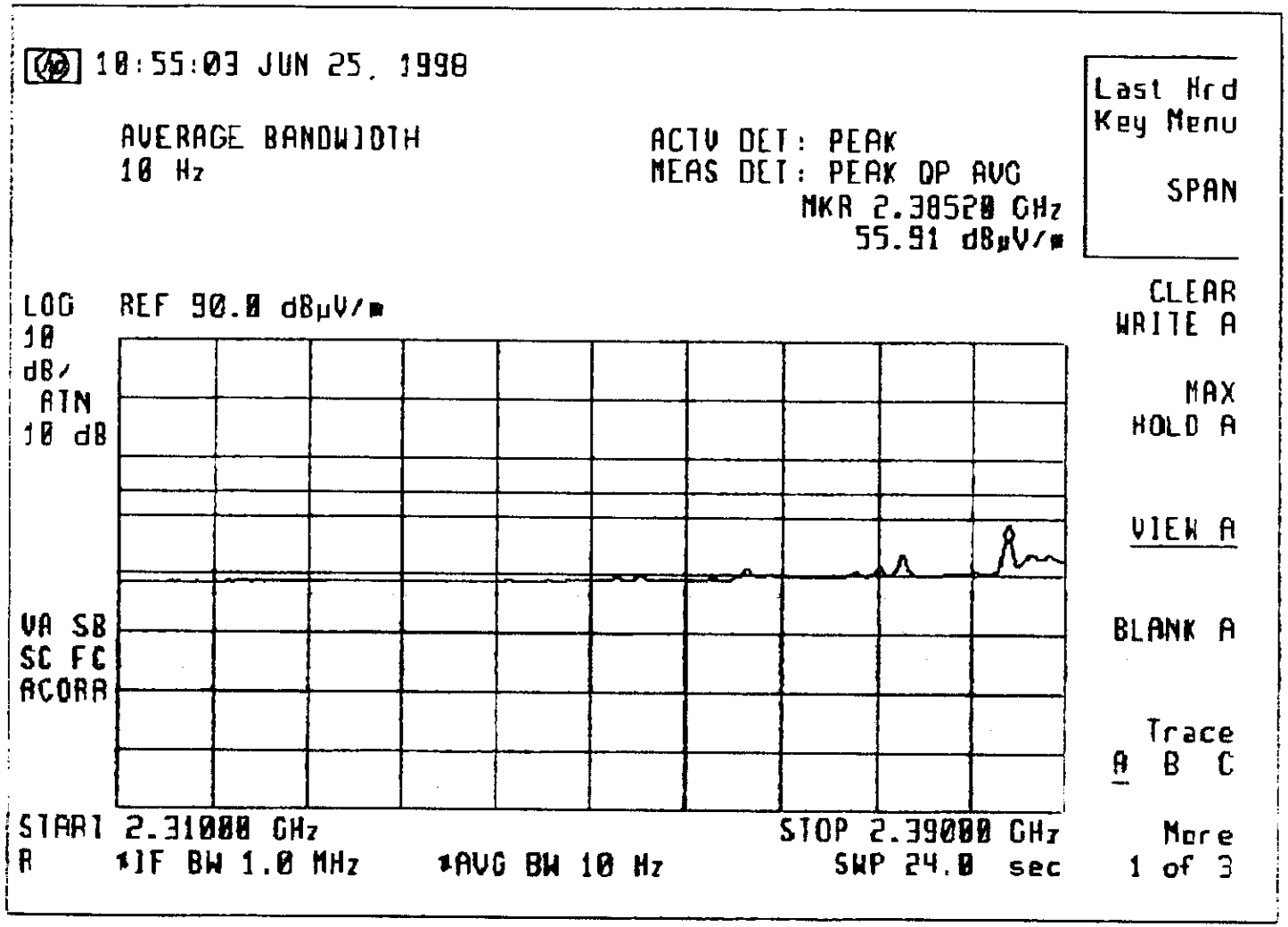
FCC ID : LXX-11

Channel 1 Transceiver, Tx mode, emissions 1 to 5 GHz, vertical Polarity



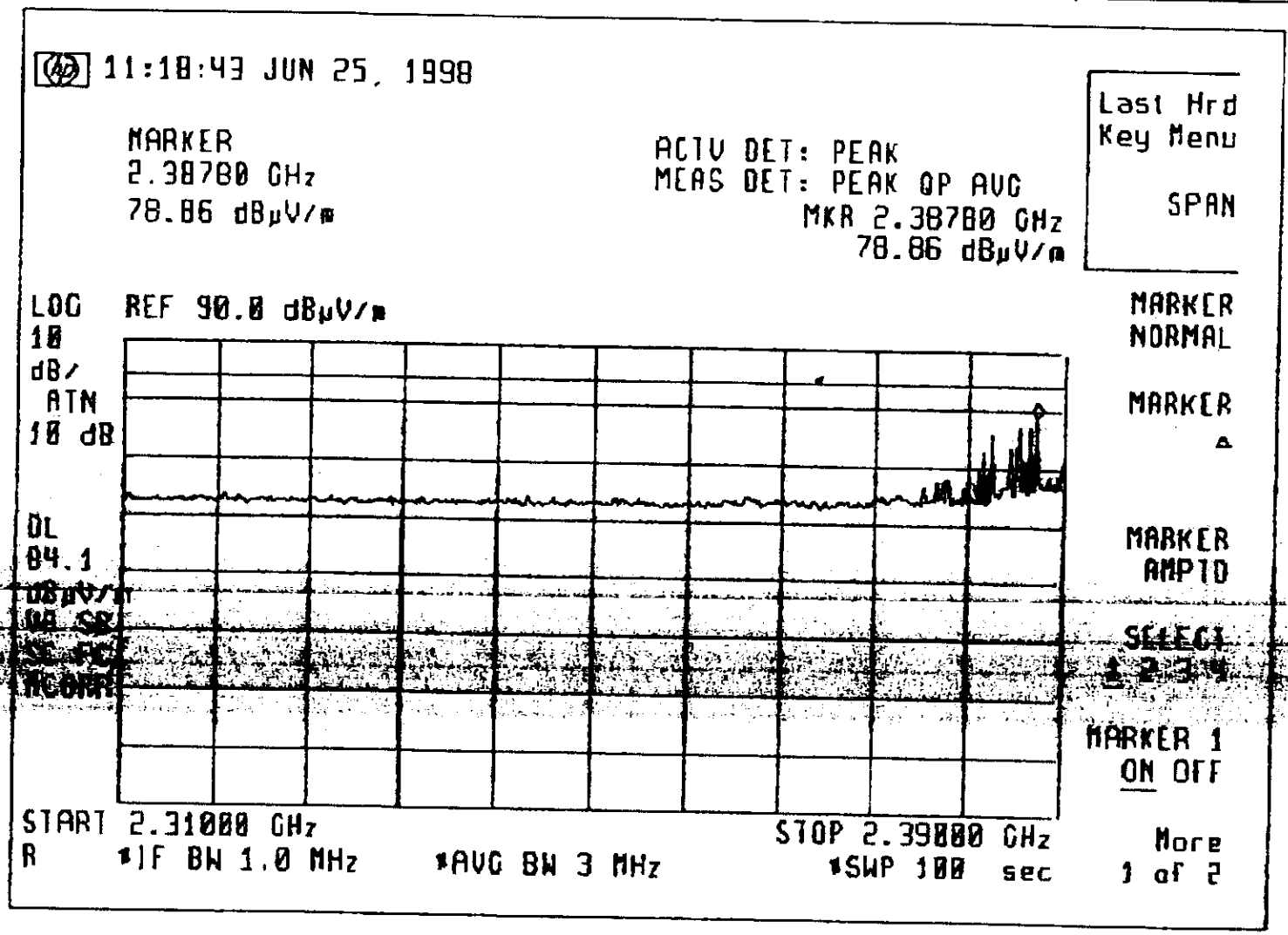
FCC ID : LXX-11

Channel 1 TX, emissions within adjacent restricted band, during continuous operation, Vertical polarity



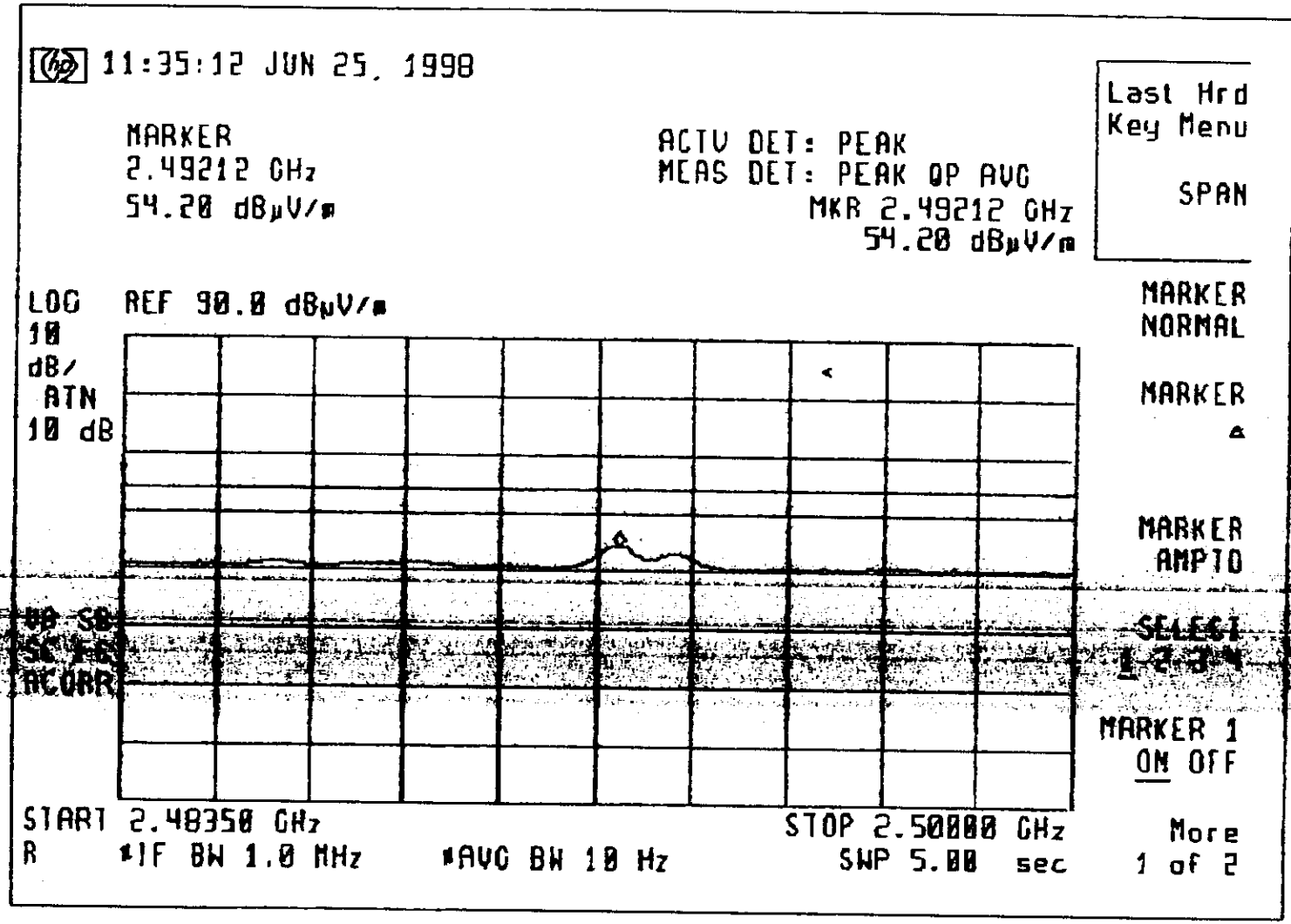
FCC ID : LXX-11

Channel 1 TX, emissions within adjacent restricted band, during TDD operation, Vertical Polarity



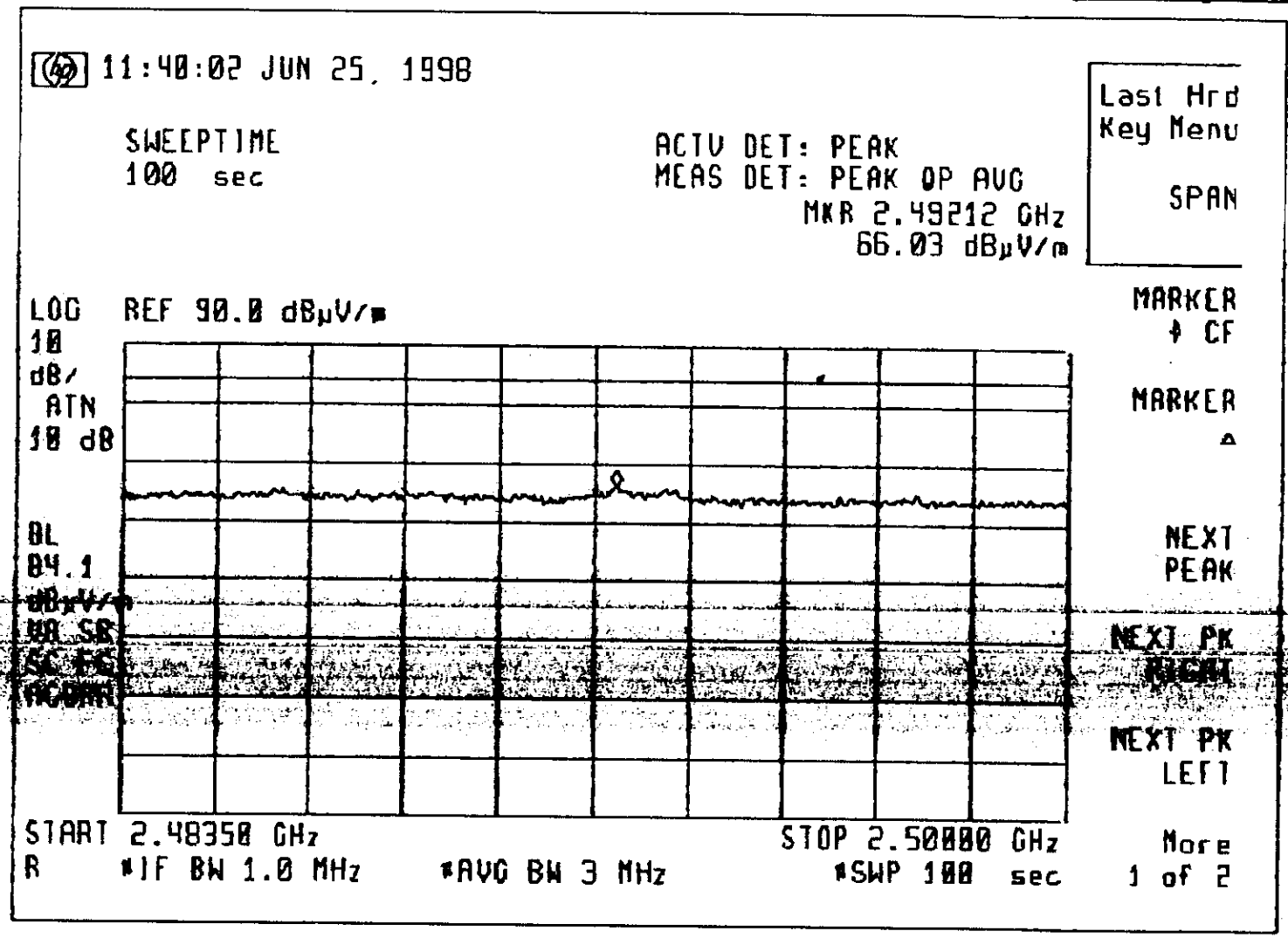
FCC ID : LXX-11

Channel 6 TX, emissions within adjacent restricted band, during continuous operation, Vertical Polarity



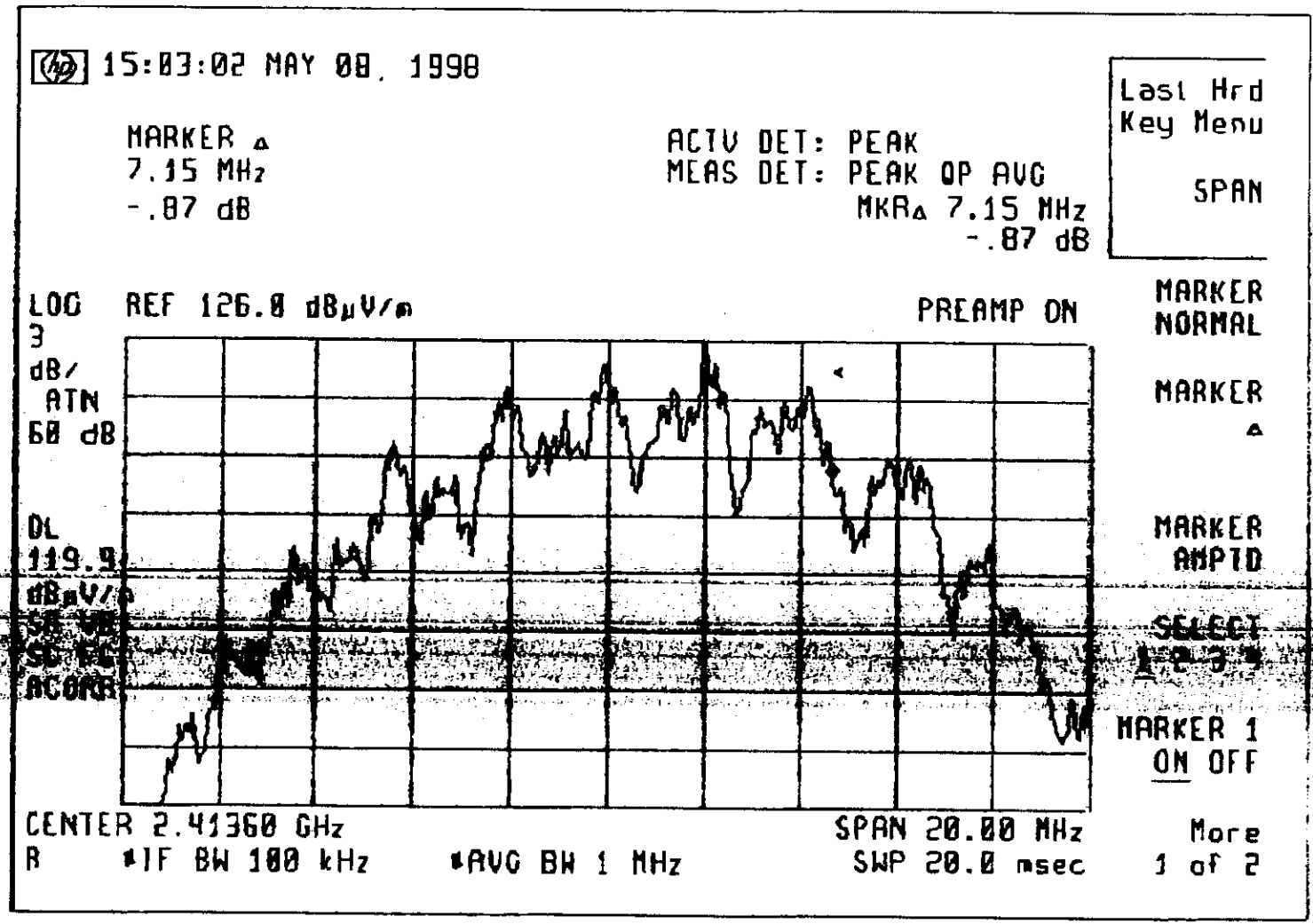
FCC ID : LXX-11

Channel 6 TX, emissions within adjacent restricted band, during TDD operation, vertical polarity



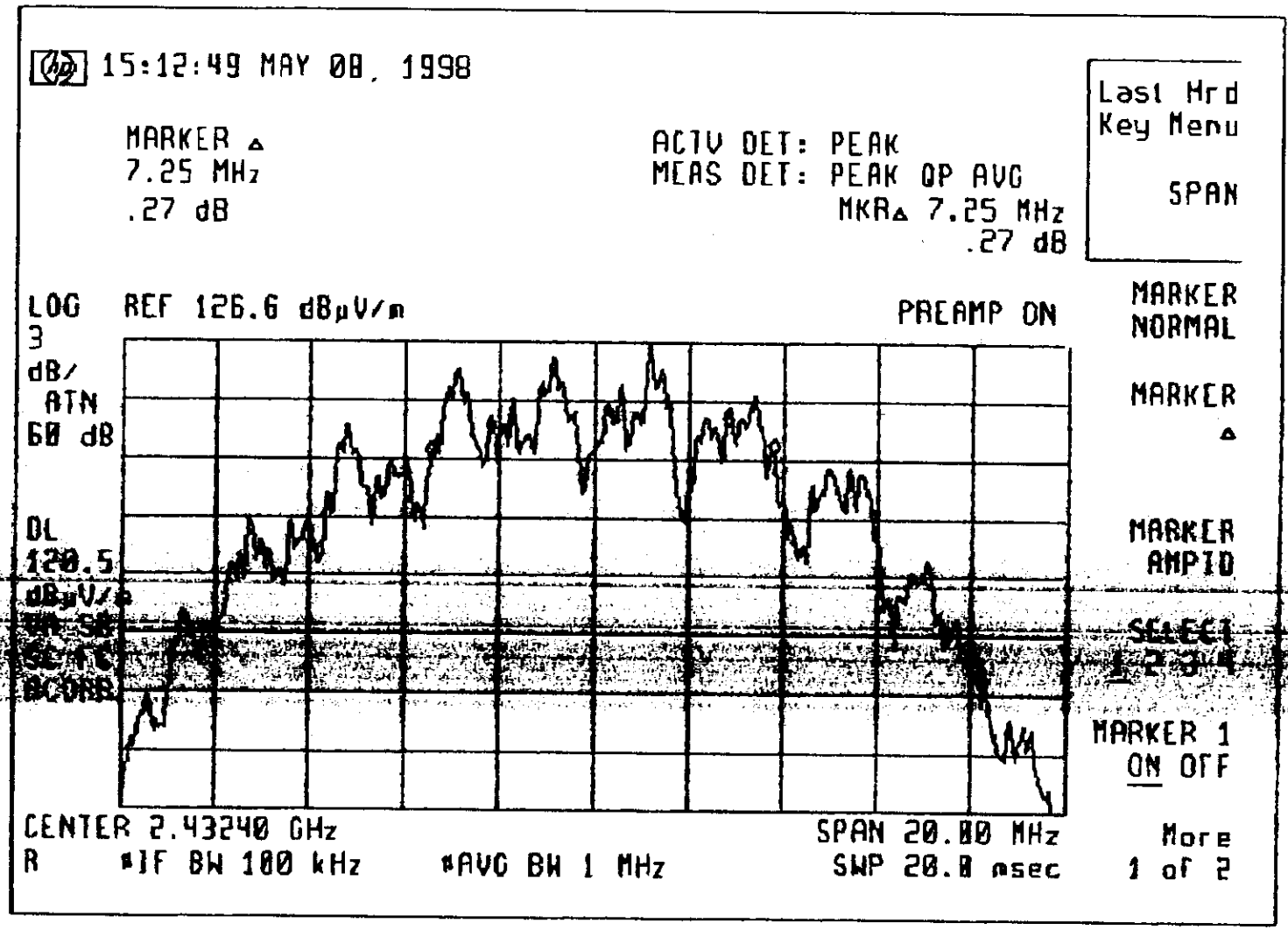
FCC ID : LXX-11

Channel 1 TX, 6dB occupied bandwidth



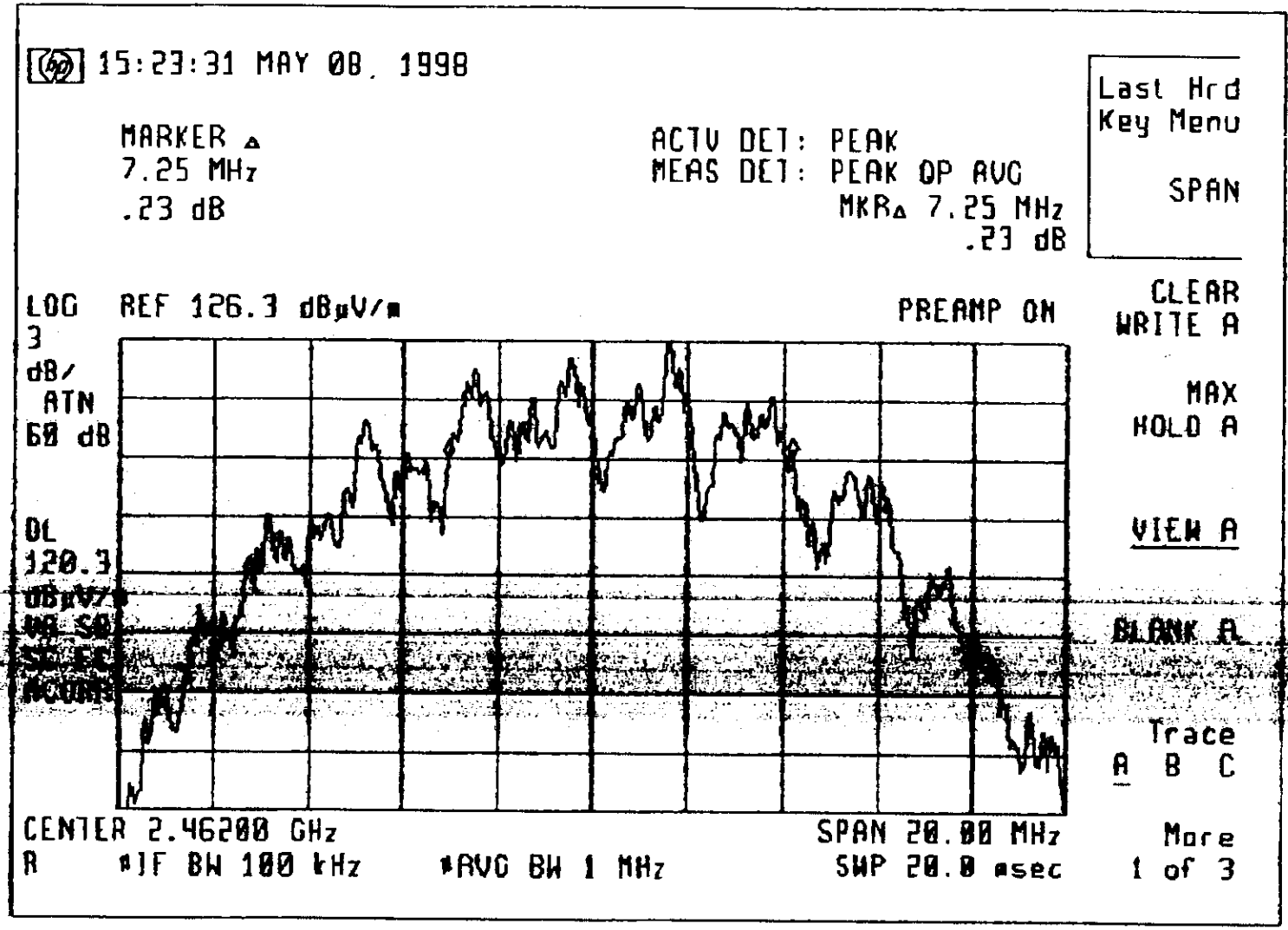
FCC ID : LXX-11

Channel 3 TX, 6dB occupied bandwidth



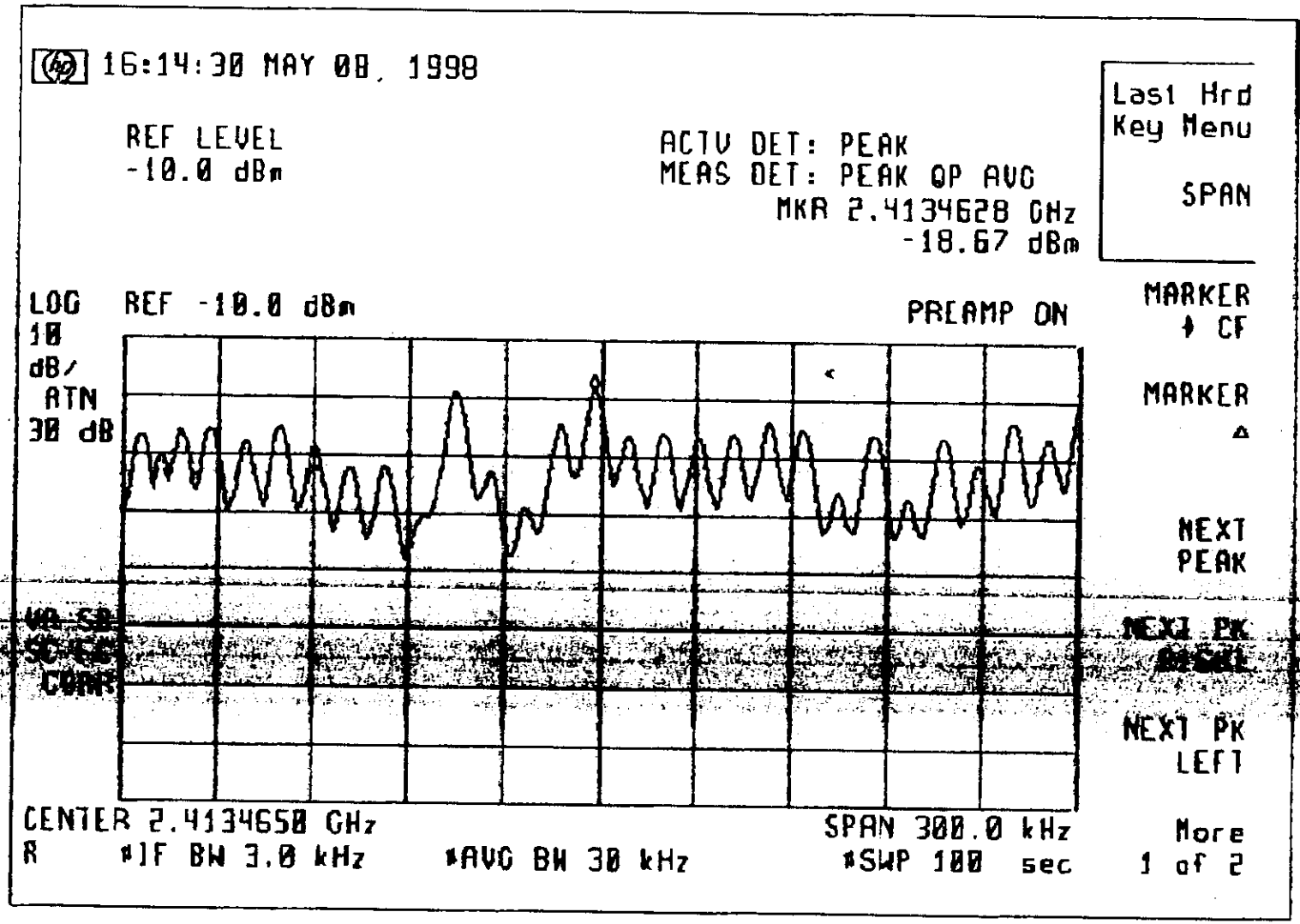
FCC ID : LXX-11

Channel 6 TX, 6dB occupied bandwidth



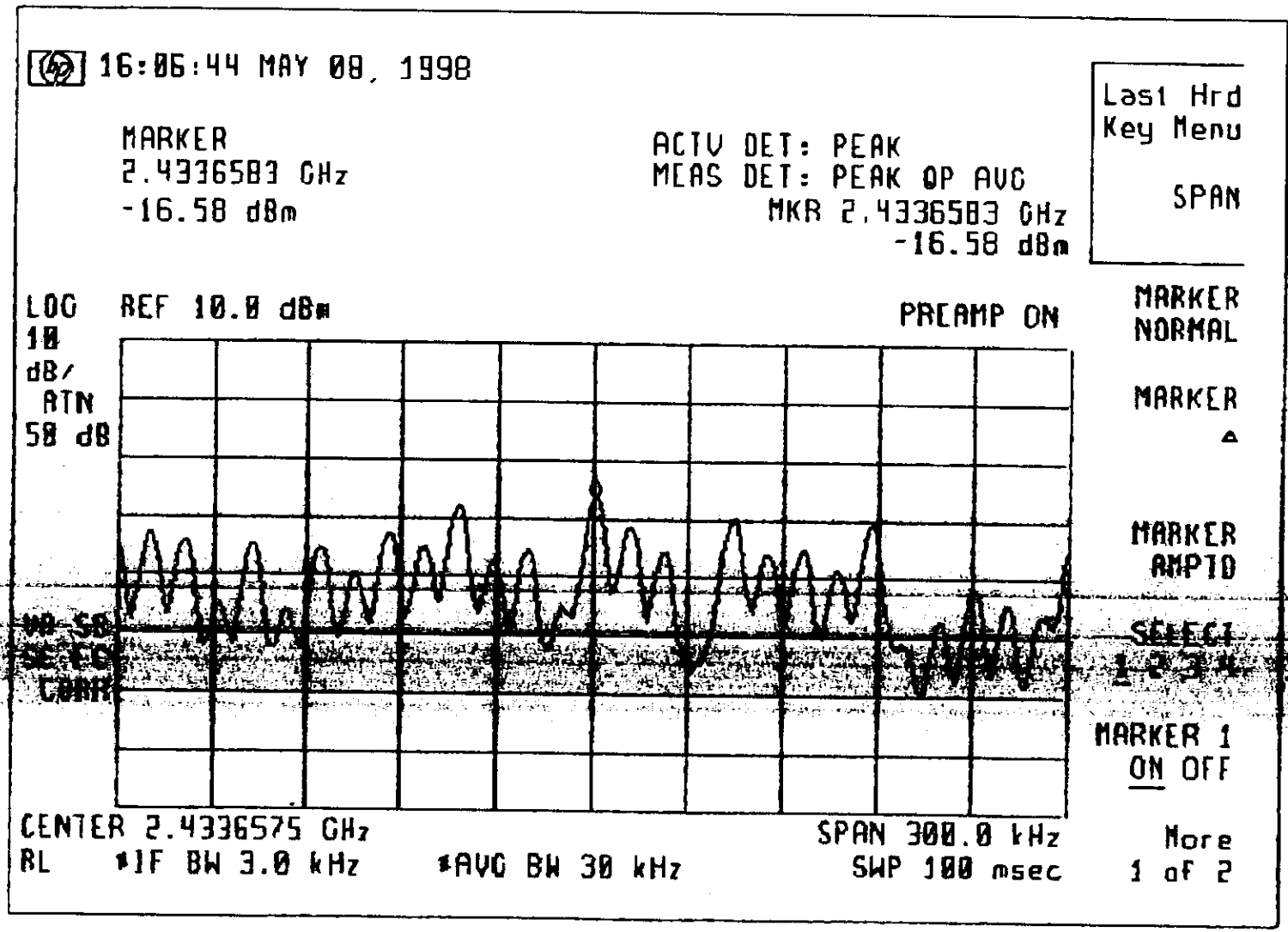
FCC ID : LXX-11

3 Kilohertz Spectral Density; channel 1



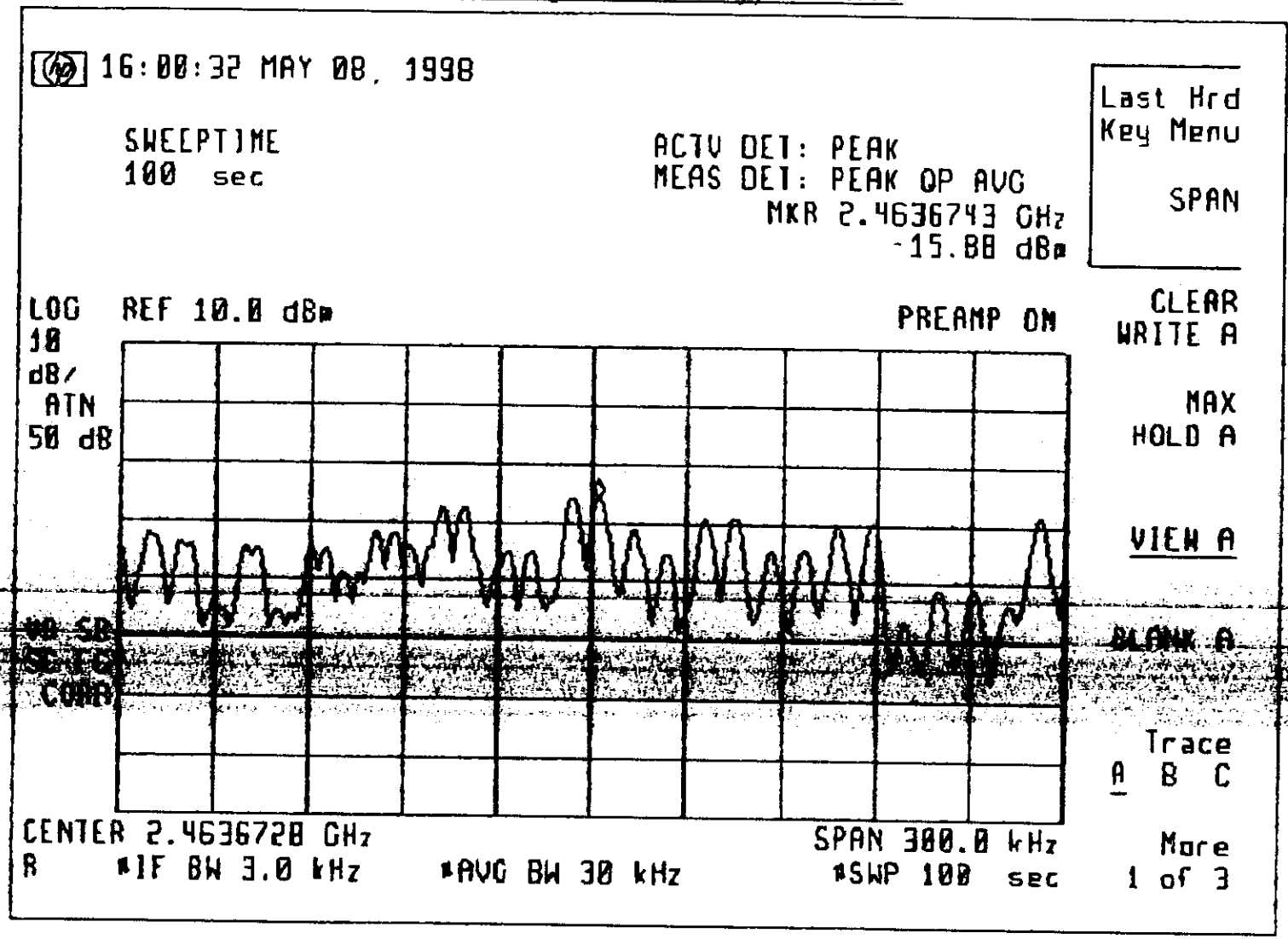
FCC ID : LXX-11

3 Kilohertz Spectral Density; channel 3



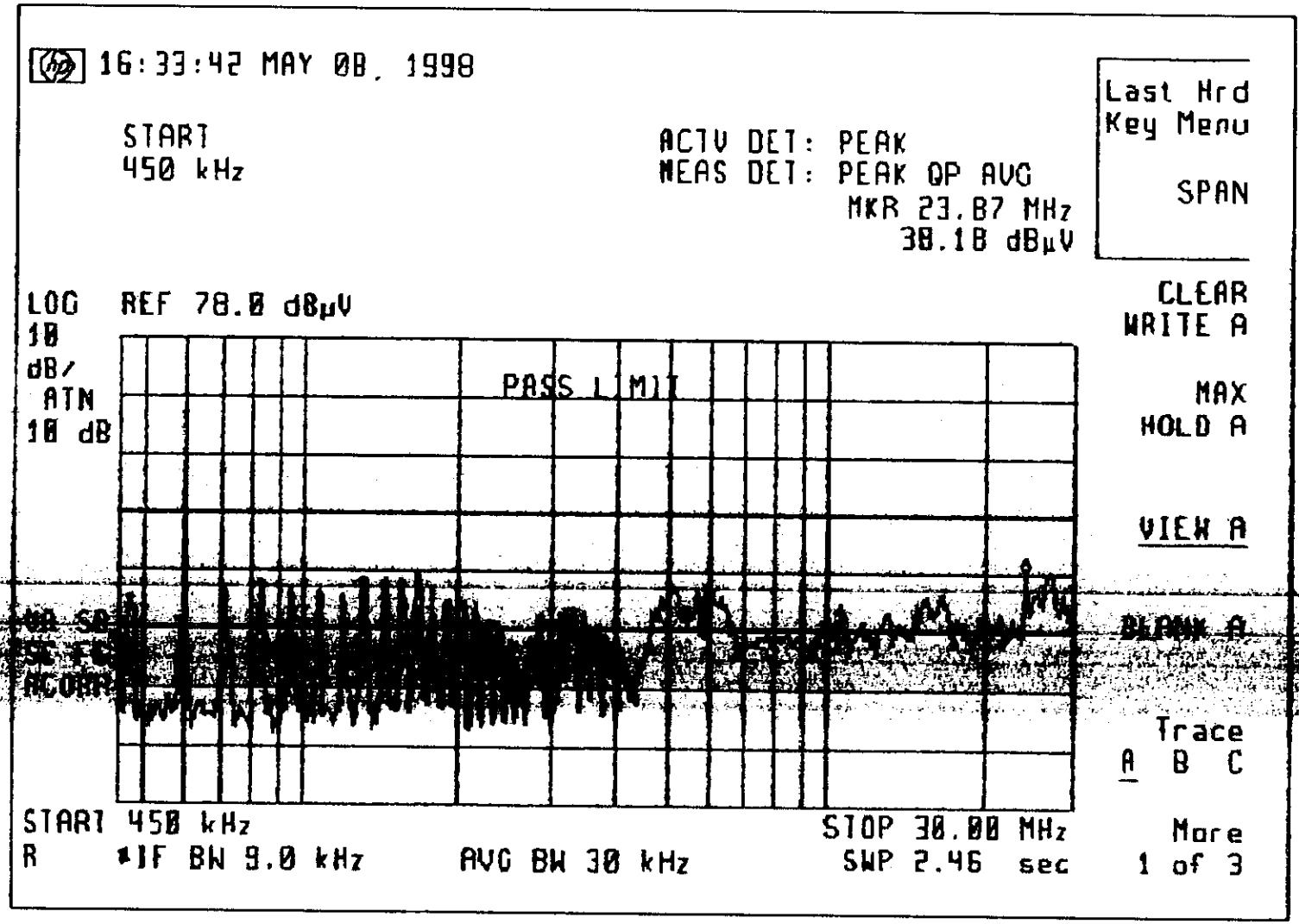
FCC ID : LXX-11

3 Kilohertz Spectral Density; channel 6



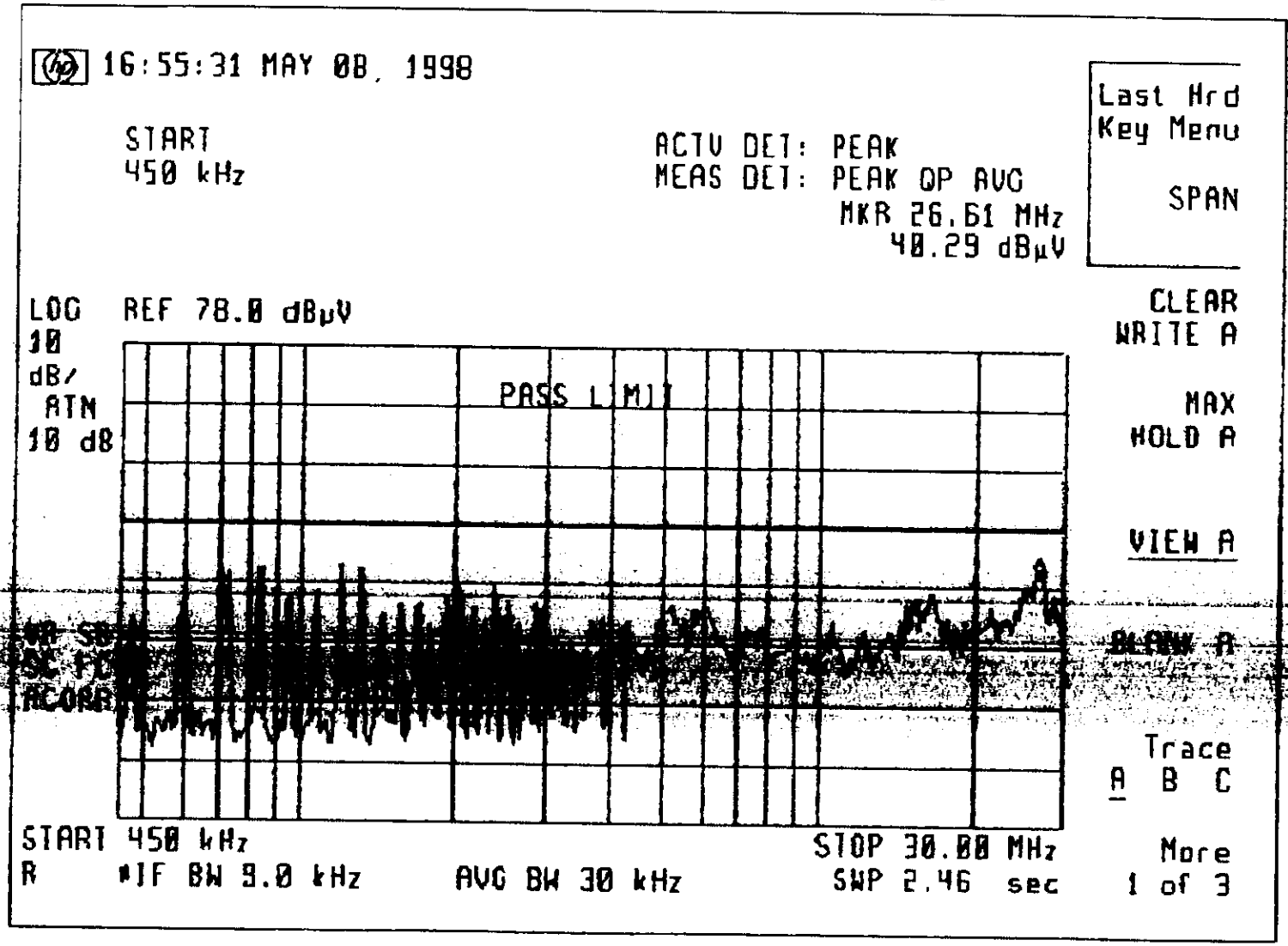
FCC ID : LXX-11

Conducted Emissions, Line 1, Channel 1 TX



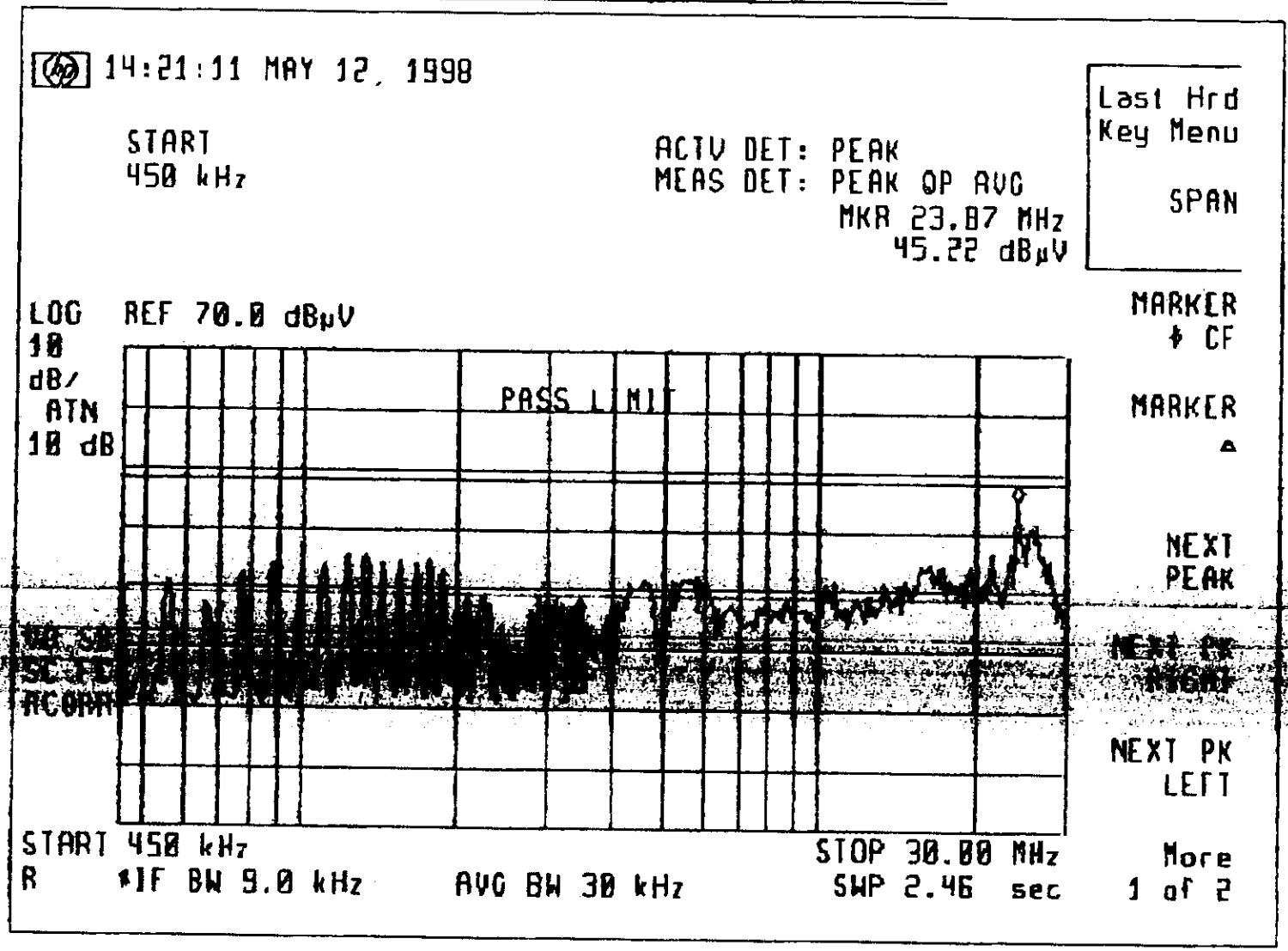
FCC ID : LXX-11

Conducted Emissions, Line 2, Channel 1 TX



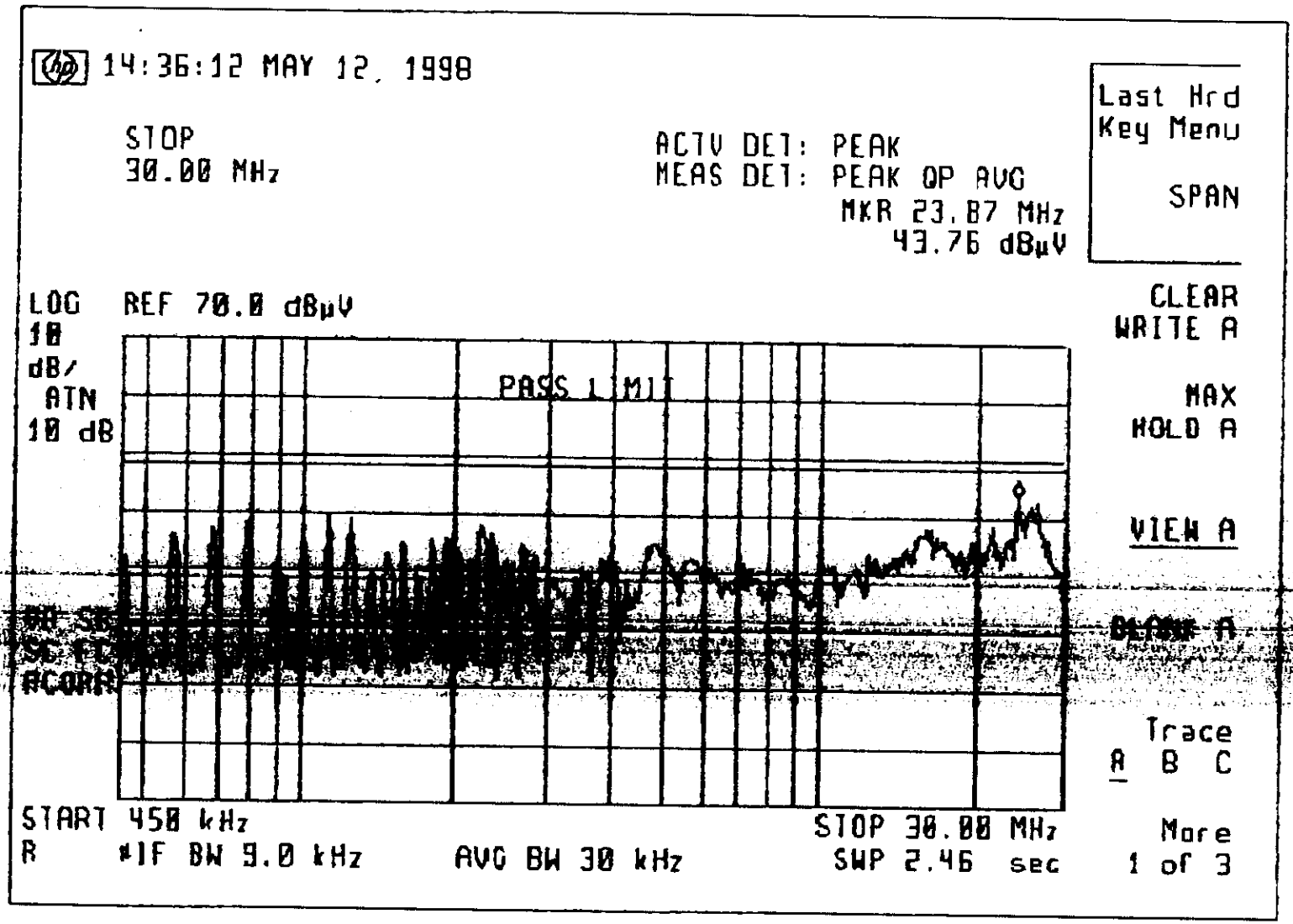
FCC ID : LXX-11

Conducted Emissions, Line 1, Channel 3 Rx



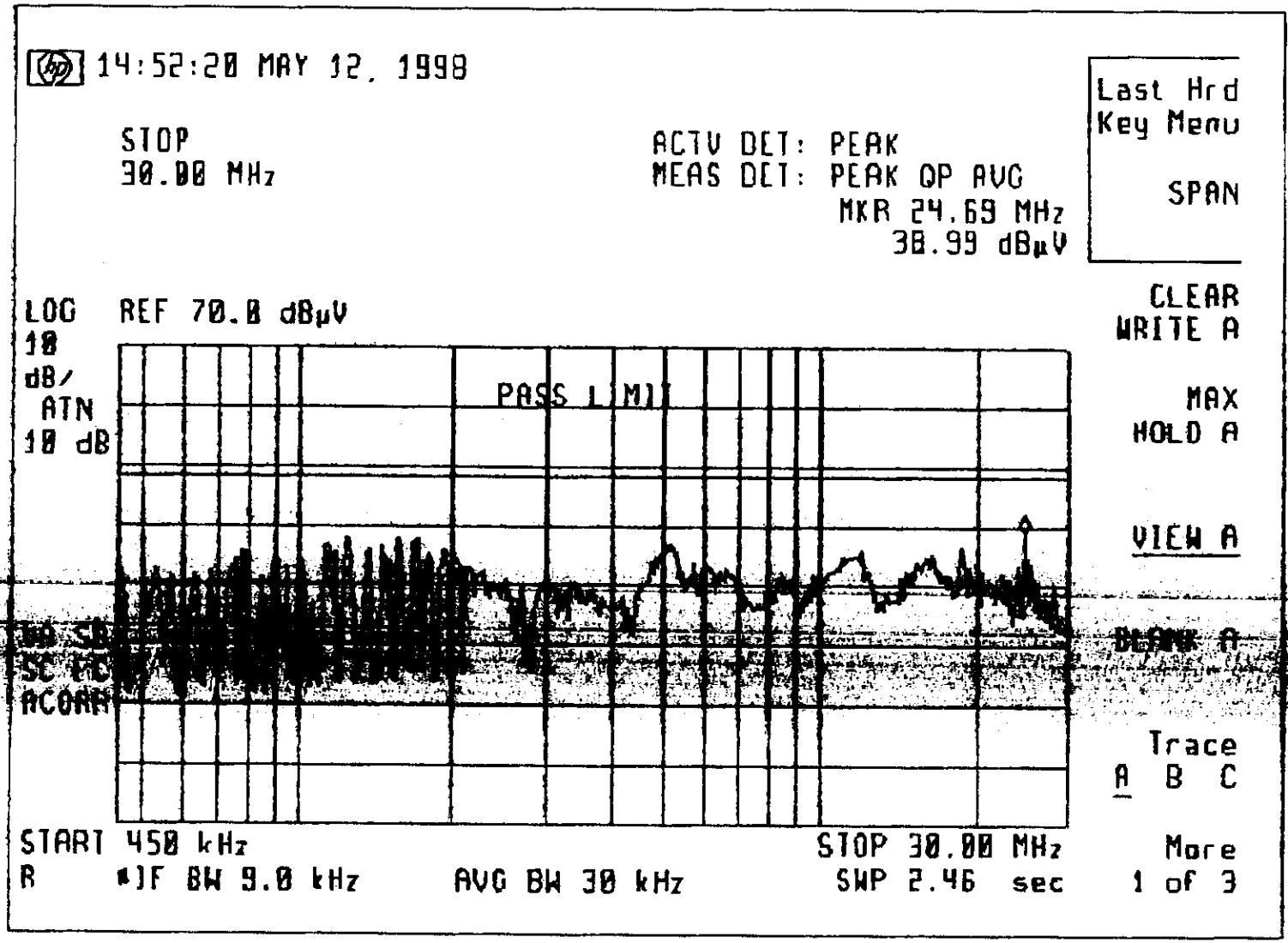
FCC ID : LXX-11

Conducted Emissions, Line 2, Channel 3 Rx



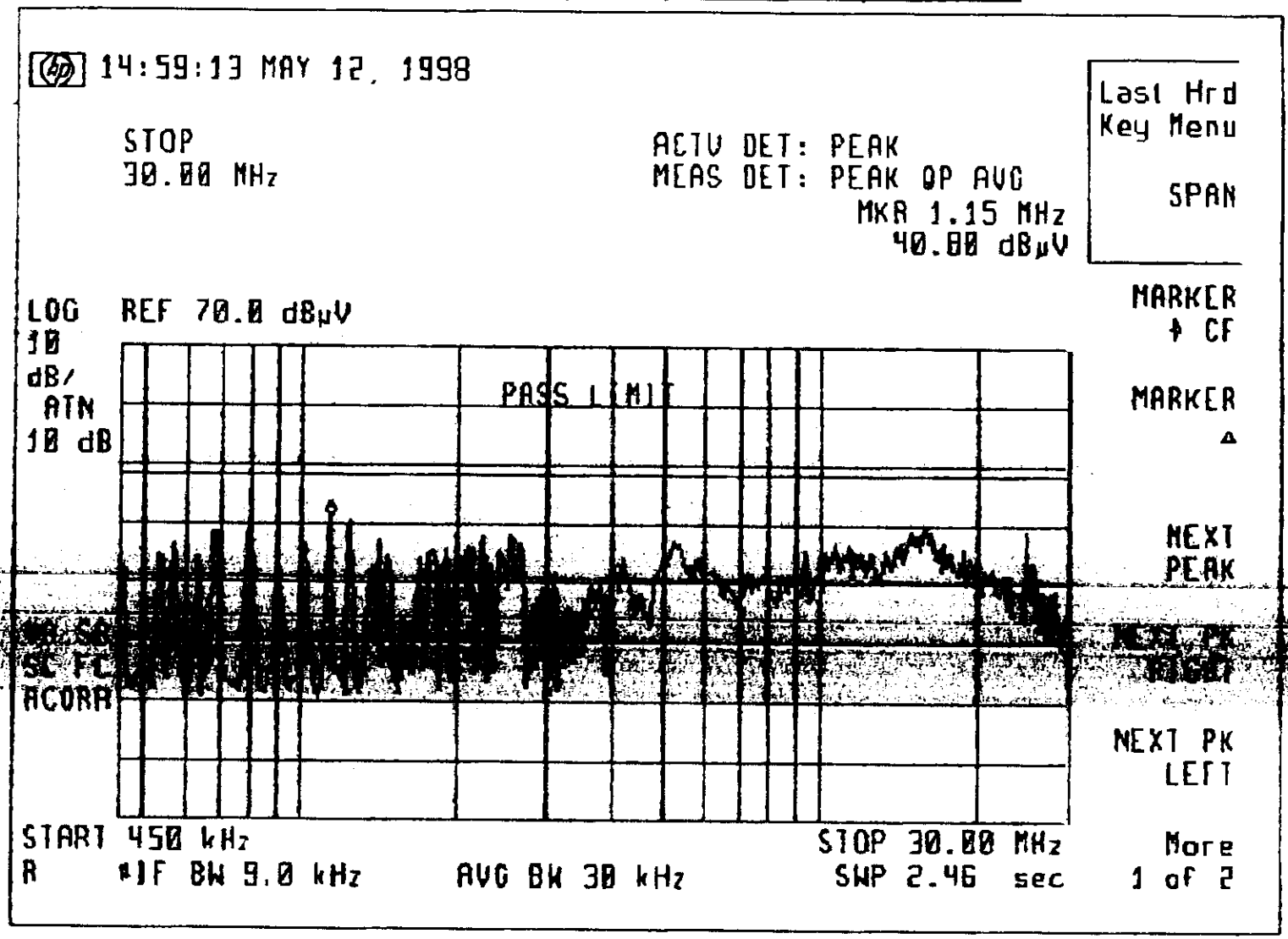
FCC ID : LXX-11

Conducted Emissions, Line 1, Channel 3 TX, TDD mode



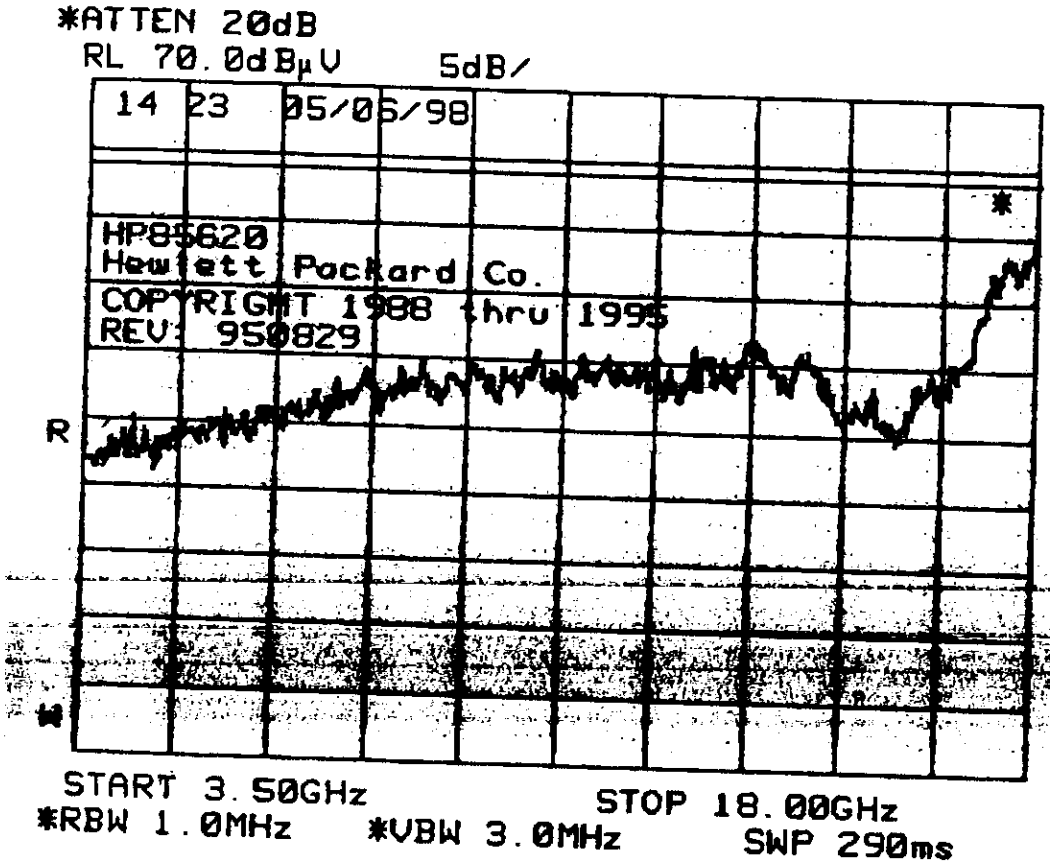
FCC ID : LXX-11

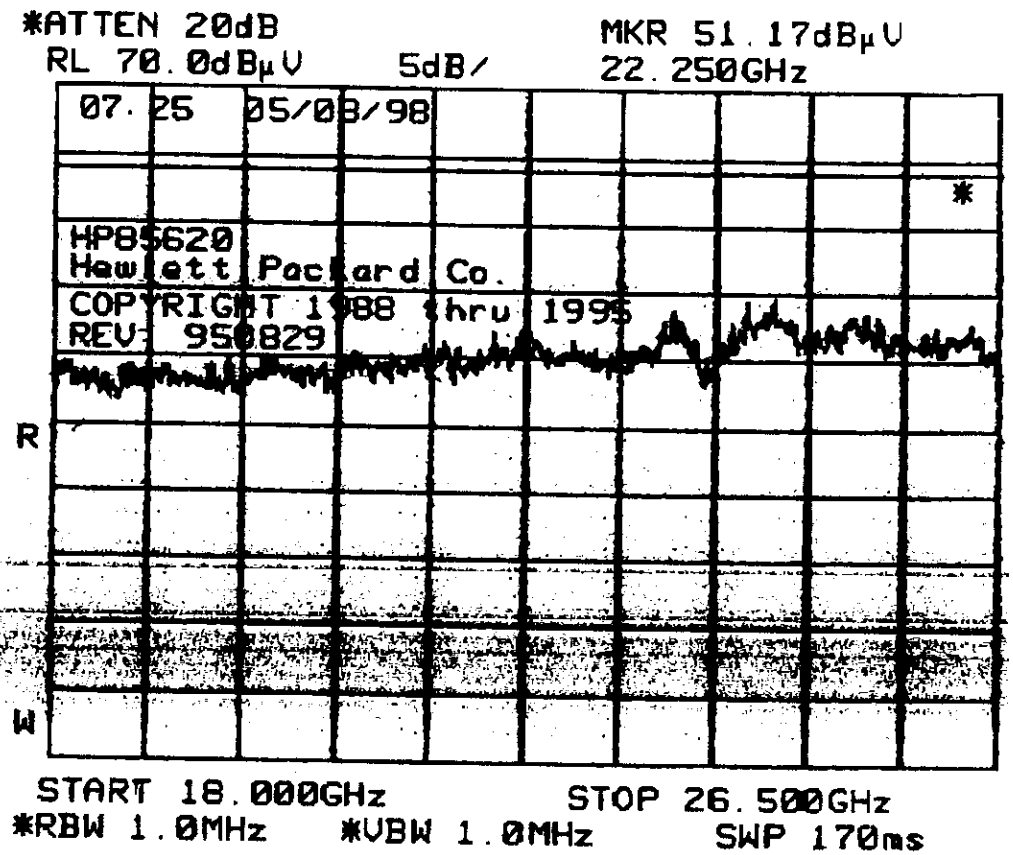
Conducted Emissions, Line 1, Channel 3 TX, TDD Mode



FCC ID : LXX-11

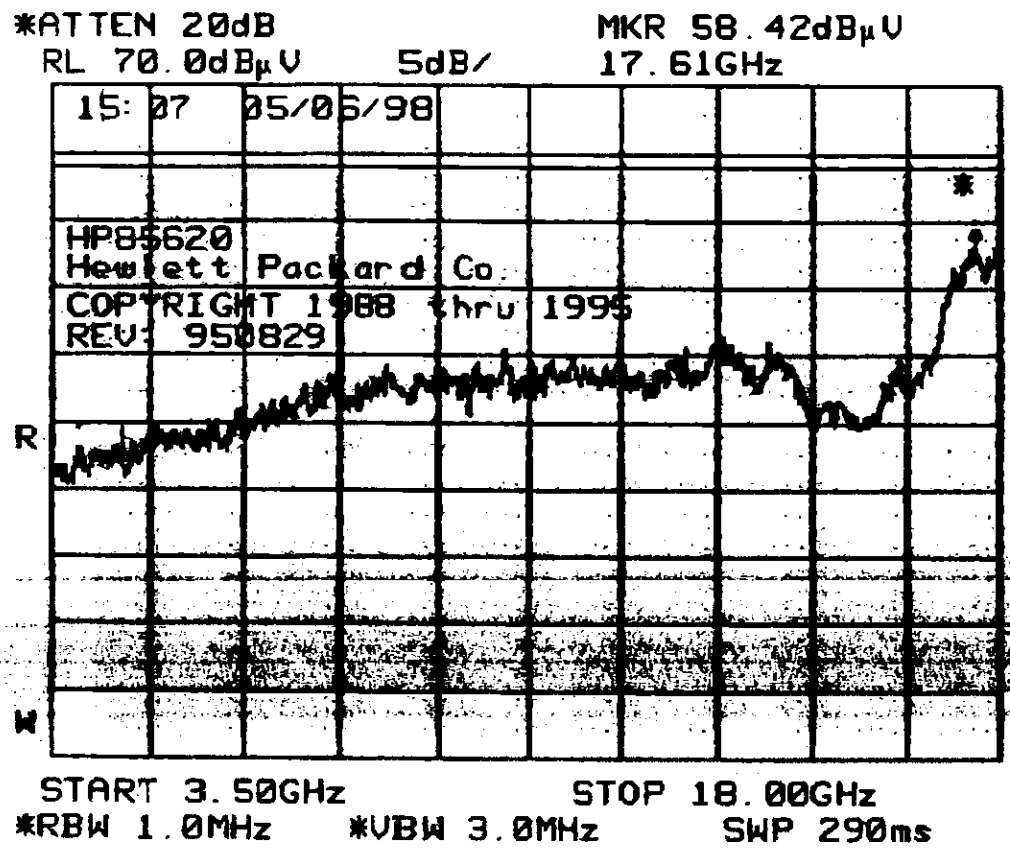
Channel 1 Emissions, second harmonic and above, measured on boresite at 1 meter.

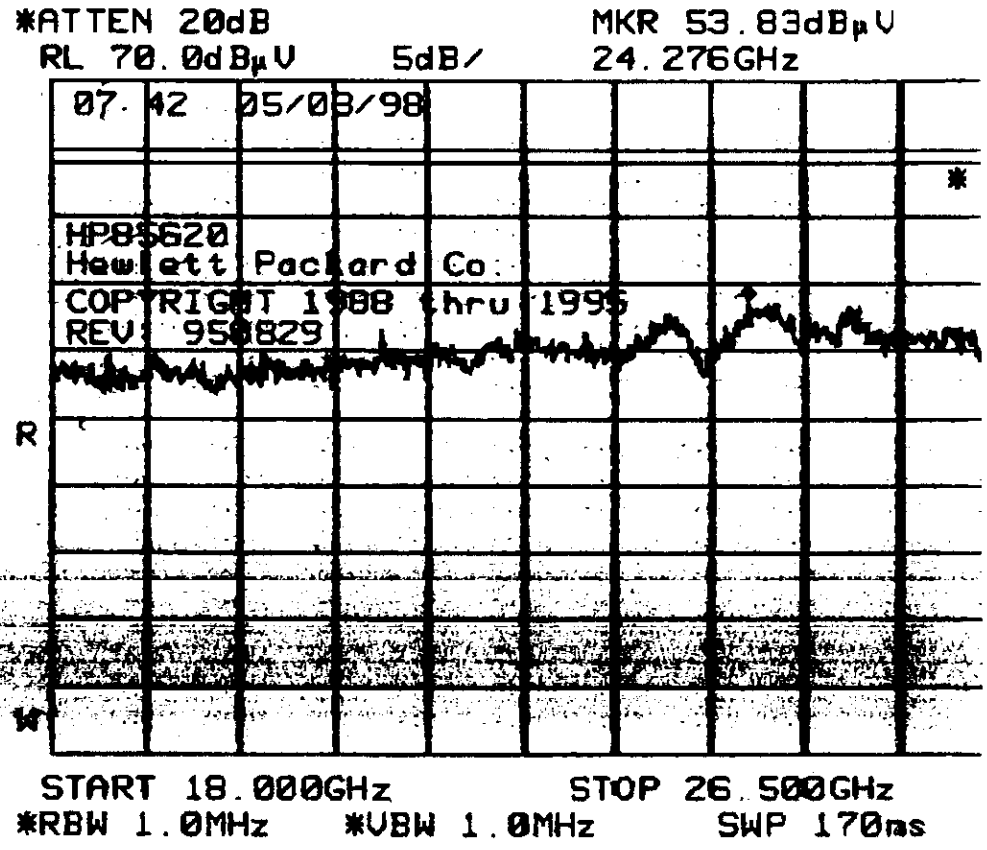




FCC ID : LXX-11

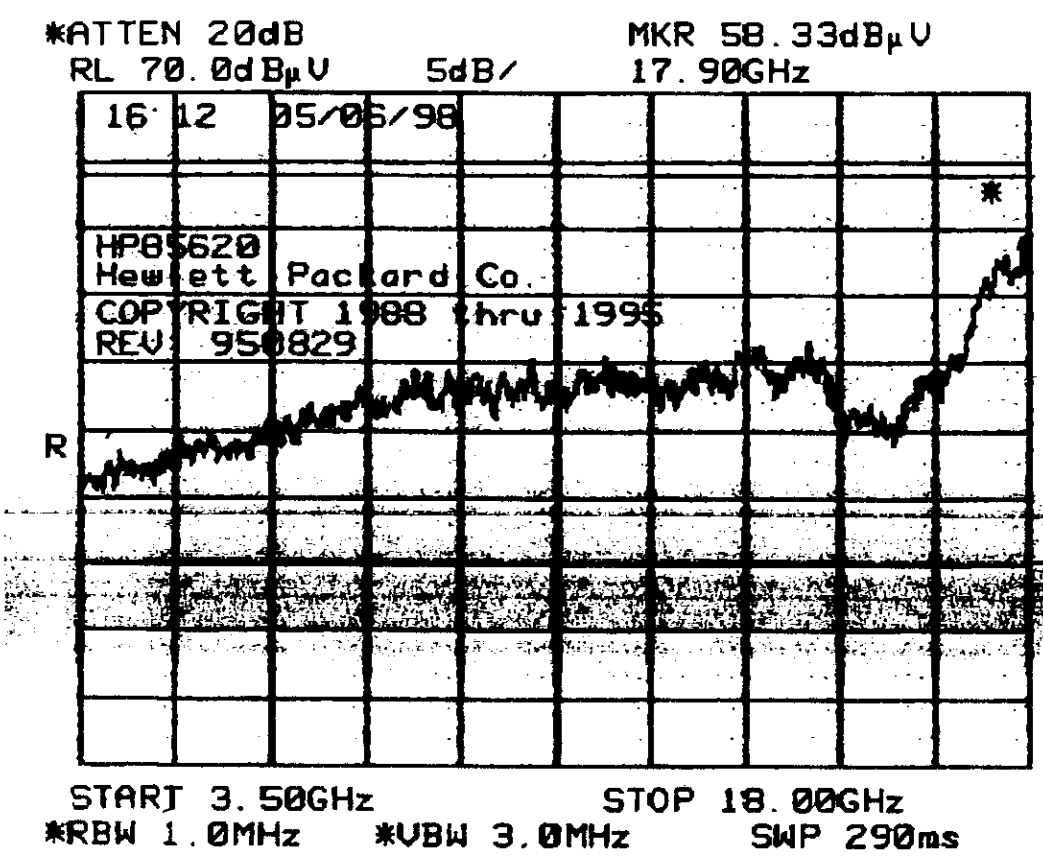
Channel 3 Emissions, second harmonic and above, measured on boresite at 1 meter.

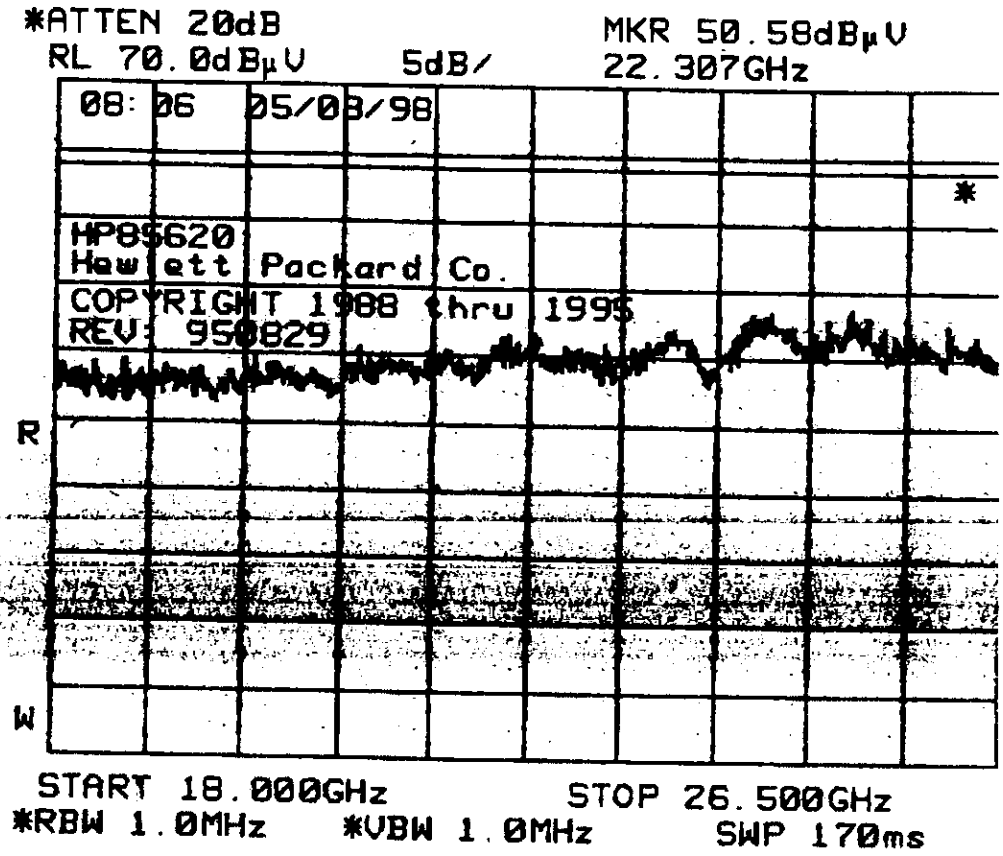




FCC ID : LXX-11

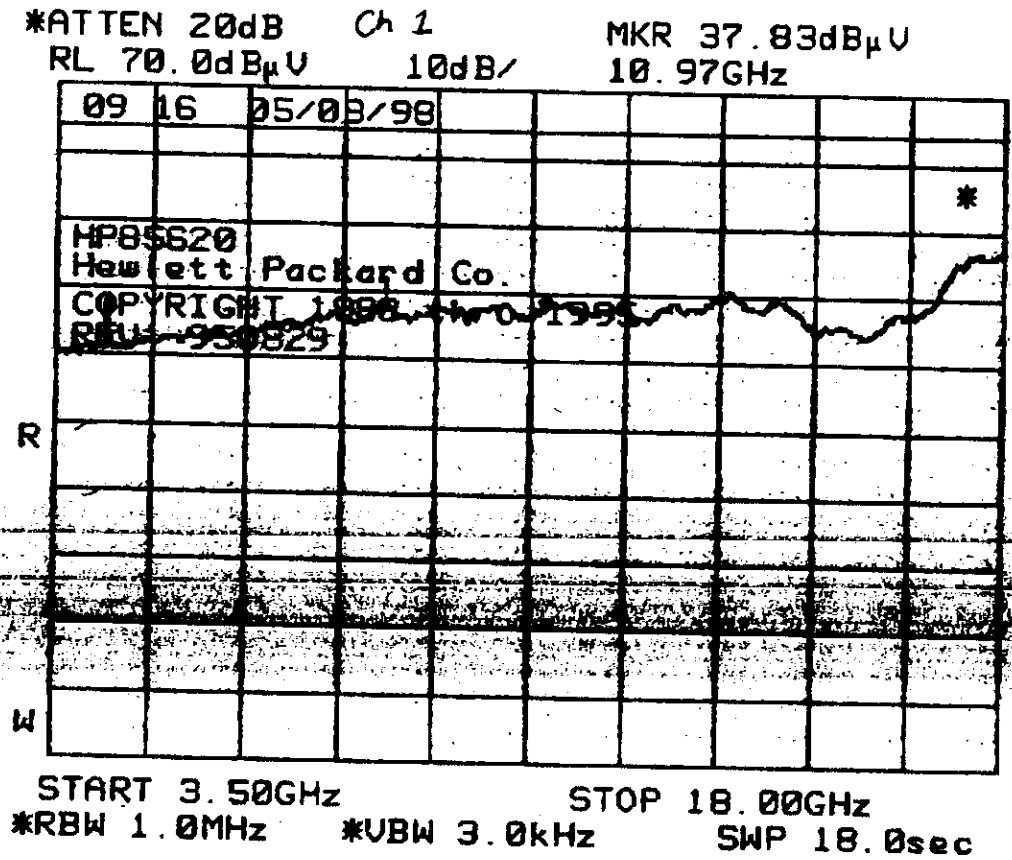
Channel 6 Emissions, second harmonic and above, measured on boresite at 1 meter.





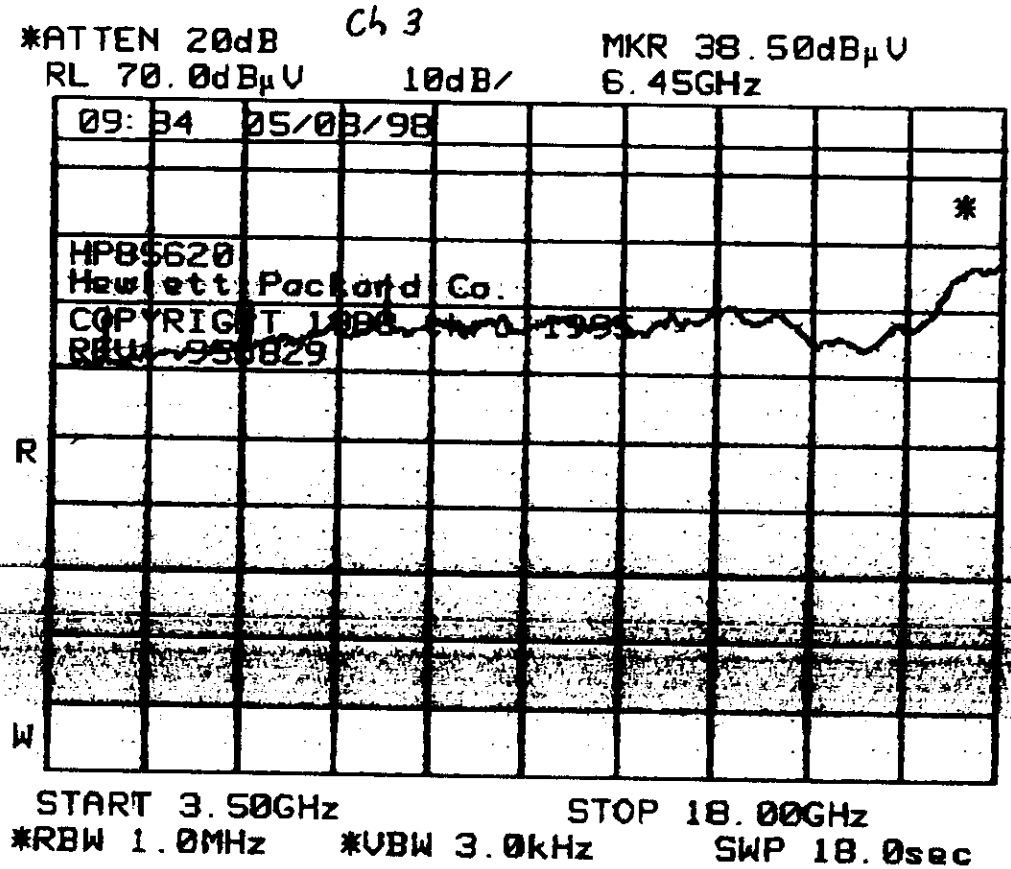
FCC ID : LXX-11

Channel 1 Emissions, second harmonic and above, measured from the system perimeter at 1 meter.



FCC ID : LXX-11

Channel 3 Emissions, second harmonic and above, measured from the system perimeter at 1 meter.



FCC ID : LXX-11

Channel 6 Emissions, second harmonic and above, measured from the system perimeter at 1 meter.