



COMPLIANCE TESTING
OF
R.F. TECHNOLOGIES
TAG TRANSPONDER

~ TEST REPORT ~

NOVEMBER 6TH , 18TH AND 19TH , 1997

Prepared for:

R.F. Technologies, Inc.

3125 N 126th Street

Brookfield, WI 53005



FCC ID: KXU-LUXP1

SIGNATURE PAGE

Prepared By:

Thomas T Lee *14 April 1998*
Thomas T Lee, EMC Engineer Date

Approved By:

Kenneth L. Boston *14 April 1998*
Kenneth L. Boston, EMC Lab Manager Date
PE #31926
Registered Professional Engineer
(State of Wisconsin)



FCC ID: KXU-LUXP1

7.3 SUMMARY OF TEST REPORT

MANUFACTURER:	R.F. TECHNOLOGIES, INC
MODEL:	TRANSPONDER
SERIAL:	N/A
DESCRIPTION:	LOW POWER TRANSPONDER
FREQUENCY RANGE:	TRANSMITTER; 315, 318 MHz channels RECEIVER; 131 kHz T.R.F.

The R.F. Technologies model LUXP1 Tag transponder was found to “meet” the radiated emission specification of Title 47 CFR FCC, Part 15, subpart C. for an intentional radiator

R.F. Technologies model LUXP1 Tag transponder was also found to “meet” the radiated emission specification of Title 47 CFR, FCC Part 15, subpart B for emissions with regards to the T.R.F. 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: KXU-LUXP1

7.4 INTRODUCTION

On November 6th, 18th, and 19th of 1997, a series of Radiated Emissions tests were performed on 2 sample models of the R.F. Technologies LUXP1 product; a transponder unit which is designed to receive an alarm signal from a low frequency transmitter and then respond with a short burst of data transmission containing an I.D. code. These tests were performed using the test procedures outlined in ANSI C63.4-1992 for intentional radiators, and in accordance with the limits set forth in FCC Part 15.231a,b 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 a TRF receiver, 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 Jan Reik of R. F. Technologies, Inc.

7.5 PURPOSE

The above mentioned tests were performed in order to determine the compliance of the R. F. Technologies LUPX1 product with limits contained in various provisions of Title 47 CFR, FCC Part 15, including:

15.109
15.205
15.209
15.231c
15.231b

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).

7.6 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 placed on an 80cm high wooden pedestal, which was centered on the flush-mounted 2m diameter metal turntable. The test sample was operated on its own [new] internal battery. The test sample was configured to run in a continuous transmit mode during the 15.231c and 15.231b measurements. Two test samples set to operate on standard channels were tested as intentional radiators, in order to determine compliance within a frequency range of 315-318 MHz, as determined by FCC part 15.31m

Please refer to Section 7.11 for pictures of the test setup.



7.7 RADIATED EMISSION TEST PROCEDURE

The fundamental and spurious (harmonic) emissions of the transmitter were tested for compliance to Title 47 CFR, FCC Part 15.231b limits for periodic devices. For the calculations used to determine the limits applicable for each of the two test samples (at their respective operating frequencies) refer to Appendix A. These limits are expressed in decibels (dB) above 1 microvolt per meter ($\mu\text{V}/\text{m}$). The samples were tested from the lowest frequency generated by the transmitter (without going below 9 kHz) to the 10th harmonic of the fundamental frequency generated by the device. The appropriate limits were also observed when the fundamental or 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 7.10. The samples were placed on a nonconductive (wooden) pedestal in the 3 Meter chamber and the antenna mast was placed such that the antenna was 3m from the test object. A biconical antenna or tuned dipole was used to measure emissions from 30 to 200 MHz, a log periodic or tuned dipole 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.

No significant emissions were found aside from the transmitter fundamental and several harmonics. The unit was scanned for emissions in both transmit and receive modes, over the range 30 to 3500 MHz to establish compliance with Part 15.109 for both the transmitter and the receiver (which is subject to verification under Part 15.101b). Also, the scans were performed to evaluate the digital controller section of the product, which is subject to verification as a Class B digital device. The same procedures as detailed for the transmitter tests described above were used to perform these measurements. No spurious signals, other than the noise floor of the system at the band edges, could be found within 20 dB of the limits.

In addition to measuring the levels of radiated emissions, the occupied bandwidth of the transmitters were measured. In accordance with FCC Part 15.231c, the 20dB bandwidth of the transmitted signal should be within a window of 0.25% of the center carrier frequency. The calculation for this bandwidth can be found in Appendix A. The resolution bandwidth was set to the closest available filter setting on the HP8546A EMI system that corresponded to 5% of the allowable bandwidth determined in the calculation mentioned above, without going below the resolution bandwidth of 10kHz, as dictated in ANSI C63.4-1992 section 13.1.7.

The samples were activated to transmit in a continuous mode and were placed on the aforementioned pedestal within the 3 meter chamber. The transmitted signal was received on a tuned dipole antenna and fed to the HP8546A EMI System, where the fundamental frequency was displayed, and a plot of the occupied bandwidth was produced. These plots are included in Appendix C.

From the data supplied, it can be seen that the test samples do indeed "meet" the bandwidth requirement established by FCC Part 15.231(c).



7.8 TEST EQUIPMENT UTILIZED FOR RADIATED EMISSIONS TEST

A list of the test equipment and antennas used for the tests can be found in Section 7.13, 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. When a reading is taken using the peak detector, a duty cycle correction factor can be applied for conversion to an average reading. This operation can be used when measuring periodic data transmission, under FCC part 15.231b, and Part 15.35c. The calculation for deriving this duty factor can be found in Appendix A. The resulting average reading was then compared to the appropriate limit in order to determine compliance. 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.

7.9 CONDUCTED EMISSION TEST

Due to the fact that this product operated on its own internal battery power, as opposed to using a power cord, it was not necessary to perform a test for Conducted Emissions.



FCC ID: KXU-LUXP1

Manufacturer: R.F. Technologies, Inc.

Model: LUXP1

Serial Number(s): N/A

7.10 - Restricted Bands affecting this product

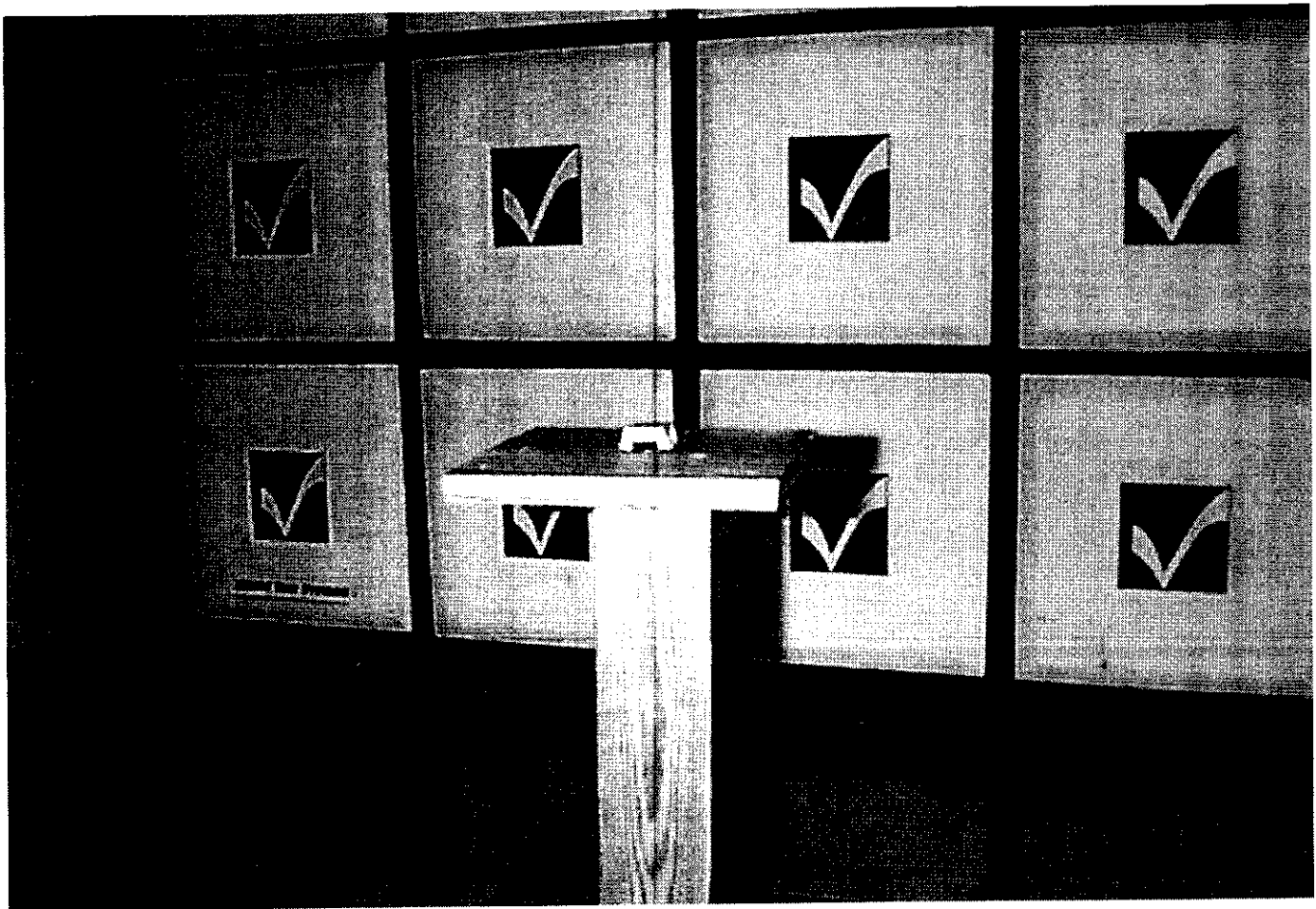
Frequency (MHz)	Limit (μ V)	Limit (dB/ μ V/m)
322-335.4	200	46.0
399.9-410	200	46.0
608-614	200	46.0
960-1240	500	54.0
1300-1427	500	54.0
1435-1626.5	500	54.0
1645.5-1646.5	500	54.0
1660-1710	500	54.0
1718.8-1722.2	500	54.0
2200-2300	500	54.0
2310-2390	500	54.0
2483.5-2500	500	54.0
2655-2900	500	54.0



7.11 – Photos taken during testing



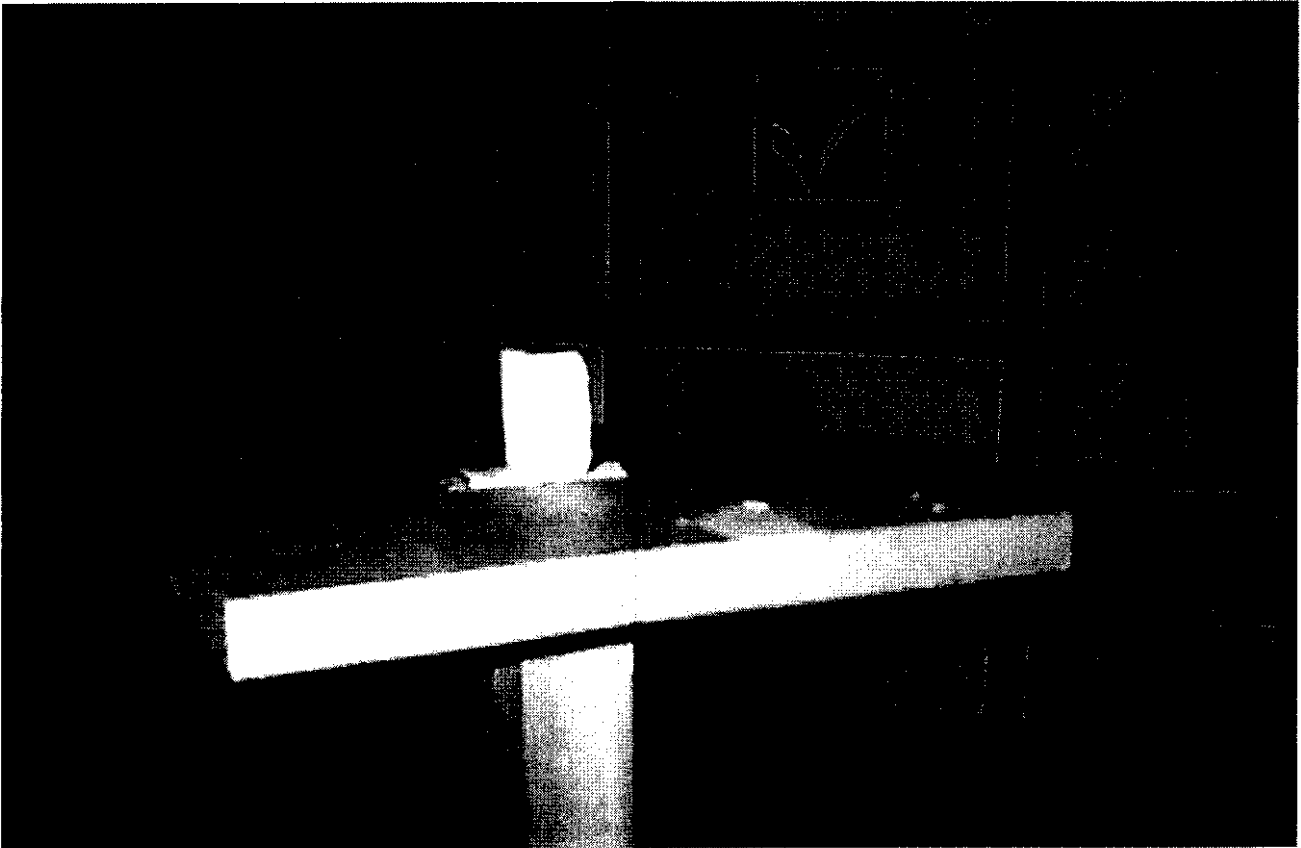
FCC ID: KXU-LUXP1



View of the LUXP1 during the Radiated Emissions tests. This view shows the orientation of the product where the maximum signal levels were present (horizontal polarity).



FCC ID: KXU-LUXP1



View of the LUXP1 during the Radiated Emissions tests. This view shows the orientation of the product where the maximum signal levels were present (vertical polarity - azimuth=0°).



FCC ID: KXU-LUXP1

7.12. 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 Small Transponder model LUXP1 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: KXU-LUXP1

7.13 - 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



APPENDIX A:

SAMPLE CALCULATIONS



FCC ID: KXU-LUXP1

Manufacturer: R.F. Technologies, Inc.

Model: LUXP1

Serial Number(s): pre-production

Calculation of Radiated Emissions limits for FCC Part 15.231(b) (260-470 MHz)

FIELD STRENGTH OF FUNDAMENTAL FREQUENCIES:

The calculation involves a linear interpolation of 3750 to 12500 $\mu\text{V/m}$ over 260-470 MHz,
Where field strength of the fundamental frequency (f_0) when, $260 \leq f_0 \leq 470$ MHz, can be found by:
 $3750.0 + 41.667(f_0 - 260)$, where f_0 is in MHz.

FIELD STRENGTH OF SPURIOUS/HARMONIC FREQUENCIES:

The calculation involves a linear interpolation of 375 to 1250 $\mu\text{V/m}$ over 260 to 470 MHz,
Where field strength of the harmonic frequencies ($2f_0, 3f_0, \dots$), when $260 \leq f_0 \leq 470$ MHz, can be
found by: $375.0 + 4.1667(f_0 - 260)$, where f_0 is in MHz.

❖ Where $f_0 = 315$ MHz

Fundamental: $3750 + 41.667(315 - 260) = 6041.7 \mu\text{V/m}$

Harmonic: $375 + 4.1667(315 - 260) = 604.17 \mu\text{V/m}$

❖ Where $f_0 = 318$ MHz

Fundamental: $3750 + 41.667(318 - 260) = 6166.7 \mu\text{V/m}$

Harmonic: $375 + 4.1667(318 - 260) = 616.67 \mu\text{V/m}$

Frequency (MHz)	Fundamental limit ($\mu\text{V/m}$)	Fundamental limit (dB $\mu\text{V/m}$)	Harmonic limit ($\mu\text{V/m}$)	Harmonic limit (dB $\mu\text{V/m}$)
315	6041.7	75.62	604.17	55.62
318	6166.7	75.80	616.67	55.80

Manufacturer: R.F. Technologies, Inc.



FCC ID: KXU-LUXP1

Manufacturer: R.F. Technologies, Inc.

Model: LUXP1

Serial Number(s): pre-production

Duty Cycle Correction Factor Calculation

For a graphical presentation of the data bursts being transmitted from the transponder, refer to Appendix C. for a zero span picture of the modulation burst from one representative unit. This plot was taken of a unit, which has been programmed to send its recognition code repeatedly, with a shortened wait period between bursts, to permit radiated emissions tests to be readily performed. When the unit is activated upon entering an alarm zone provided by the 131 kHz door transmitter, the transponder sends out a pre-set identifier code of 30.2 milliseconds duration, followed by a blanking interval of 350 milliseconds. While activated, and using the identifier code of the maximum possible duration, the total On-time is 8.4 milliseconds and the total Off-time is 21.8 milliseconds. When the total On-time is computed over a 100 millisecond window, according to FCC Part 15.35(c), where the pulse train exceeds 100 milliseconds, a total of 8.4 milliseconds is obtained. This results in a relaxation factor of 21.5 dB, which is above the allowable cap of 20 dB, as stated in FCC Part 15.35(b)

$$\text{Relaxation Factor} = 20 \log (8.40/100)$$

$$= 21.5 \text{ dB}$$

Therefore, the maximum value of 20 dB is used.



FCC ID: KXU-LUXP1

Manufacturer: R.F. Technologies, Inc.

Model: LUXP1

Serial Number(s): pre-production

Occupied Bandwidth Calculations

FCC Part 15.231(c) states that the bandwidth of the periodic device shall be no wider than 0.25% of the center frequency for devices operating between 70 and 900 MHz. Said bandwidth is determined at the -20 dB reference to peak carrier points.

For 315 MHz, the 20 dB bandwidth is $0.0025 \times 315 = 787.5 \text{ kHz}$

For 318 MHz, the 20 dB bandwidth is $0.0025 \times 318 = 795 \text{ kHz}$

Refer to Appendix C for the set of graphs that show the actual occupied bandwidth of the two test samples.



APPENDIX B:

DATA CHARTS



FCC ID: KXU-LUXP1

Measurement of Electromagnetic Radiated Emission within 3 Meter FCC Listed Chamber

Frequency Range inspected: 30 to 3500 MHz

Date of Test:	11/6, 18, 19 /1997	Manufacturer:	R.F. Technologies
Location:	L.S. Compliance, Inc.	Model No.:	LUXP1
	W66 N220 Commerce Court		315 MHz
	Cedarburg, WI 53012		
Specifications:	Title 47CFR, FCC Part 15.231b	Serial No.:	Pre-production
Distance:	3 meters	Configuration:	Active, continuous burst
Equipment:	HP 8546A EMI Receiver	Detector(s) Used:	Peak
	EMCO 3115 Double Ridged Waveguide		
	EMCO 3146A Log Periodic		

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

Higher order harmonics were found to be below the noise floor of the receiving system:

Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	EMI Meter Reading (dB μ V/m)	Duty Cycle Correction (dB)	Corrected Reading (dB μ V/m)	15.231b Limit (dB μ V/m)	Margin (dB)
314.95	H	1.00	160.00	58.1	20.0	38.1	75.62	37.52
314.95	V	1.90	70.00	52.5	20.0	32.5	75.62	43.12
629.9	H	1.45	160.00	57.0	20.0	37.0	55.62	18.62
629.9	V	1.00	90.00	51.8	20.0	31.8	55.62	23.82
944.84	H	1.00	160.00	45.2	20.0	25.2	55.62	30.42
944.84	V	1.15	80.00	42.1	20.0	22.1	55.62	33.52
1259.77	H	1.20	205.00	42.8	20.0	22.8	55.62	32.82
1259.77	V	1.00	230.00	39.4	20.0	19.4	55.62	36.22
1574.72	H	1.00	205.00	46.0	20.0	26.0	54.00	28.00
1574.72	V	1.10	260.00	44.7	20.0	24.7	54.00	29.30
1889.65	H	1.15	225.00	44.7	20.0	24.7	55.62	30.92
1889.65	V	1.00	290.00	41.8	20.0	21.8	55.62	33.82



FCC ID: KXU-LUXP1

Measurement of Electromagnetic Radiated Emission within 3 Meter FCC Listed Chamber

Frequency Range inspected: 30 to 3500 MHz

Date of Test:	11/6, 18, 19 /1997	Manufacturer:	R.F. Technologies
Location:	L. S. Compliance, Inc.	Model No.:	LUXP1
	W66 N220 Commerce Court		318 MHz
	Cedarburg, WI 53012		
Specifications:	47CFR FCC Part 15.231b,15.205	Serial No.:	Pre-production
Distance:	3 meters	Configuration:	Active, continuous burst
Equipment:	HP 8546A EMI Receiver	Detector(s) Used:	Peak
	EMCO 3115 Double Ridged Waveguide		
	EMCO 3146A Log Periodic		
	EMCO 3110B Biconical		

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

Higher order harmonics were found to be below the noise floor of the receiving system:

Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	EMI Meter Reading (dB μ V/m)	Duty Cycle Correction (dB)	Corrected Reading (dB μ V/m)	15.231b Limit (dB μ V/m)	Margin (dB)
318.07	H	1.00	160.00	59.1	20.0	39.1	75.80	36.7
318.07	V	1.60	70.00	54.1	20.0	34.1	75.80	41.7
636.14	H	1.40	160.00	59.9	20.0	39.9	55.80	15.9
636.14	V	1.00	75.00	54.7	20.0	34.7	55.80	21.1
954.21	H	1.50	160.00	41.6	20.0	21.6	55.80	34.2
954.21	V	1.15	80.00	37.2	20.0	17.2	55.80	38.6
1272.3	H	1.20	225.00	44.0	20.0	24.0	55.80	31.8
1272.3	V	1.00	270.00	42.3	20.0	22.3	55.80	33.5
1590.4	H	1.00	240.00	46.0	20.0	26.0	54.00	28.0
1590.4	V	1.05	270.00	44.4	20.0	24.4	54.00	29.6



FCC ID: KXU-LUXP1

Measurement of Electromagnetic Radiated Emission within 3 Meter FCC Listed Chamber

Frequency Range inspected: 30 to 2000 MHz

Date of Test:	11/6, 18, 19 /1997	Manufacturer:	R.F. Technologies
Location:	L. S. Compliance, Inc.	Model No.:	LUXP1
	W66 N220 Commerce Court		315 and 318 MHz units
	Cedarburg, WI 53012		
Specifications:	Title 47CFR, FCC Part 15.109	Serial No.:	Pre-production
Distance:	3 meters	Configuration:	No burst, receive only
Equipment:	HP 8546A EMI Receiver	Detector(s) Used:	Quasi-peak
	EMCO 3115 Double Ridged Waveguide		
	EMCO 3146A Log Periodic		
	EMCO 3110B Biconical		

No significant radiated emissions within 20 dB of the limit could be found.



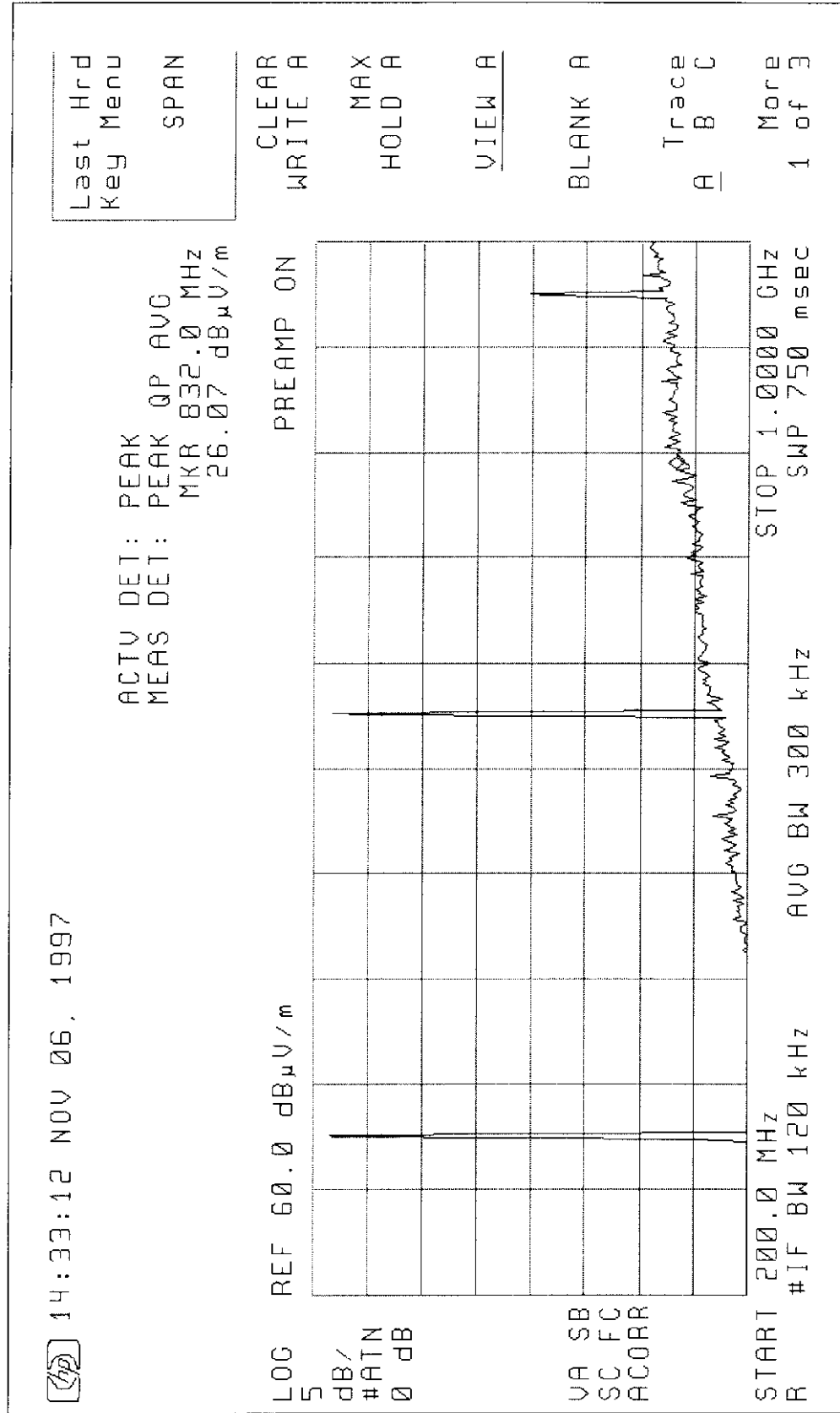
APPENDIX C:

GRAPHS



FCC ID: KXU-LUXP1

318 MHz Transponder, emissions below 1 GHz, horizontal polarity



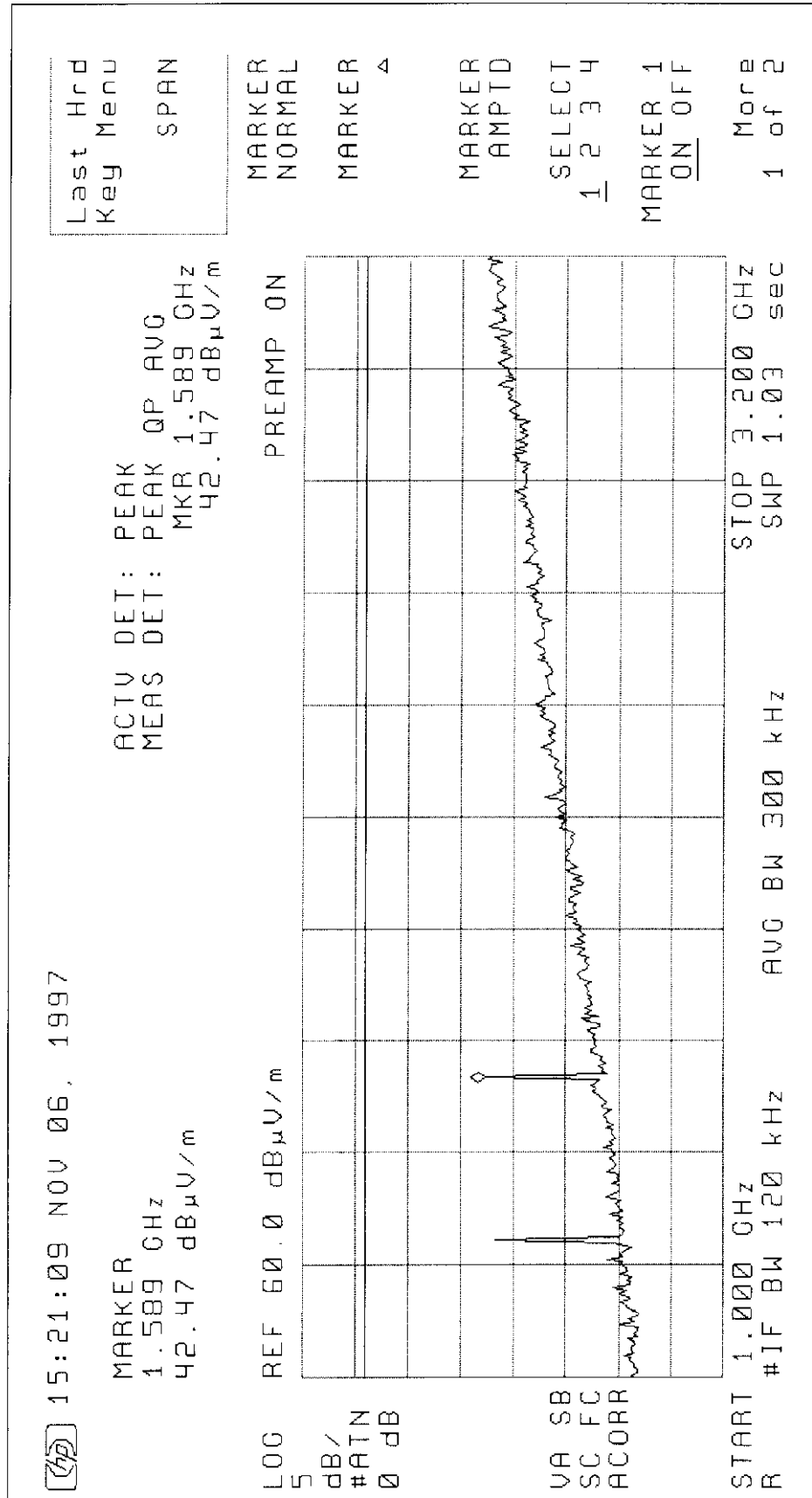
318 MHz Transponder, emissions below 1 GHz, vertical polarity





FCC ID: KXU-LUXP1

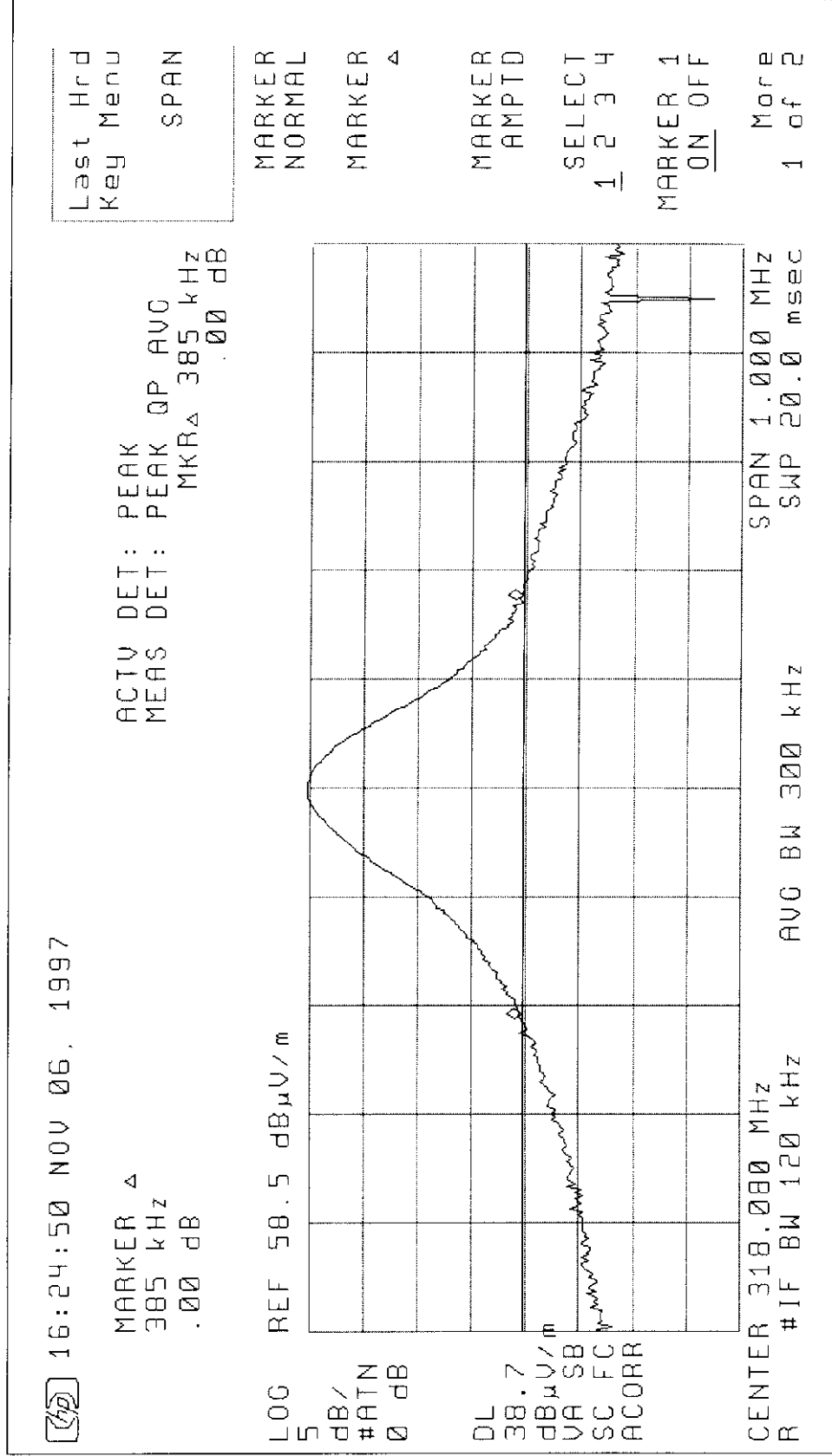
318 MHz Transponder, emissions above 1 GHz, horizontal polarity





FCC ID: KXU-LUXP1

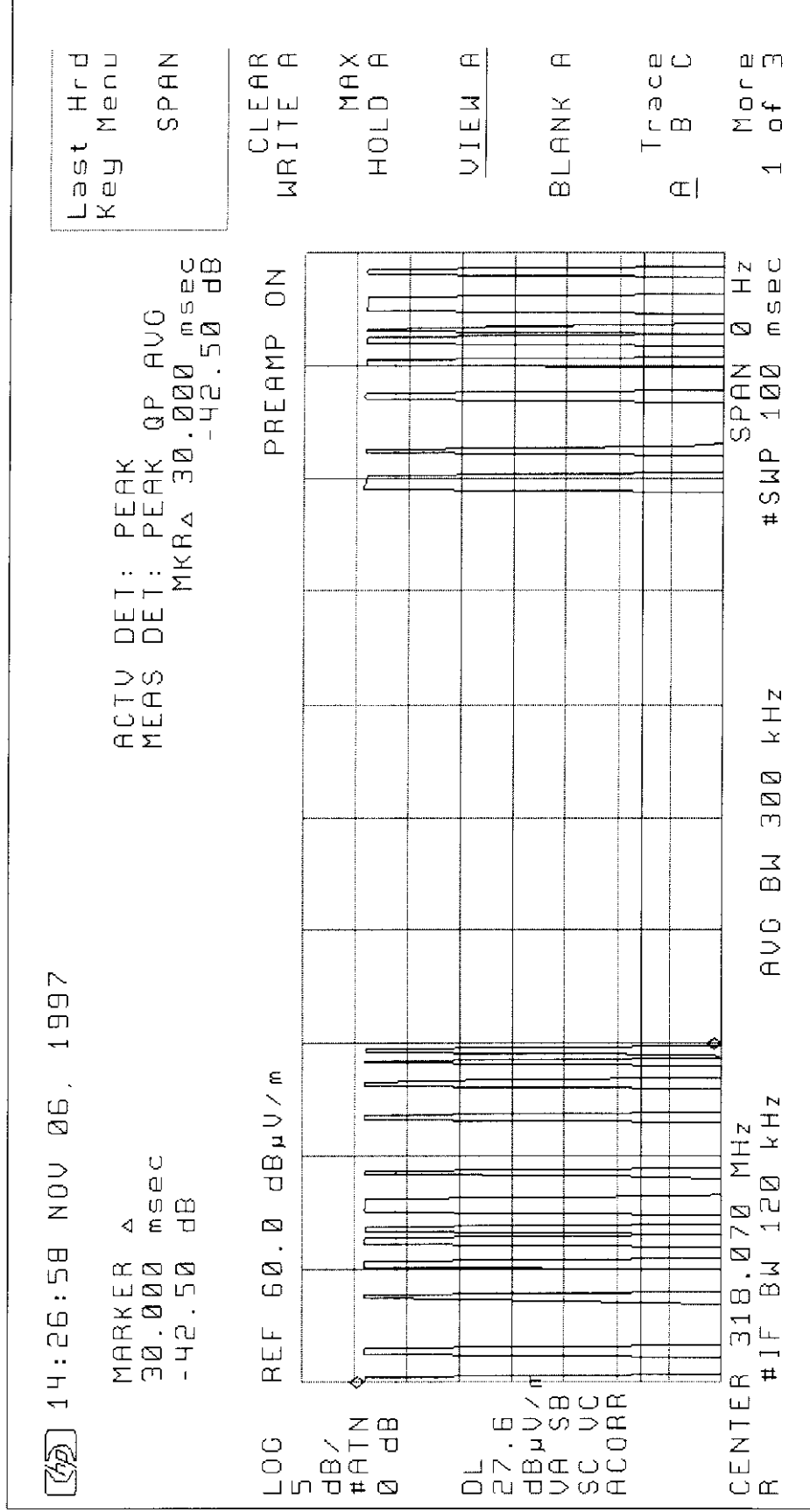
318 MHz Transponder, occupied bandwidth





FCC ID: KXU-LUXP1

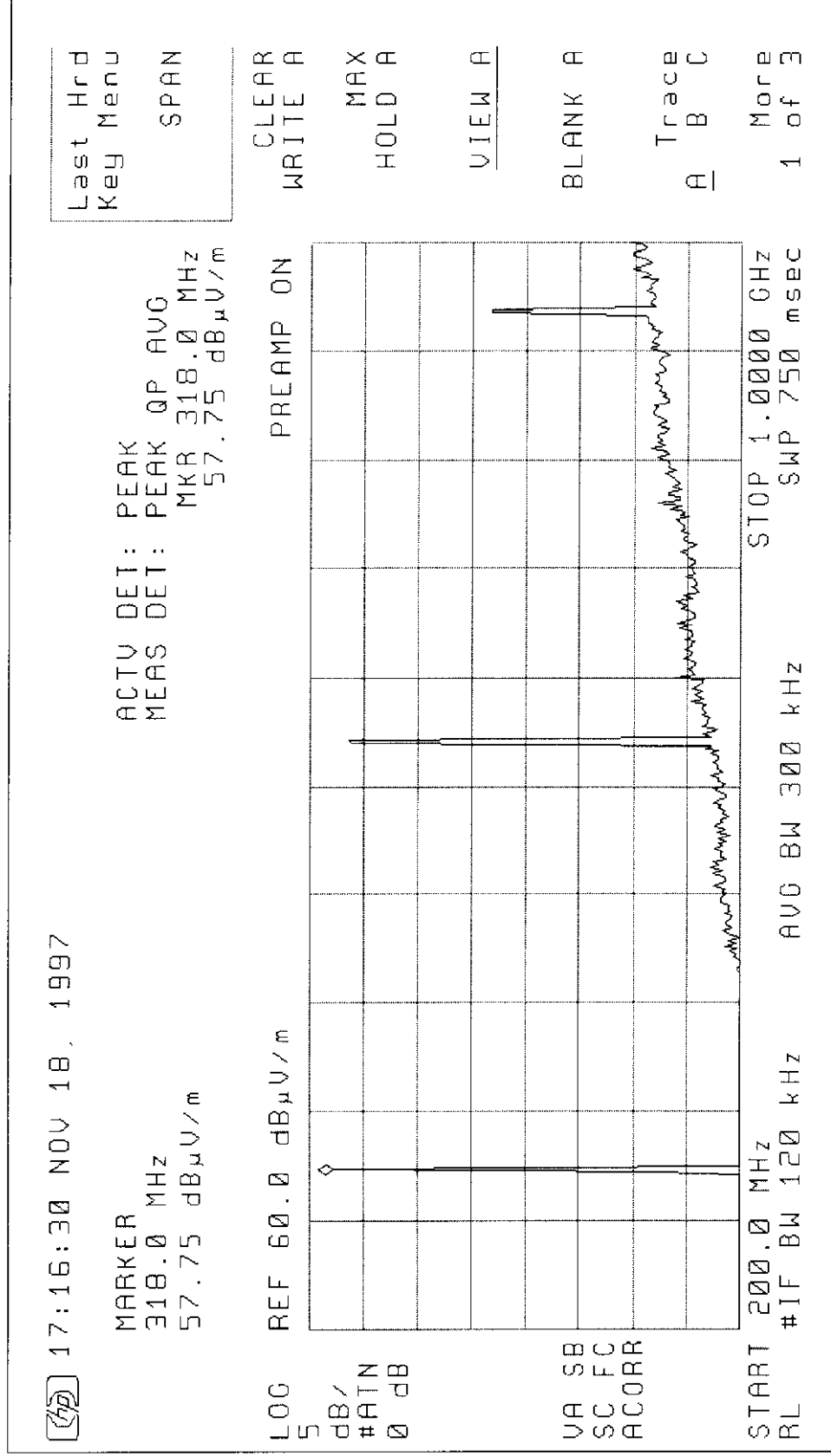
318 MHz Transponder, duty cycle, shortened repetition period





FCC ID: KXU-LUXP1

315 MHz Transponder, emissions below 1 GHz, horizontal polarity





FCC ID: KXU-LUXP1

315 MHz Transponder, emissions below 1 GHz, vertical polarity

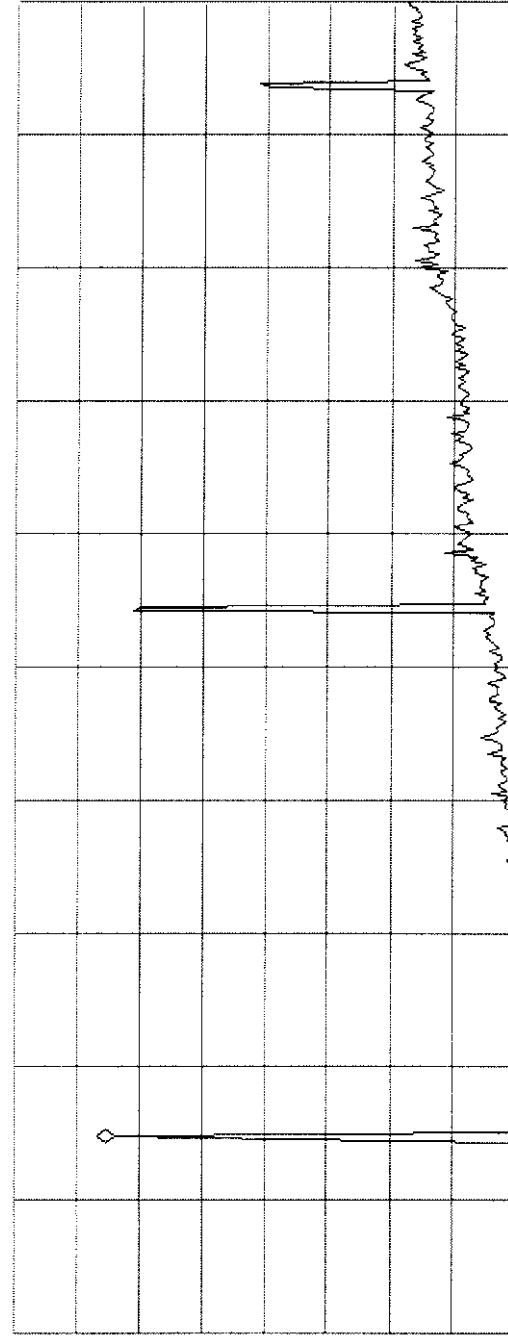
16:55:21 NOV 18, 1997

MARKER
318.0 MHz
51.92 dB μ V/m

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 318.0 MHz
51.92 dB μ V/m

LOC REF 60.0 dB μ V/m

PREAMP ON



START 200.0 MHz
R #IF BW 120 kHz
AUG BW 300 kHz
SWP 750 msec

Last Hrd
Key Menu

SPAN

MARKER
NORMAL

MARKER
4

MARKER
AMPTD

SELECT
1 2 3 4

MARKER 1
ON OFF

More
1 of 2



FCC ID: KXU-LUXP1

315 MHz Transponder, emissions above 1 GHz, horizontal polarity

12:11:53

NOV 19, 1997

MARKER

1.573 GHz

43.45 dB μ V/m

ACTV DET: PEAK

MEAS DET: PEAK QP AVG

MKR 1.573 GHz

43.45 dB μ V/m

Last Hrd
Key Menu

SPAN

LOG

5

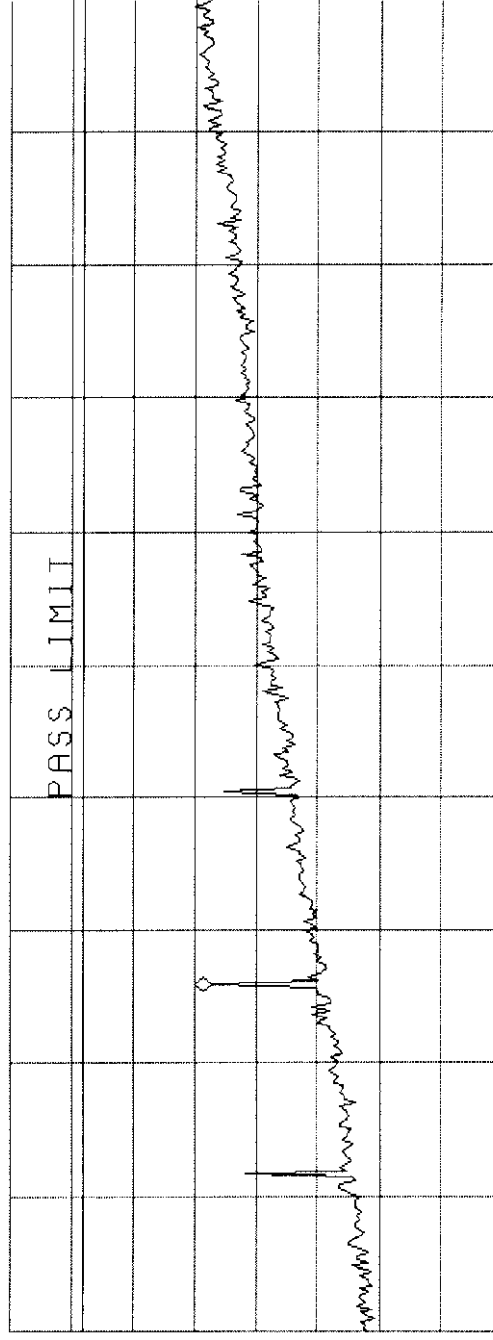
dB/

#ATN

0 dB

REF 60.0 dB μ V/m

PREAMP ON



VA SB

SC FC

ACORR

CLEAR
WRITE A

MAX
HOLD A

VIEW A

BLANK A

Trace
A B C

START 1.000 GHz

R IF BW 120 kHz

AVG BW 300 kHz

STOP 3.200 GHz

SWP 1.03 sec

More

1 of 3



FCC ID: KXU-LUXP1

315 MHz Transponder, occupied bandwidth

17:14:22 NOV 18, 1997

MARKER Δ
410 kHz
- .15 dB

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR Δ 410 kHz
- .15 dB

Last Hrd
Key Menu

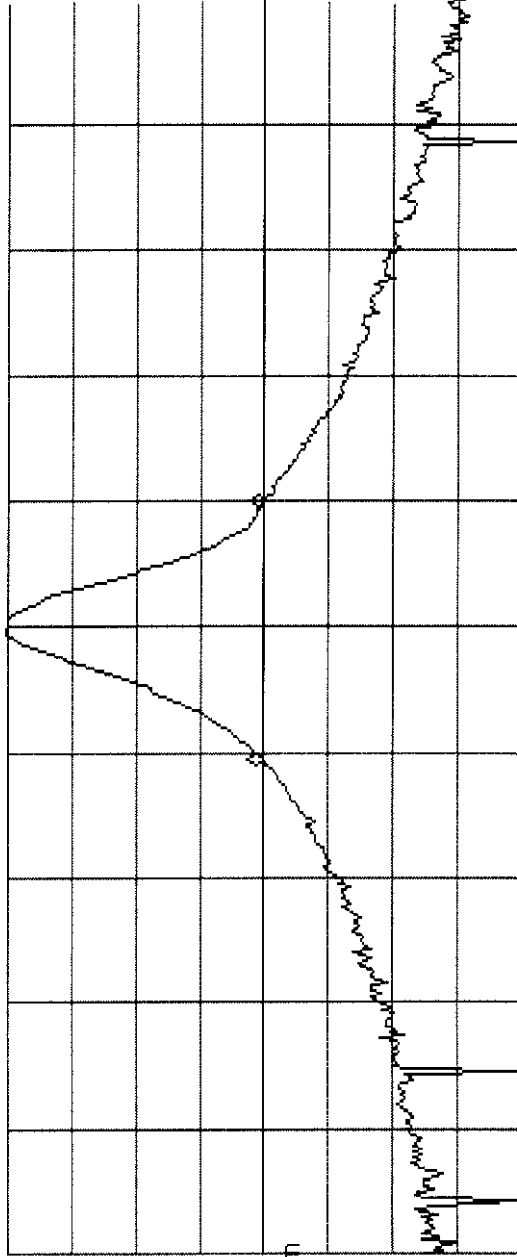
SPAN

LOG REF 57.5 dB μ V/m

PREAMP ON

5
dB/
#ATN
0 dB

DL 37.5
dB μ V/m
VA SB
SC FC
ACORR



CENTER 314.951 MHz

R #JF BW 120 kHz

AVG BW 300 kHz

SPAN 2.000 MHz
#SWP 100 msec

MARKER
NORMAL

MARKER
 Δ

MARKER
AMPTD

SELECT
1 2 3 4

MARKER 1
ON OFF

More
1 of 2



FCC ID: KXU-LUXP1

315 MHz Transponder duty cycle, reduced repetition period

 17:10:05 NOV 10, 1997

MARKER
29.750 msec
12.80 dBμV/m

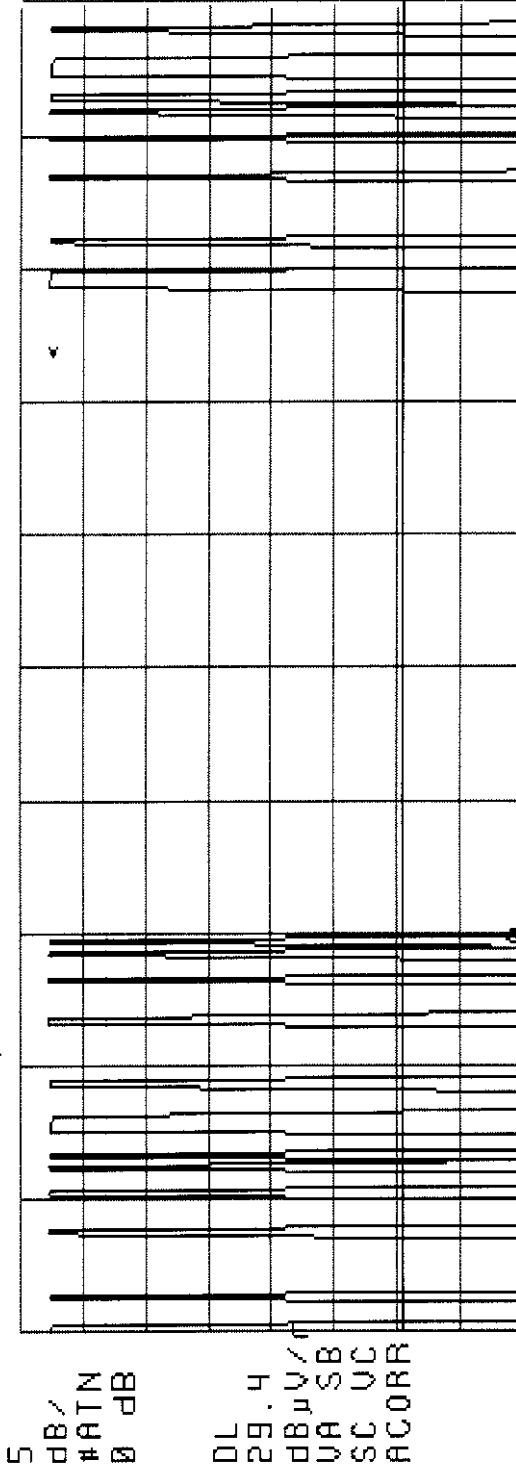
ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 29.750 msec
12.80 dBμV/m

Last Hrd
Key Menu

SPAN

LOG REF 60.0 dBμV/m

PREAMP ON

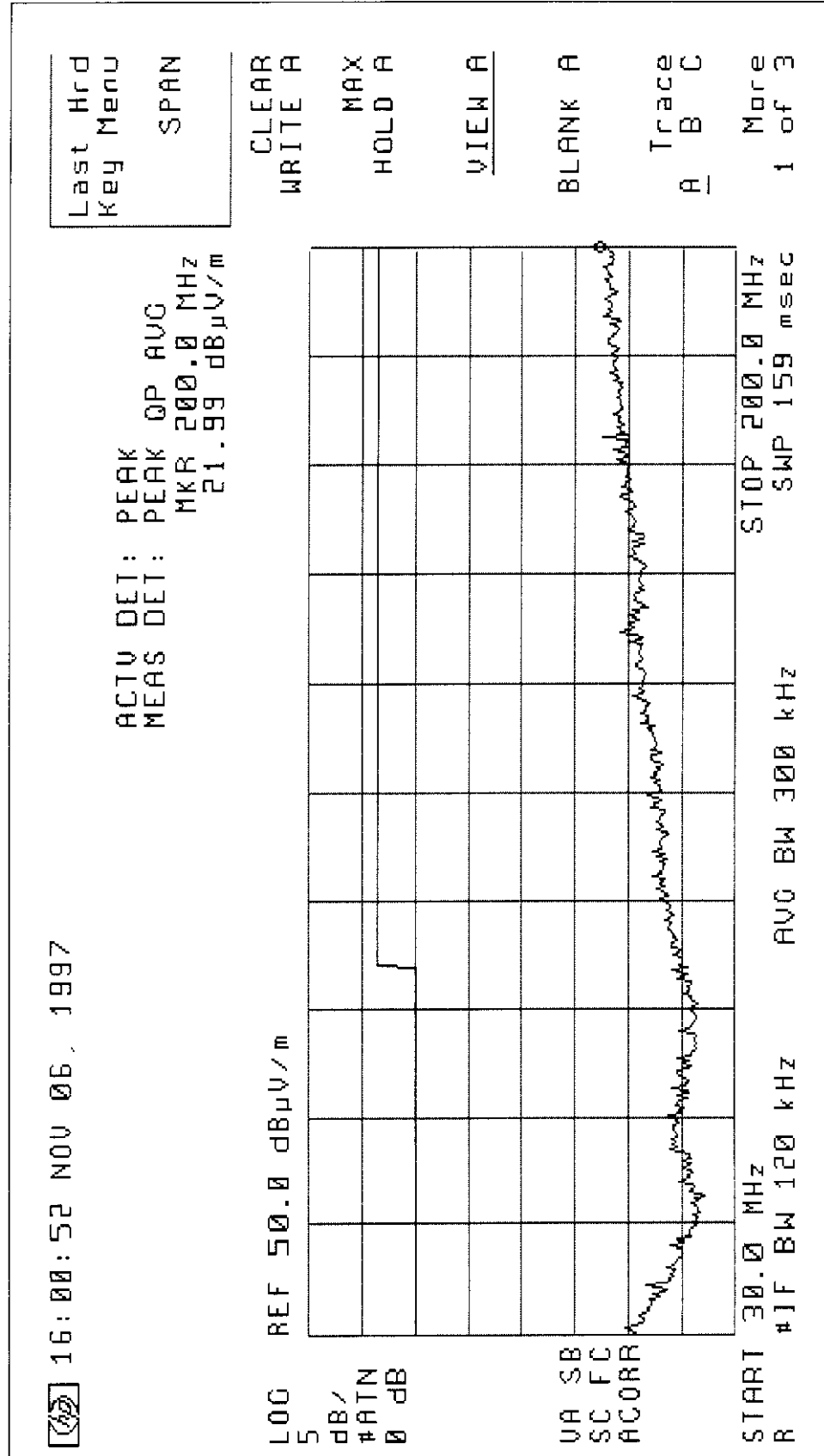


CENTER 314.951 MHz
RL #JF BW 120 kHz
AVG BW 300 kHz
#SWP 100 msec
SPAN 0 Hz



FCC ID: KXU-LUXP1

318 MHz/315 MHz Transponder, emissions of units in frequency range 30-200 MHz





FCC ID: KXU-LUXP1

Duty cycle of representative LUXP1 unit, during actual operating conditions.

