Electromagnetic Compatibility (EMC) Test Report

for

RF Code, Inc.
Spider TAG Family

concerning conformance to the U.S. requirement

47 CFR, Part 15, Subpart C

Manufacturer and Applicant for Certification:

RF Code, Inc.
1250 South Clearview, Suite 104
Mesa, Arizona 85208

Prepared By: National Technical Systems
1536 E. Valencia Drive
Fullerton, California 92831

Issued: September 11, 2001

LIST OF RESPONSIBLE PARTIES

Test Laboratory Customer

The customer listed on page one of this report under "Manufacturer and Applicant for Certification" is responsible for the following with respect to the standards contained in the Test Summary:

1. Ensuring that subsequent product will be manufactured to the same specifications as the sample tested.
2. Ensuring that the product retains electromagnetic compatibility after modifications to its design and/or it manufacturing process.
3. Conducting the appropriate EMC auditing of subsequent product unless conformance herein has been demonstrated by statistical means.

If manufacture of the product is by a third party then the customer is strongly encouraged to implement an agreement with his supplier(s) whereby adherence to the above responsibilities is ensured.

Test Laboratory Responsibilities

With our signatures we, the undersigned, attest to the accuracy of this report and to testing having been conducted with adherence to the appropriate international quality standards and test procedures.

Steven C. Halme, 14 Aug 01
Steven C. Halme, Date
Sr. Program Manager/EMC Engineer
National Technical Systems

Betty Matteson, NTS 3 QA 8/14/01
Betty Matteson, Date
Quality Assurance Manager
National Technical Systems

TEST SUMMARY

This test record demonstrates conformance of the RF Code, Inc. Spider TAG Family with the below listed standard.

Region	Specification	Title/Intent	Notes	Conforms
US	47 CFR, Part 15, Sub C	Radio Frequency Devices	15.231 (e) Periodic operation in the band 40.66-40.70 MHz and above 70 MHz 15.209 (a) Radiated Emissions Limits: General Requirements	Yes

TABLE OF CONTENTS

1.0 GENERAL INFORMATION

1.1 Product Description

The RF Code, Inc. Spider TAG Family (hereafter and collectively the "Spider TAG ") is a family of low power intentional radiators used as wireless identification devices. The individual members of the Spider TAG family are identical in design, differing mainly in the rates of periodicity of their transmissions (see paragraph 1.3.1, "EUT", model numbers). The nearly identical transmissions are pulse modulated to allow for multiple identification codes (See NTS Test Report No. 174-0976-1-0A-N).

Two power options are available, standard power and low power. The circuitry for the low-power version has three additional passive components added.

Physically the Spider TAG consists of an electronic circuit board with integral battery and a non-conductive case of varying design (see paragraph 1.1.1, "Model Variants"). The case designs will be such as to not change the rf emissions characteristics of the Spider TAG circuit board.

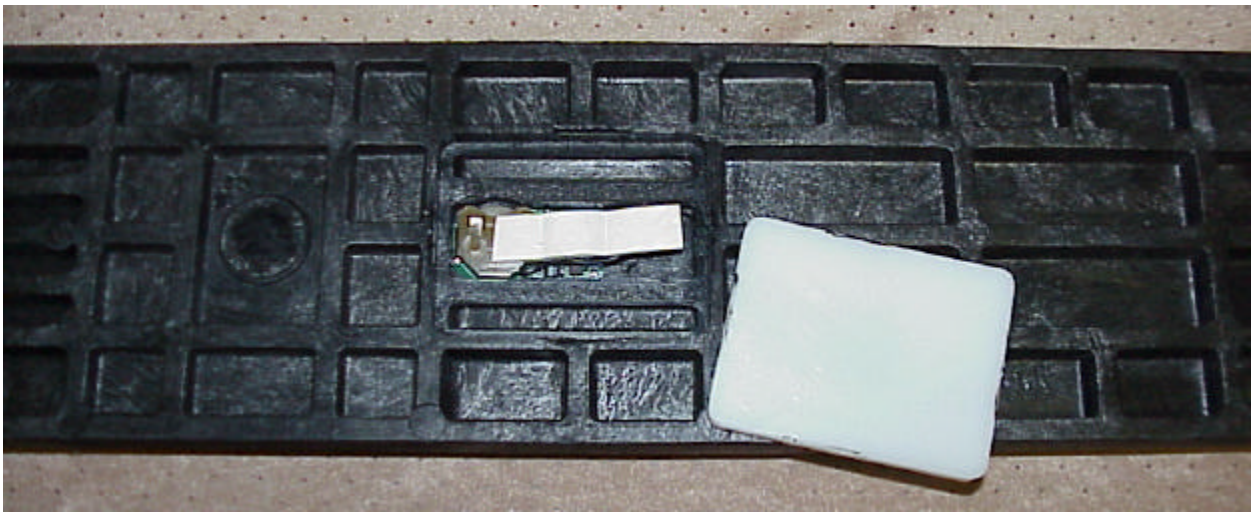
The Spider TAG is part of a RFID tracking system. They are attached to a person or object whose location is then tracked by the RF Code Spider Reader (not included in this report). Potential uses are automated inventory control, factory automation, asset management and security, reusable transport material tracking, warehouse administration, and time and attendance tracking.

Spider TAG, Equipment Under Test (EUT)

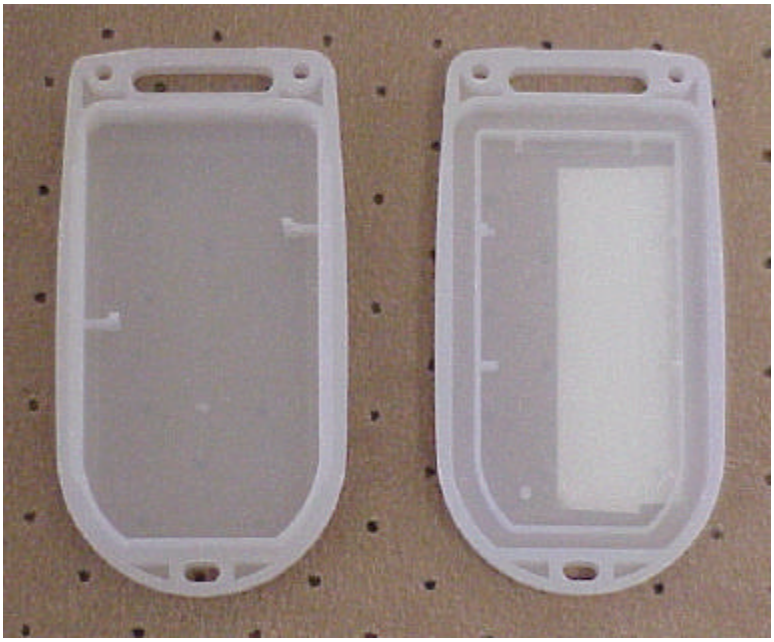
1.1.1 Model Variants

There are no model variants to the EUT's printed circuit board other than rates of periodicity, and the Spider TAG is not marketed under alternate model names.

The case design will vary in accordance with the application. Two examples are shown below.



"Plastic Board" application (white, plastic TAG cover shown moved aside)



"Palm-sized" case application

1.1.2 Accessories Tested With This Product

No accessories were identified by the customer.

1.1.3 Internal, Fundamental Oscillator Frequencies

Refer to NTS Test Report No. 174-0976-1-0A-N for the Spider TAG fundamental oscillator frequencies.

1.2 Administrative Data

1.2.1 References

1. CFR 47, Part 15, Subpart C
2. ANSI C63.4-1992
3. A2LA Certificate No. 0214.02
4. NTS Test Report No. 174-0976-1-0A-N
5. RF Code, Inc. Purchase Order No. 041-2680

1.2.2 Test Measurement Instrument Calibration

All test instrumentation requiring calibration had a valid calibration sicker attached and was calibrated in accordance with ANSI Standard NCSL Z540-1.

1.3 Tested System Details

1.3.1 Equipment Under Test (EUT)

There are no external interconnects such as interface or power associated with the Spider TAG.

Tested EUT Components	Model No.	Serial No.
Spider TAG	13.0 sec R1 100 Ω	IAVFXMA
	25.0 sec R1 100 Ω	GYPCJTU
	50.0 sec R1 100 Ω	HCLNFEL

1.3.2 Support Equipment

None

1.4 EMC Labels/Marks

Label (1.5 in x 0.75 in.)

Example of "palm-sized" case (actual size) with label installed

1.4.1 Electrical Schematics

Refer to NTS Report No. 174-0976-1-0A-N for the Spider TAG electrical schematics.

1.5 PCB Layout

Refer to NTS Report No. 174-0976-1-0A-N for the Spider TAG Printed Circuit Board (PCB) layouts.

2.0 GENERAL TEST METHODOLOGY AND FACILITY INFORMATION

2.1 Emissions

Required emissions testing was performed in accordance with ANSI C63.4 :92 and CFR 47, Part 15. Specifics such as test locations are listed in the appropriate data sections of this report.

Conducted measurements of powerlines were made with power supplied to the EUT through a 50Ω/50µh Line Impedance Stabilization Network (LISN); support equipment not part of the EUT were powered through a similar but separate LISN. If required, measurements of interface cables were made through either an appropriate Impedance Stabilization Network (ISN) or a suitable substitute.

Radiated measurements were made at either an Open Area Test Site (OATS) or an Alternate OATS, with an antenna to EUT distance of 3m or 10m, as appropriate. Where 3m measurements using an alternate OATS are allowed, final measurements were made in the listed 3m chamber. The actual test distance are listed in the respective test data sections. The applicable frequency spectrum was searched with a calibrated antenna system for rf emissions approaching the appropriate limits. "Maximization" of each suspect frequency was accomplished by a combination of a 360° azimuth search and varying the antenna to ground plane height from 1m to 4m, in both the vertical and horizontal polarizations. Final data was collected in the worst case configurations of the EUT producing the highest emission levels.

Typically, conducted and radiated emissions measurements were first made with a peak detector. The highest peak amplitudes relative to the appropriate limits were identified and re-measured using quasi-peak and/or average detectors as required. Conducted emissions testing was performed using automatic EMI test equipment. This equipment utilizes HP EMI measurement software running on an HP computer. The computer interfaced directly with HPIB (IEEE) compatible instruments having graphical displays presented on the spectrum analyzer's CRT, and to a plotter which generated hard copies of the data. The program automatically selected the range of test frequencies or band, and set the specification line limits to be used during the test. This equipment/software allowed for real-time data reduction and prints tabulated data on peak, quasipeak or average value measurements.

Measurements are made at the National Technical Systems EMC facility located at 1536 E. Valencia Dr., Fullerton, CA 92831-4797. The 3m semi-anechoic chamber meets the NSA requirements of an alternate OATS and is so listed with the Federal Communications Commissions.

2.2 Basic Calculations

2.2.1 Radiated Emissions Field Strength Calculations

[1] FS = RA + AF + CL - AG

where: FS = field strength (dbμv/m) CL = cable loss (db) AF = antenna factor (db)
RA = receiver amplitude (dbμv) AG = amplifier gain (db)

The receiver used for radiated emissions measurements performed the field strength calculations automatically. The program has resident AF and CL figures for individual antennas and cables.

47CFR, Part 15 §231(e) emission limits for signals in the frequency ranges of 130 MHz to 174 MHz and 260 MHz to 470 MHz are calculated as follows:

[2] S = (y2 - y1) / f2 - f1)

[3] IP = y1 – (f1 * S)

[4] Lμv/m = S * f + IP

[5] Ldbμv/m = 20log (Lμv/m)

where:
S = slope of limit line
f = frequency of measured signal
f1 = lowest frequency end-of-slope
f2 = highest frequency end-of-slope
y1 = f1 end of slope limit
y2 = f2 end of slope limit
IP = intersection point
L = limit of f on slope, in μv/m or dbμv/m, as specified

hence:

pt. 15.231(e) limit of (f = 303.8MHz fundamental) = 67 dbμv/m

2.2.2 Averaged Levels of Pulsed Emissions Calculations

[6] Ave = Peak – |((P * N)/100ms)|

where:
P = average pulse width in milliseconds
N = number of pulses in worse case 100 millisecond window
Ave = Calculated average level in dbµv/m
peak = corrected peak measurement in dbµv/m

Hence, as an example, the average value for the IAVFXMA 13 sec R1 100W peak emission:

[7] Ave = Peak – |20log((P * N)/100ms)|

[8] Ave = 59.7 – |20log((1.18(10^{-4}) * 10) / .1)|
Ave = 21.1dbµv/m

2.3 Deviation From Standard Test Methods

None

2.4 Ambient Conditions During Testing

During this test the average ambient conditions were as follows: Relative humidity between 30-60%, temperature 15-35° C, and barometric pressure between 860-1060 mbar.

2.5 Test Facility

Testing was accomplished at the National Technical Systems EMC Test Facility, 1536 East Valencia Drive, Fullerton, California, USA. The EMC facility has the following accreditations, registrations, etc.:

- Compliance with the requirements of ISO/IEC 17025
- Compliance with the requirements of ISO 9000: 1997 (E).
- Accredited by the American Association for Laboratory Accreditation (A2LA)
- Compliance with the radiated and AC line conducted test site criteria in ANSI C63.4-1992 as required by the Federal Communications Commission (FCC).
- NRTL Approved, NTS Acton, MA
- U.S. Conformity Assessment Body as defined in the US/EU Mutual Recognition Agreement
- Accredited by the BSMI of Taiwan as a Conformity Assessment Body under the APEC Agreement, with certification number SL2-IN-E-074R.
- Accredited by the VCCI of Japan.

3.0 TEST CONFIGURATION

3.1 EUT Input Power

The EUT is powered by an internal, 3V Lithium battery.

3.2 EUT Condition, Configuration and Modes of Operation

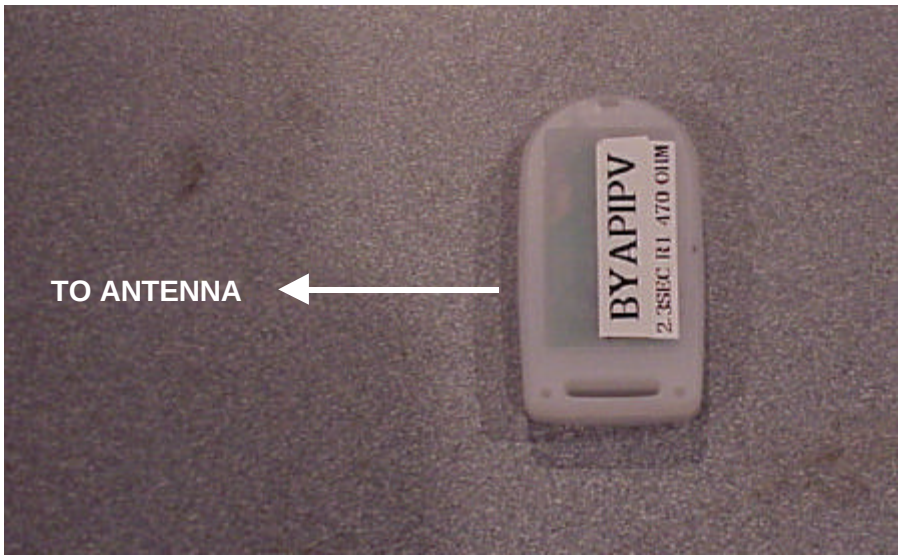
As delivered for testing the EUT condition can be described as a standard power output, production model with the below listed variation from final product:

1. Prototype, non-conductive, "palm-size" case (see paragraph 1.1.1 "Model Variants").

As per measurement procedures, the worst case test configuration, mode of operation and orientation relative to the antenna was used for all testing. The selection process was based on investigative testing of the EUT.

The mode of operation during testing was "periodic transmission". Measurements were made of the transmitted, spurious, harmonics and incidental signals during transmission.

The EUT was investigated while articulating through the three axes described by ANSI C63.4. The worst axis was noted and used for testing (shown below).



Spider TAG Test Axis

3.3 VDU Mode

There was no video display unit (VDU) associated with the EUT.

3.4 EUT Exercise Software

None

3.5 Equipment Modifications and EMC Specific Components

The information contained in this section as well as that in paragraph 4.2 shall be used for visual verification of configuration during EUT audits or other evaluations subsequent to this test.

3.5.1 Modifications Made to the EUT During This Test

None

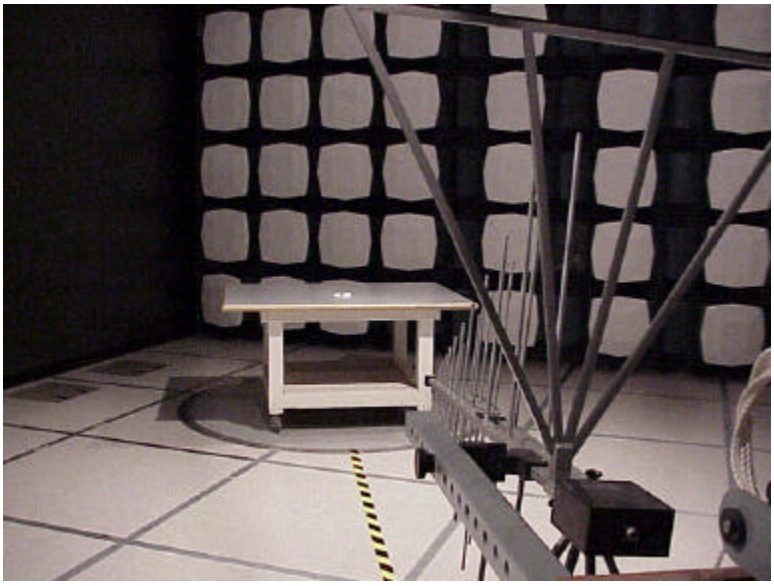
3.5.2 EMC Specific Components Present on EUT as Delivered for Testing

None

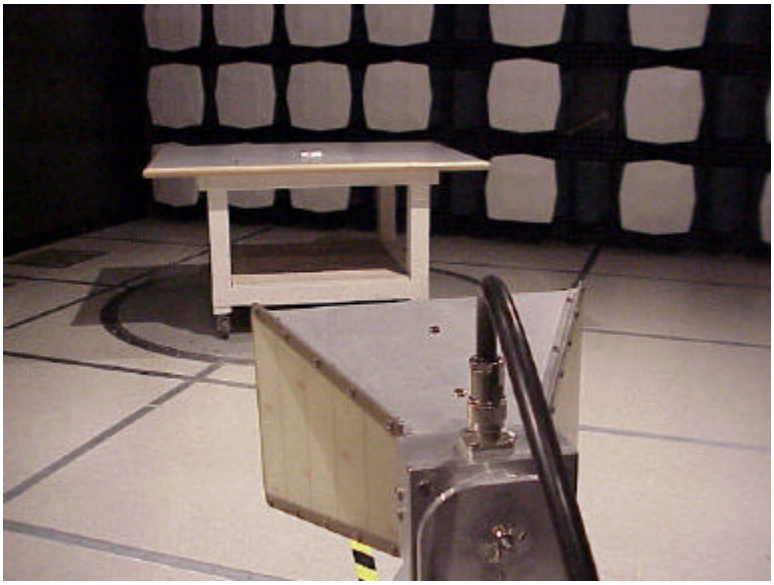
4.0 PHOTOGRAPHS

4.1 Equipment Under Test (EUT)

The EUT layout during testing is shown below. The EUT is situated atop an 80cm high wooden table.



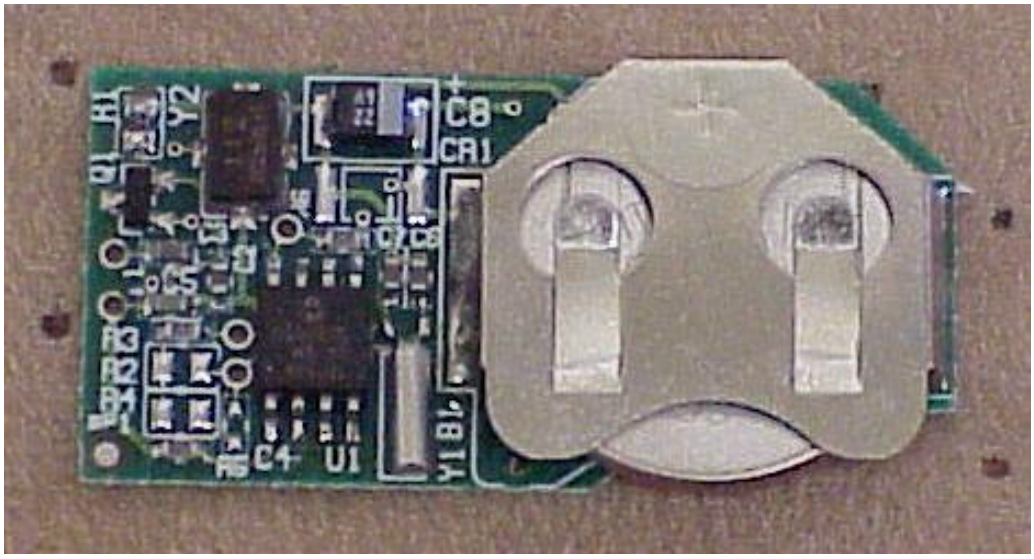
Radiated Emissions Setup, 30 MHz – 1GHz



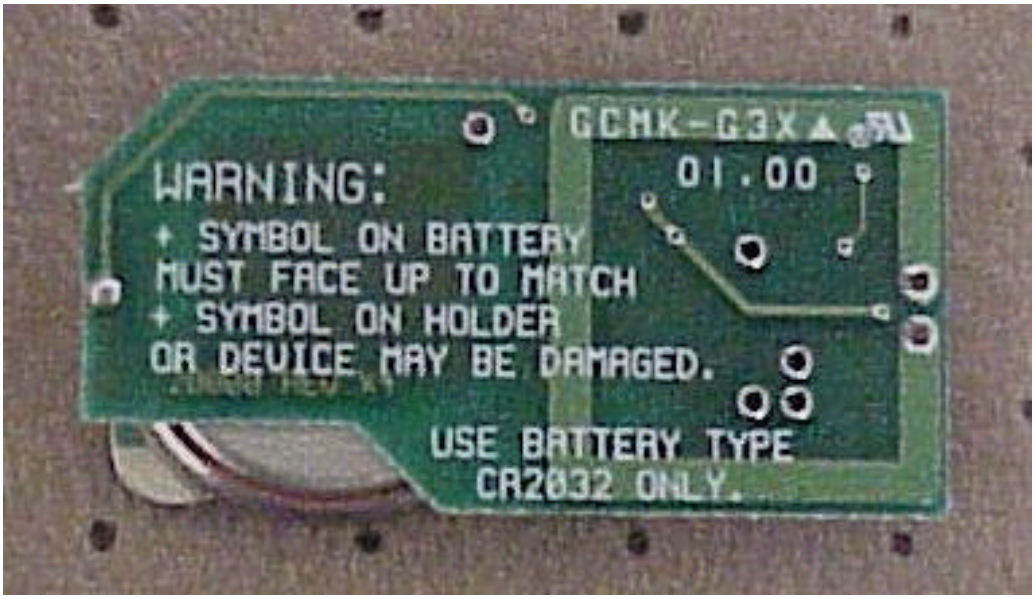
Radiated Emissions Setup, 1GHz – 10 GHz

4.2 Circuit Boards and EMC Specific Characteristics

This section contains photographs of circuit boards, EMC specific characteristics/components and of modifications required for conformance (refer to paragraph 3.5.1).



Printed Circuit Board, Component Side



Printed Circuit Board, Foil Side

5.0 TEST INSTRUMENTATION

The instrumentation calibrations contained herein are traceable to NIST.

Instrument	Manufacturer	NTS Control No.	Calibration Due
Radiated Emissions,			
HP Spectrum Analyzer	HP	E5262F	09/13/01
Quasi Peak Detector	HP	E4986F	06/07/01
Biconilog antenna	ETS	E5358F	08/16/01
Oscilloscope	Tektronix	E5182F	09/14/01
Horn antenna	EMCO	E4864F	09/29/01
Pre Amplifier	Miteq	E4969F	04/07/02
Pre Amplifier	Miteq	E4970F	04/07/02
Pre Amplifier	Miteq	E4971F	04/07/02
Pre Amplifier	Miteq	E4972F	04/07/02

6.0 EMISSIONS

The test procedures are from ANSI C63.4 :92 and 47CFR, Part 15, Subpart C. Measurements were made in a listed 3m semi-anechoic chamber. The EUT is battery powered, hence, conducted measurements were not made. Initial measurements were conducted during March 2001. Subsequently, in June 2001, the identical EUTs were evaluated for pulse modulation in the time domain.

Following the tabular data for each beacon rate Spider TAG will be found the frequency domain plots from 30 MHz to 10 GHz and the transmission pulse in time domain.

For fundamental frequencies and certain harmonics, conformance was demonstrated using calculated average values. For other than fundamental frequencies, conformance was demonstrated with peak values, if the peak value was below the appropriate limit.

All Spider TAGs had rates of periodicity >10 sec, and the time off between individual transmissions was 30 times the length of transmission. Thus the fundamental, spurious and harmonic signals were evaluated against the limits of 15.231(e). Other emissions were evaluated against 15.209(a).

All spurious, harmonic and incidental emissions in peak were lower than the fundamental in peak.

All measurements were made at 000° azimuth at a 3m distance to the antenna, which was at 100cm height and horizontal polarity. It was determined that this produced the maximum emissions in all cases.

6.1 Test Results and Data (Serial No. IAVFXMA, Model No. 13 sec R1 100Ω

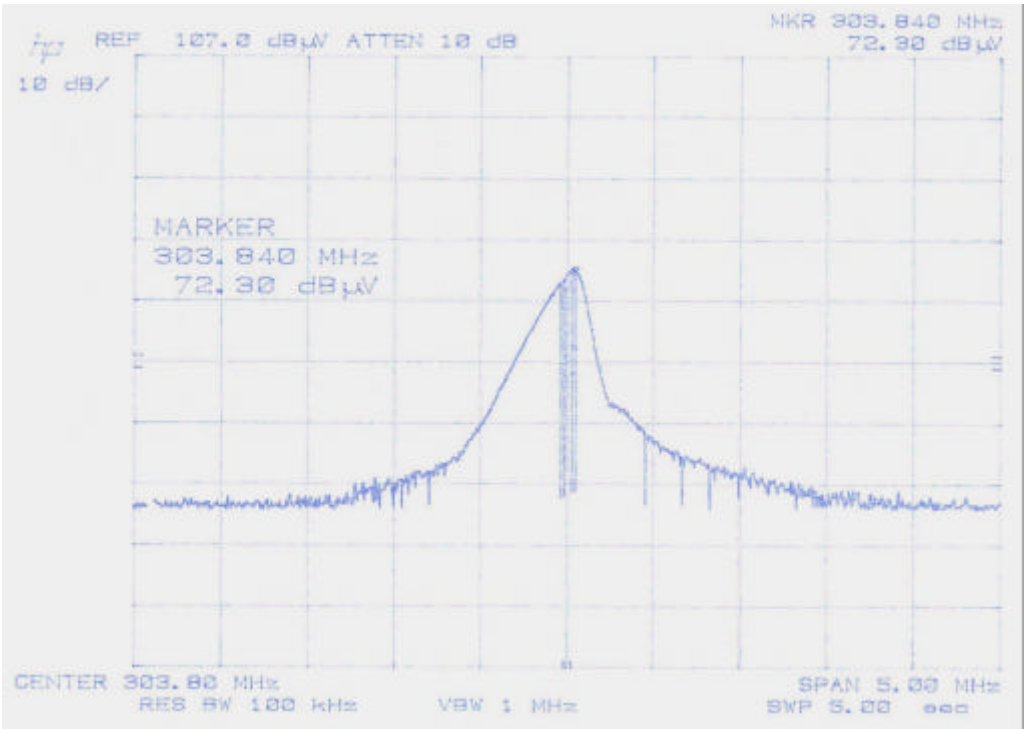
6.1.1 Tabular Data

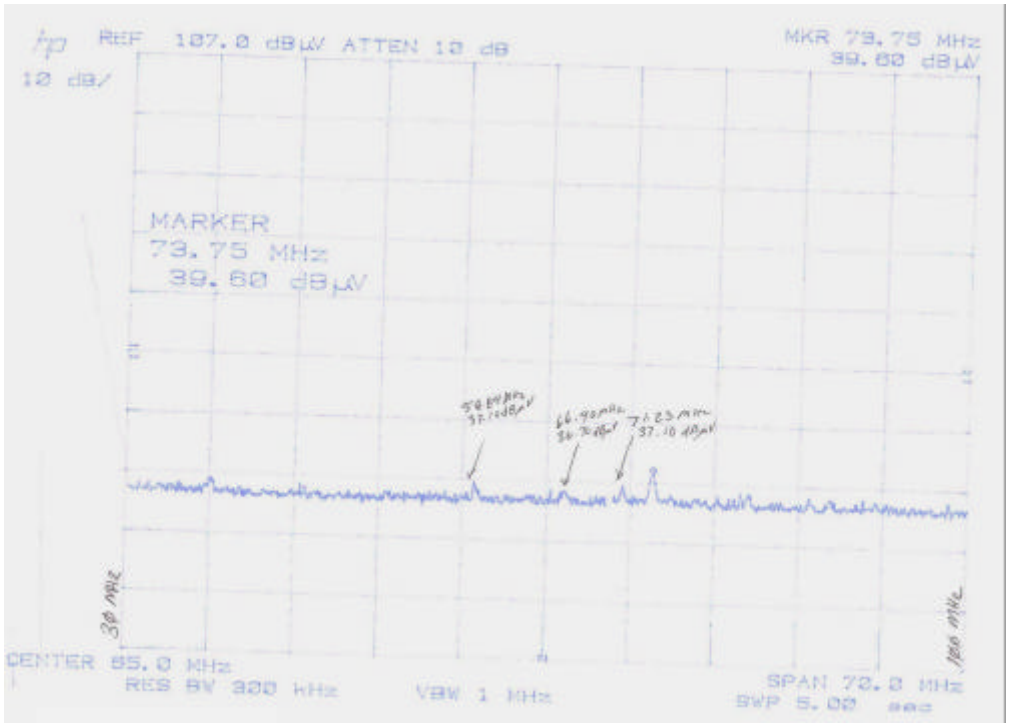
Date of measurement: March 8, 2001 Test engineer: Ba Nguyen

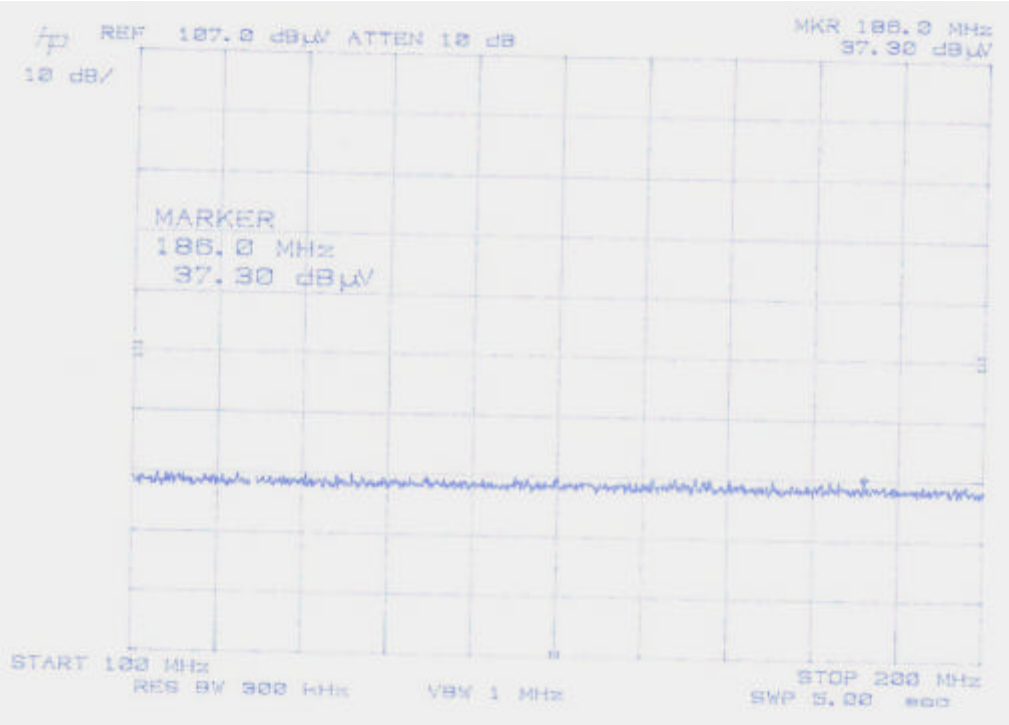
FCC RF Emissions Data, Spider TAG, Serial No. IAVFXMA, Model No. 13 sec R1 100Ω										
				Level (dbμv/m unless noted)					0.25% f_o bw	
						Limit				
Measured Frequency (MHz)	Fundamental	Spurious/Harmonic	Incidental	Corrected Peak Level	Calculated Average Level	§15.231(e)	§15.209(a)	Margin (Δ)	Max Allowed BW (kHz)	Actual BW (kHz)
303.8	X			59.7	21.1	67.0		-45.9	757.5	250.0
58.8			X	16.9			40.0	-23.1		
66.4			X	16.5			40.0	-23.5		
71.2			X	16.5			40.0	-23.5		
568.0			X	35.1			46.0	-10.9		
911.0		X		45.0	6.4	54.0		-47.6		
1823.0		X		59.4	20.8	54.0		-33.2		
2000.0			X	30.9			54.0	-23.1		

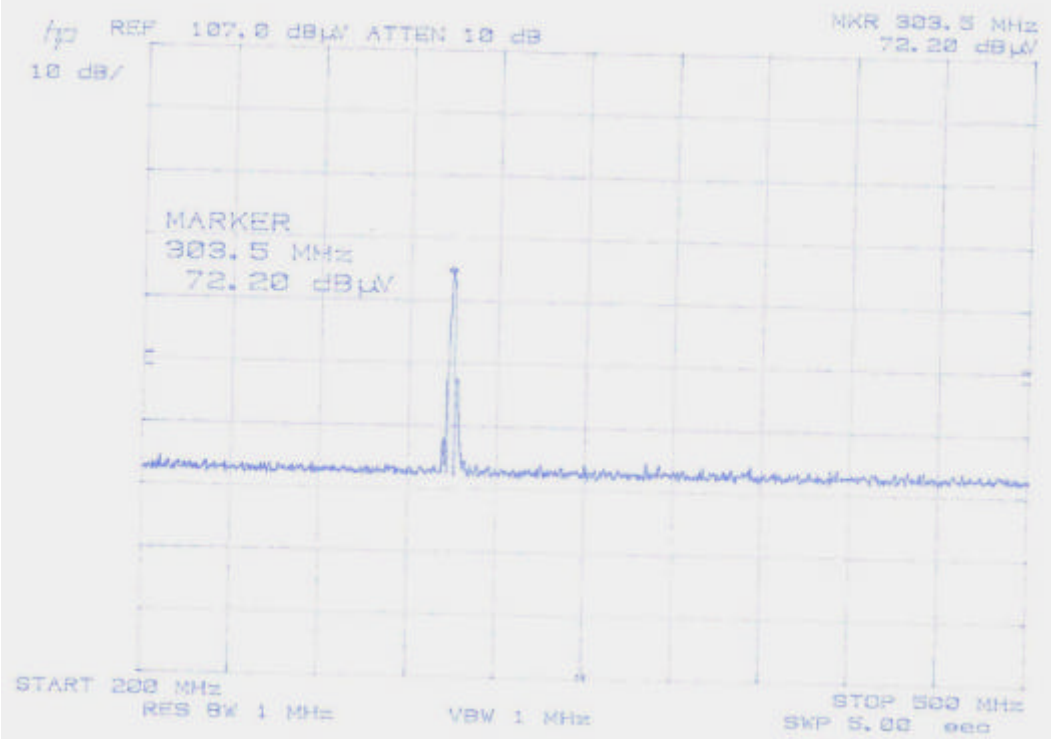
Average pulse width	$1.18(10^{-4})$ sec
Number of pulses in worse case 100 msec window	10

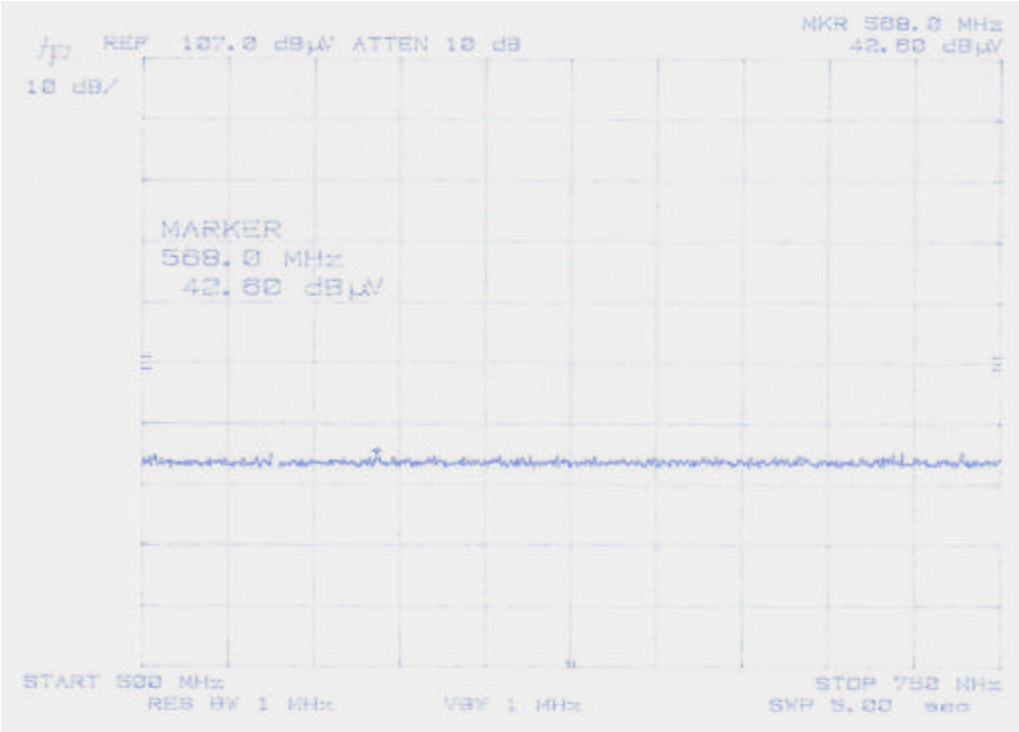
6.1.2 Frequency and Time Domain Plots

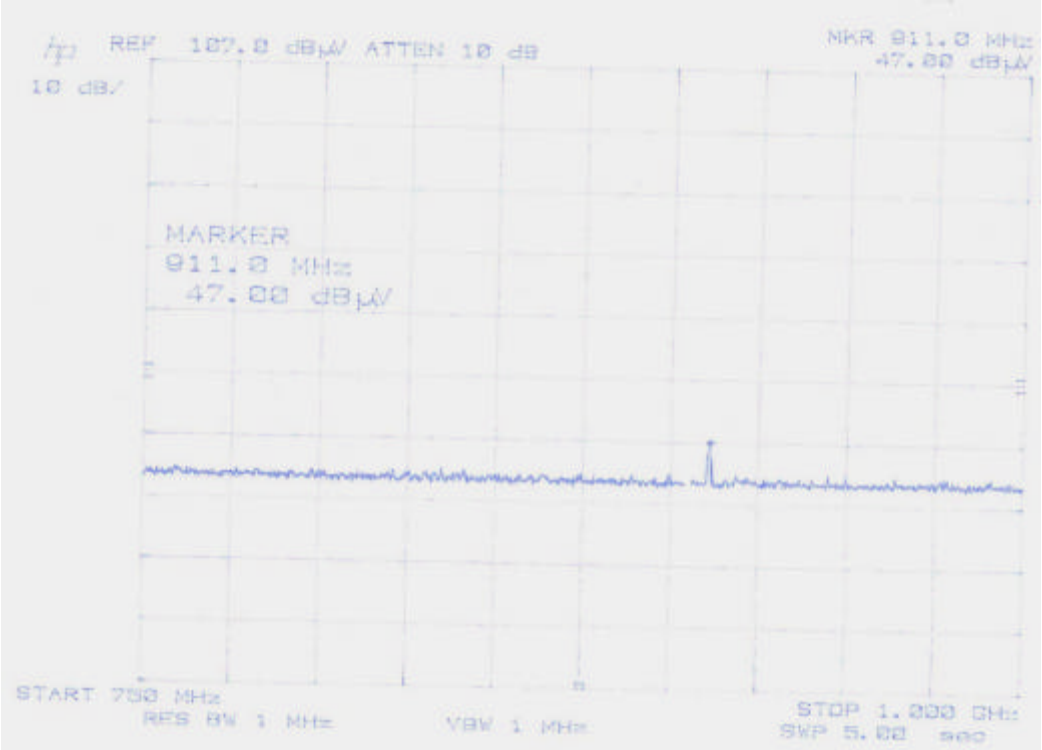


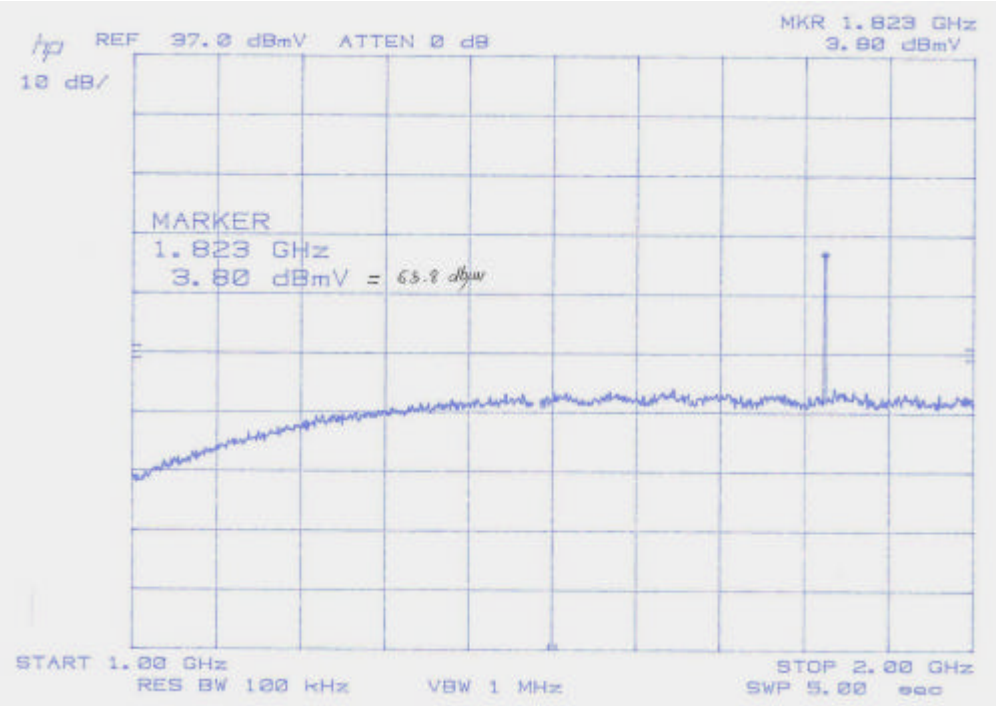


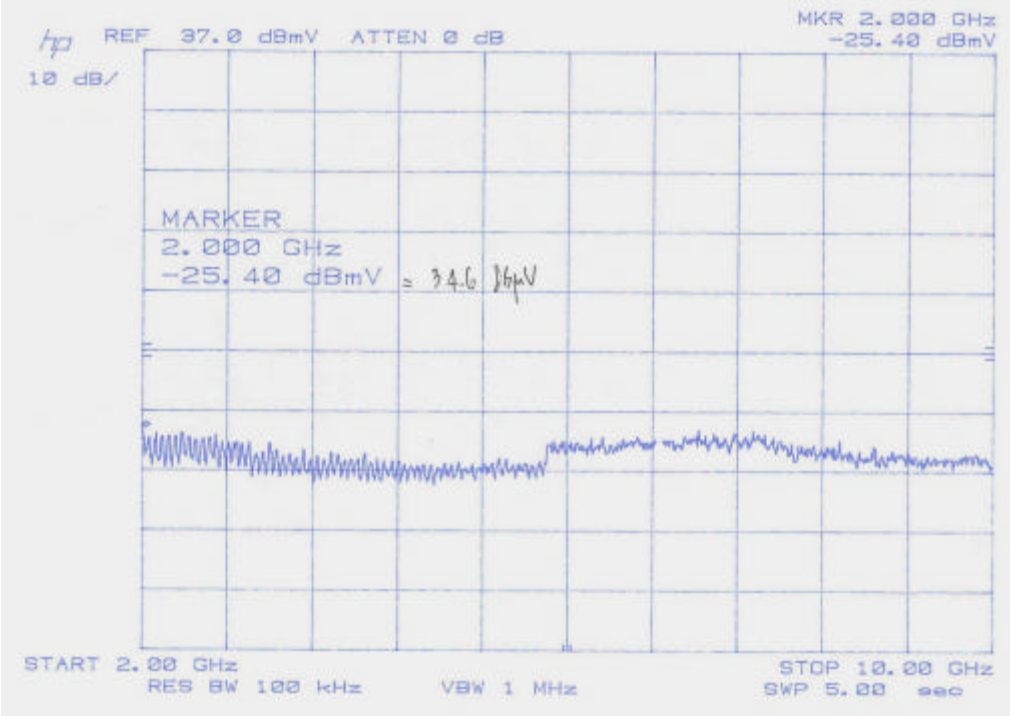

REF 107.0 dBµV ATTEN 10 dB
MKR 186.0 MHz
37.30 dBµV
10 dB/
MARKER
186.0 MHz
37.30 dBµV
START 100 MHz
RES BW 300 kHz
VBW 1 MHz
STOP 200 MHz
SWP 5.00 sec

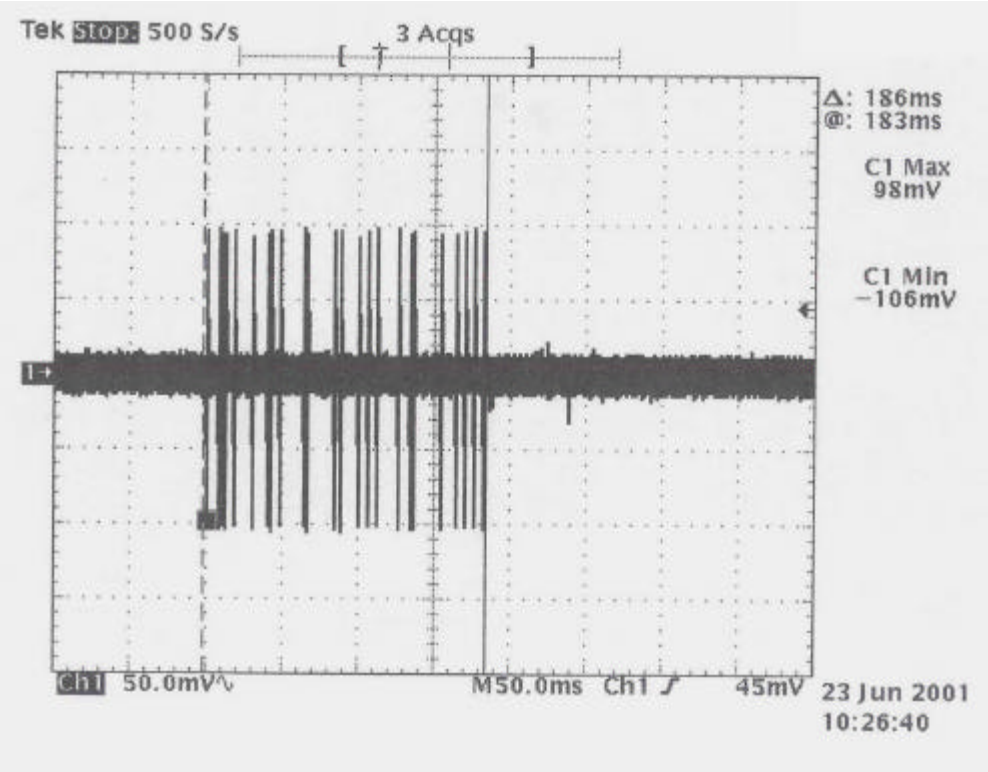

REF 107.0 dBµV ATTEN 10 dB
MKR 303.5 MHz
72.20 dBµV
10 dB/
MARKER
303.5 MHz
72.20 dBµV
START 200 MHz
RES BW 1 MHz
VBW 1 MHz
STOP 500 MHz
SWP 5.00 sec


REF 107.0 dBµV ATTEN 10 dB
MKR 568.0 MHz
42.60 dBµV
10 dB/
MARKER
568.0 MHz
42.60 dBµV
START 500 MHz
RES BW 1 MHz
VBW 1 MHz
STOP 750 MHz
SWP 5.00 sec


REF 107.0 dBµV ATTEN 10 dB
MKR 911.0 MHz
47.00 dBµV
10 dB/
MARKER
911.0 MHz
47.00 dBµV
START 750 MHz
RES BW 1 MHz
VBW 1 MHz
STOP 1.000 GHz
SWP 5.00 sec


REF 37.0 dBmV ATTEN 0 dB
MKR 1.823 GHz
3.80 dBmV
10 dB/
MARKER
1.823 GHz
3.80 dBmV
START 1.00 GHz
RES BW 100 kHz
VBW 1 MHz
STOP 2.00 GHz
SWP 5.00 sec


REF 37.0 dBmV ATTEN 0 dB
MKR 2.000 GHz
-25.40 dBmV
10 dB/
MARKER
2.000 GHz
-25.40 dBmV
START 2.00 GHz
RES BW 100 kHz
VBW 1 MHz
STOP 10.00 GHz
SWP 5.00 sec


Tek Stop: 500 S/s
3 Acqs
Δ: 186ms
@: 183ms
C1 Max
98mV
C1 Min
−106mV
Ch1 50.0mV
M50.0ms Ch1 ƒ 45mV
23 Jun 2001
10:26:40

6.2 Test Results and Data, Serial No. GYPCJTU, Model No. 25 sec R1 100Ω

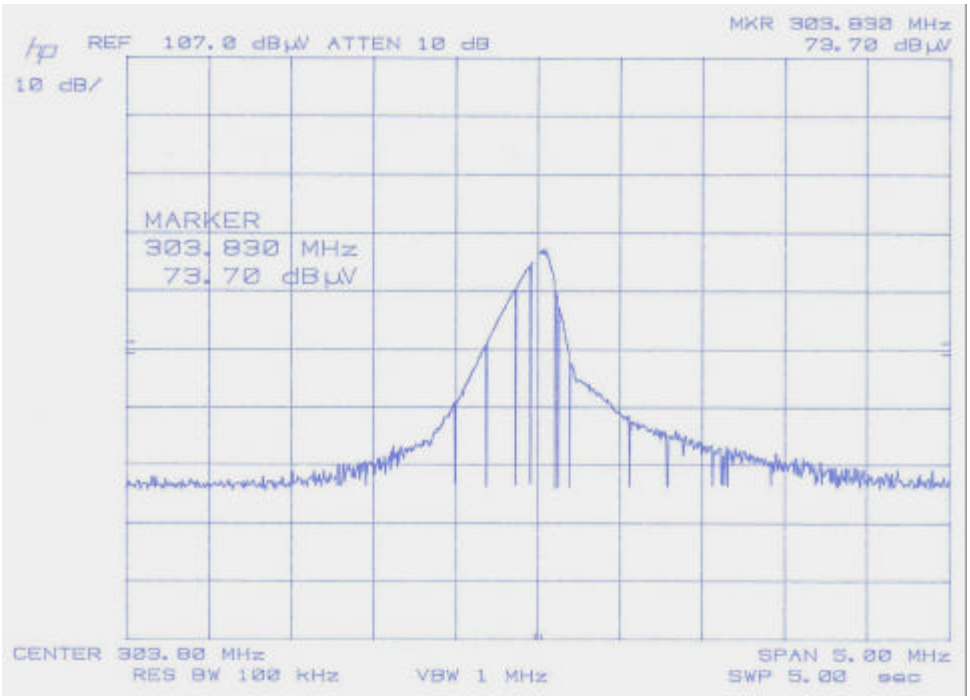
6.2.1 Tabular Data

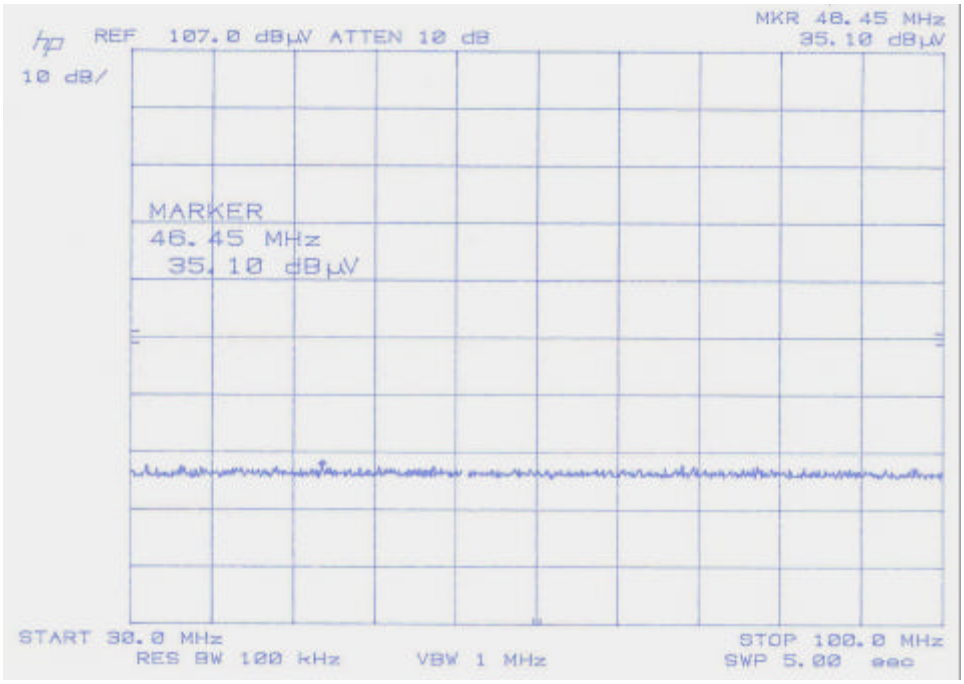
Date of measurement: March 8, 2001 Test engineer: Ba Nguyen

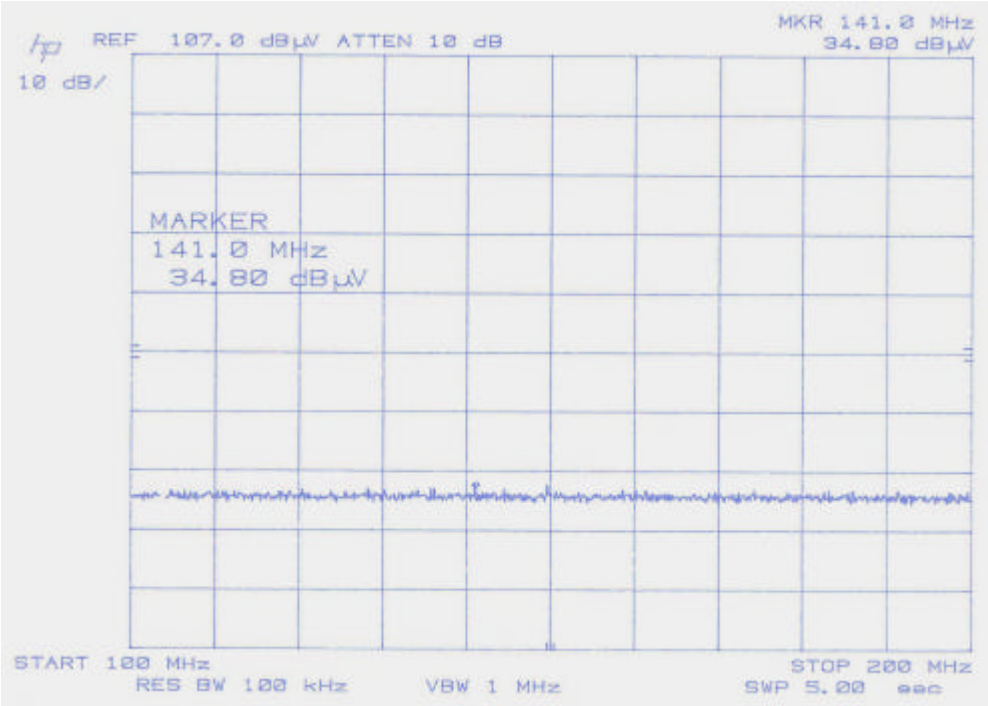
FCC RF Emissions Data, Spider TAG, Serial No. GYPCJTU, Model No. 25 sec R1 100Ω										
				Level (dbμv/m unless noted)					0.25% f_o bw	
						Limit				
Measured Frequency (MHz)	Fundamental	Spurious/Harmonic	Incidental	Corrected Peak Level	Calculated Average Level	§15.231(e)	§15.209(a)	Margin (Δ)	Max Allowed BW (kHz)	Actual BW (kHz)
303.8	X			61.1	22.5	67.0		-44.5	757.5	240.0
46.45			X	20.4			40.0	-19.6		
141.0			X	15.4			43.5	-28.1		
607.8		X		48.3	9.7	54.0		-44.3		
911.0		X		43.1	4.5	54.0		-49.5		
1823.0		X		50.1	11.5	54.0		-42.5		

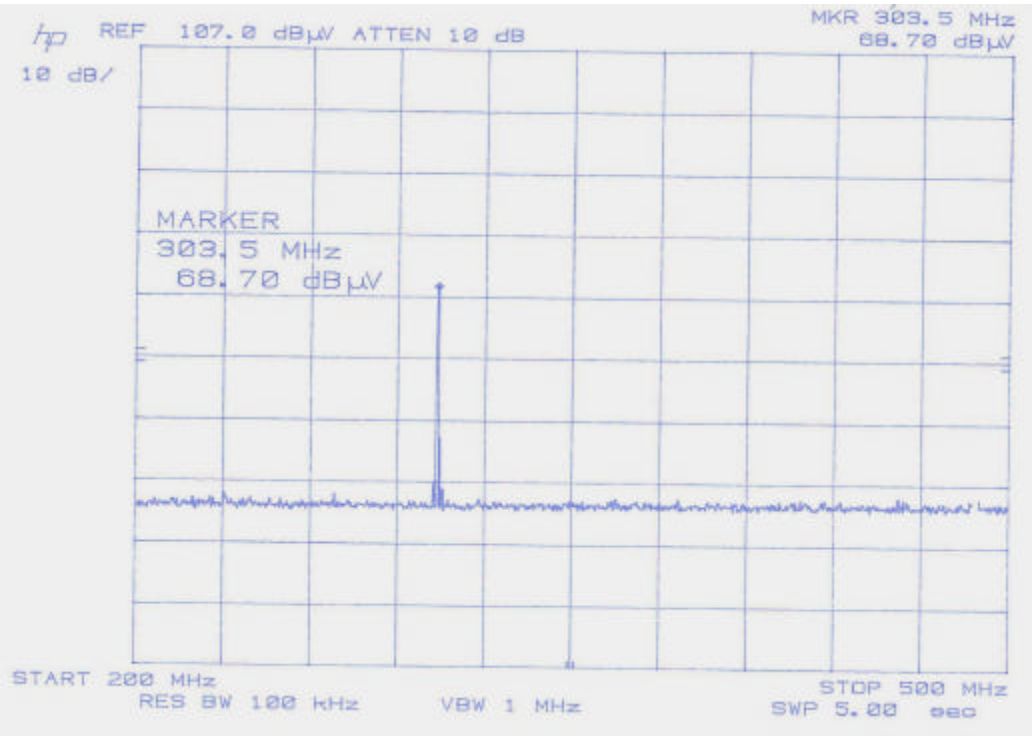
Average pulse width	$1.18(10^{-4})$ sec
Number of pulses in worse case 100 msec window	10

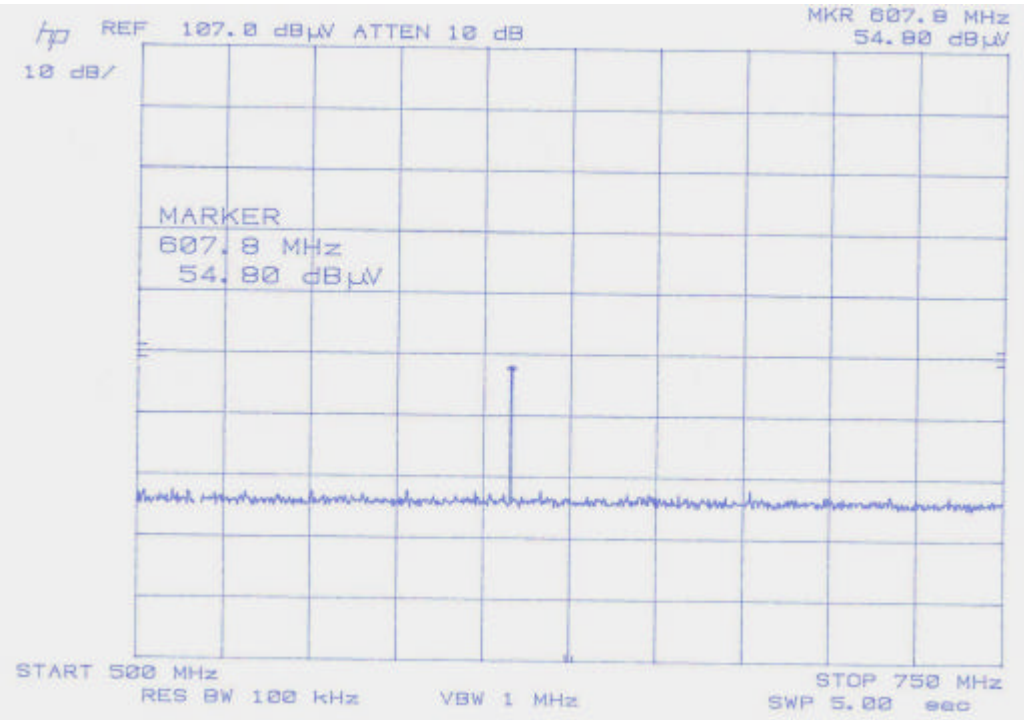
6.2.2 Frequency and Time Domain Plots

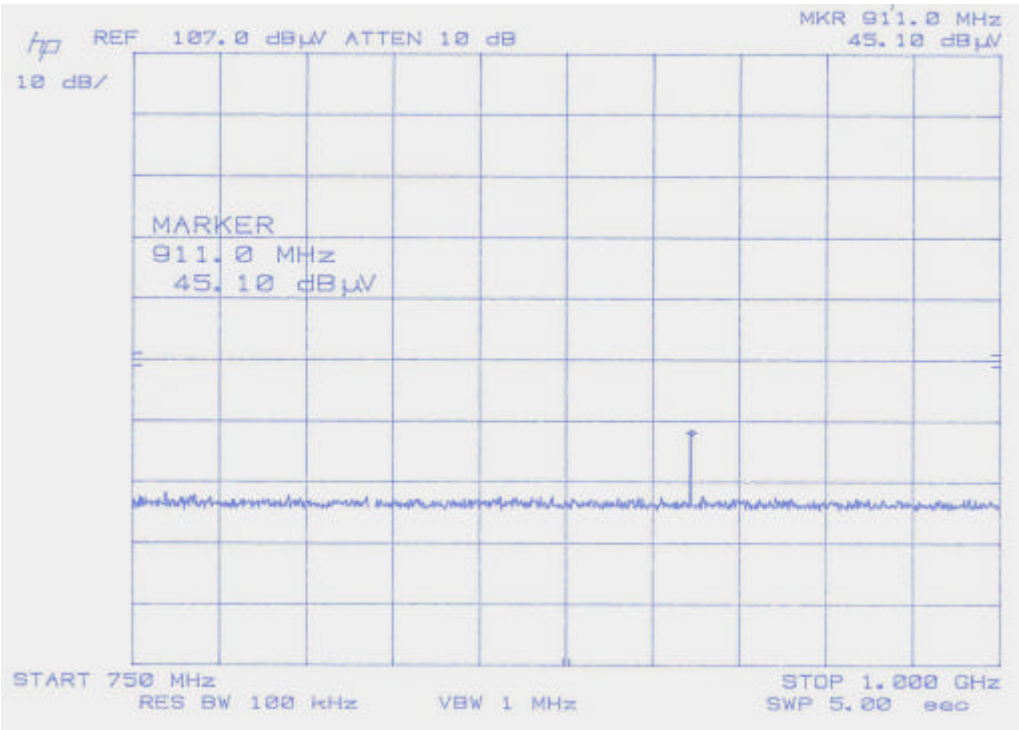


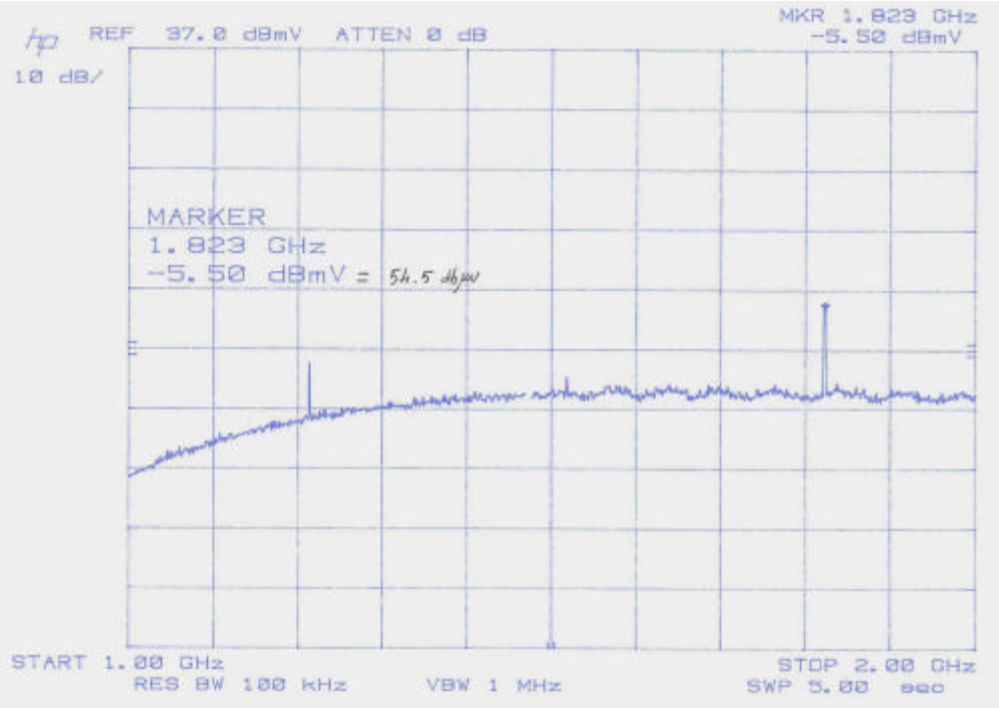


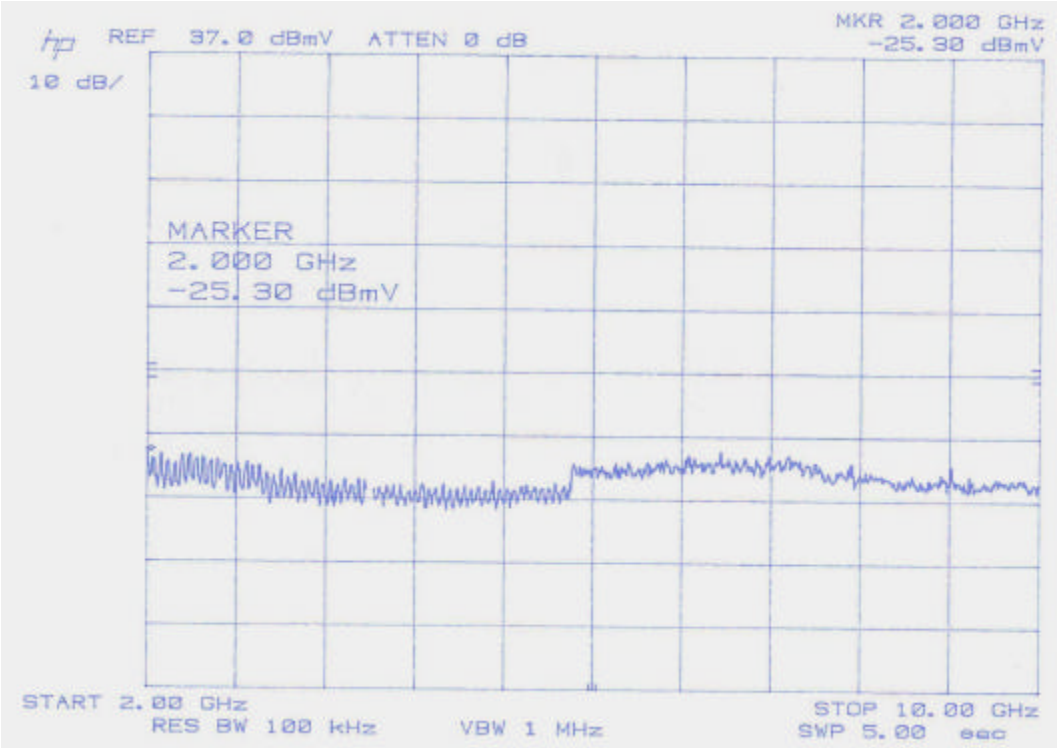

REF 107.0 dBµV ATTEN 10 dB
MKR 141.0 MHz
34.80 dBµV
10 dB/
MARKER
141.0 MHz
34.80 dBµV
START 100 MHz
RES BW 100 kHz
VBW 1 MHz
STOP 200 MHz
SWP 5.00 sec

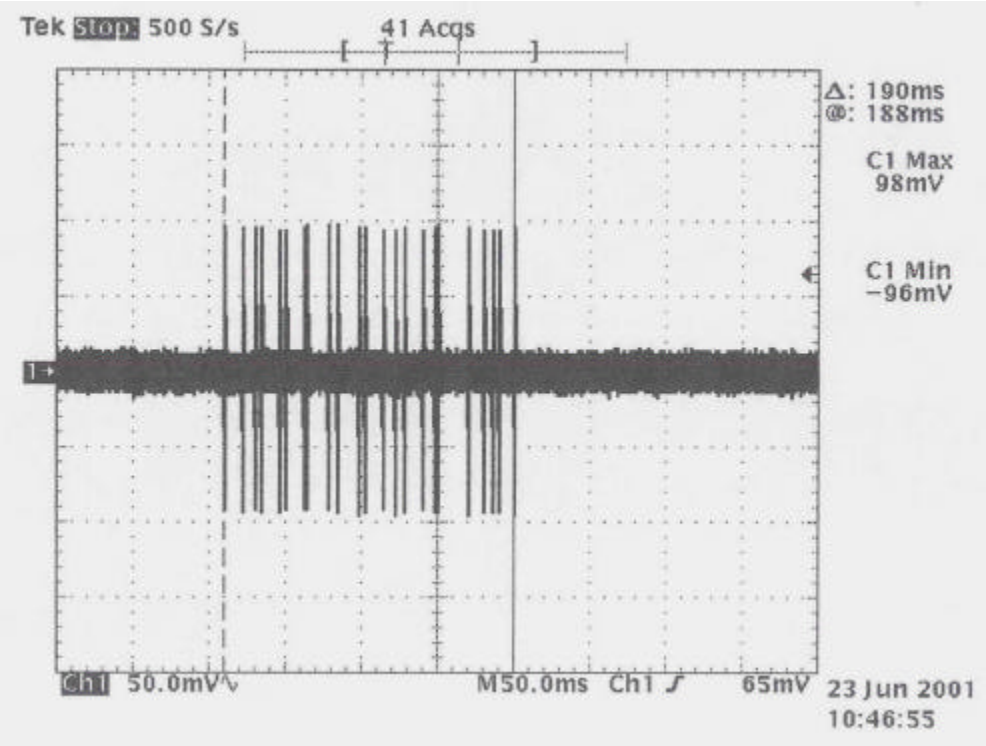

REF 107.0 dBµV ATTEN 10 dB
MKR 303.5 MHz
68.70 dBµV
10 dB/
MARKER
303.5 MHz
68.70 dBµV
START 200 MHz
RES BW 100 kHz
VBW 1 MHz
STOP 500 MHz
SWP 5.00 sec


REF 107.0 dBµV ATTEN 10 dB
MKR 607.8 MHz
54.80 dBµV
10 dB/
MARKER
607.8 MHz
54.80 dBµV
START 500 MHz
RES BW 100 kHz
VBW 1 MHz
STOP 750 MHz
SWP 5.00 sec


REF 107.0 dBµV ATTEN 10 dB
MKR 911.0 MHz
45.10 dBµV
10 dB/
MARKER
911.0 MHz
45.10 dBµV
START 750 MHz
RES BW 100 kHz
VBW 1 MHz
STOP 1.000 GHz
SWP 5.00 sec


REF 37.0 dBmV ATTEN 0 dB
MKR 1.823 GHz
-5.50 dBmV
10 dB/
MARKER
1.823 GHz
-5.50 dBmV = 54.5 dBµV
START 1.00 GHz
RES BW 100 kHz
VBW 1 MHz
STOP 2.00 GHz
SWP 5.00 sec


REF 37.0 dBmV ATTEN 0 dB
MKR 2.000 GHz
-25.30 dBmV
10 dB/
MARKER
2.000 GHz
-25.30 dBmV
START 2.00 GHz
RES BW 100 kHz
VBW 1 MHz
STOP 10.00 GHz
SWP 5.00 sec


Tek Stop: 500 S/s
41 Acqs
Δ: 190ms
@: 188ms
C1 Max
98mV
C1 Min
−96mV
Ch1 50.0mV
M50.0ms Ch1 ƒ 65mV
23 Jun 2001
10:46:55

6.3 Test Results and Data, Serial No. HCLNFEL, Model No. 50 sec R1 100Ω

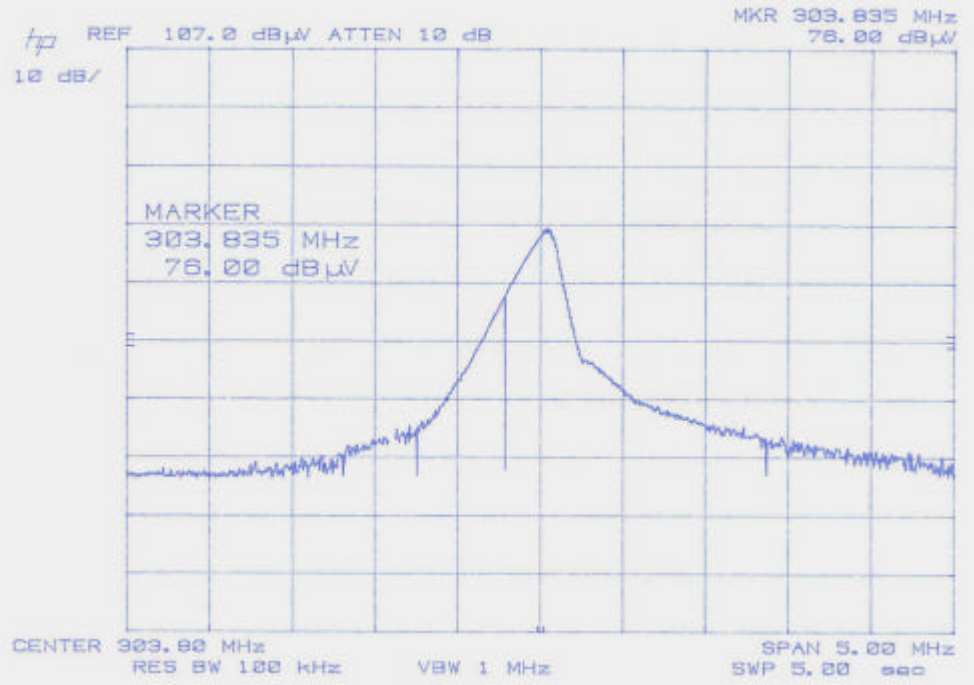
6.3.1 Tabular Data

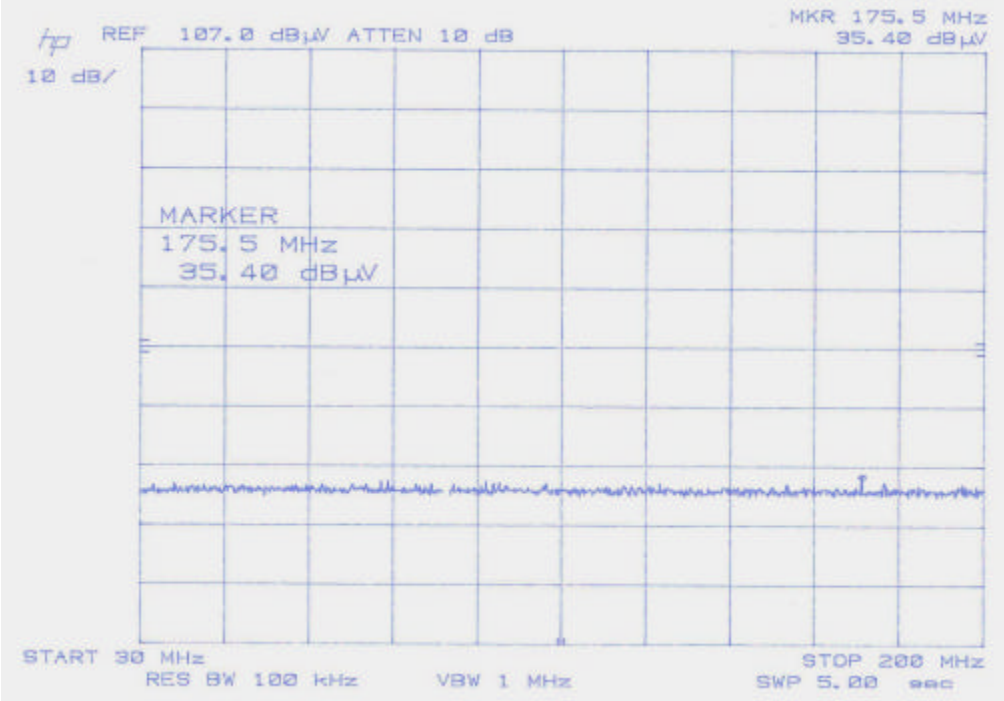
Date of measurement: March 8, 2001 Test engineer: Ba Nguyen

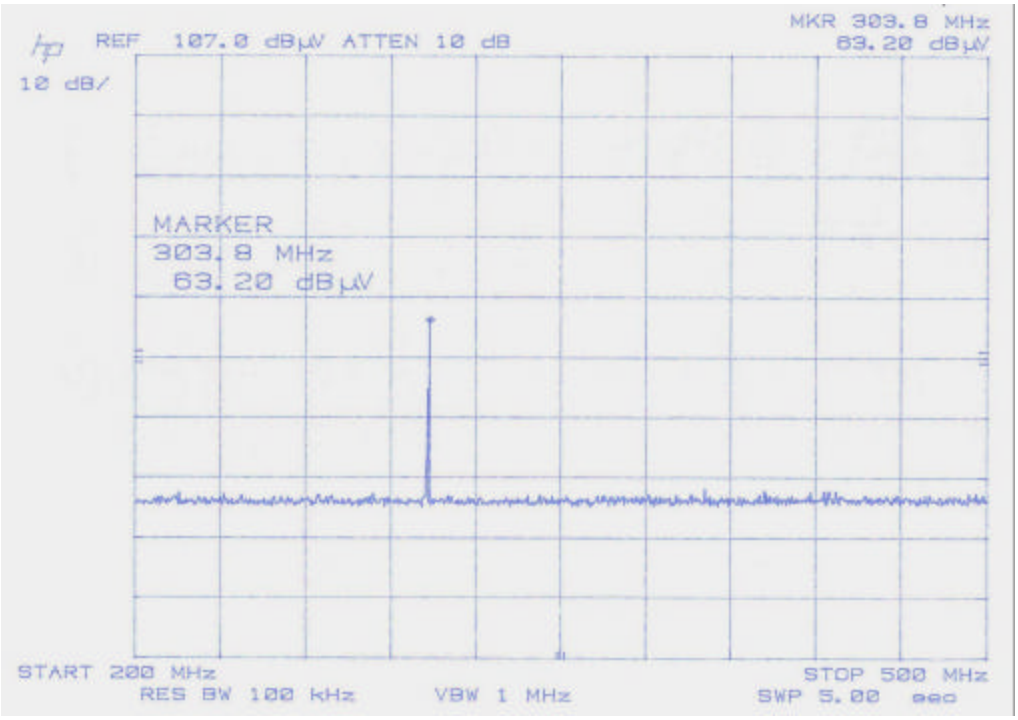
FCC RF Emissions Data, Spider TAG, Serial No. HCLNFEL, Model No. 50 sec R1 100Ω										
Measured Frequency (MHz)	Fundamental	Spurious/Harmonic	Incidental	Level (dbμv/m unless noted)					0.25% f_o bw	
				Corrected Peak Level	Calculated Average Level	Limit		Margin (Δ)	Max Allowed BW (kHz)	Actual BW (kHz)
						§15.231(e)	§15.209(a)			
303.8	X			63.4	26.4	67.0		-40.6		
175.5			X	17.6			43.5	-25.9		
607.8		X		48.3	11.3	54.0		-42.7		
911.0		X		51.6	14.6	54.0		-39.4		
663.0			X	32.2			54.0	-21.8		
1220.0			X	50.8			54.0	-3.2		
1520.0		X		53.9	16.9	54.0		-37.1		

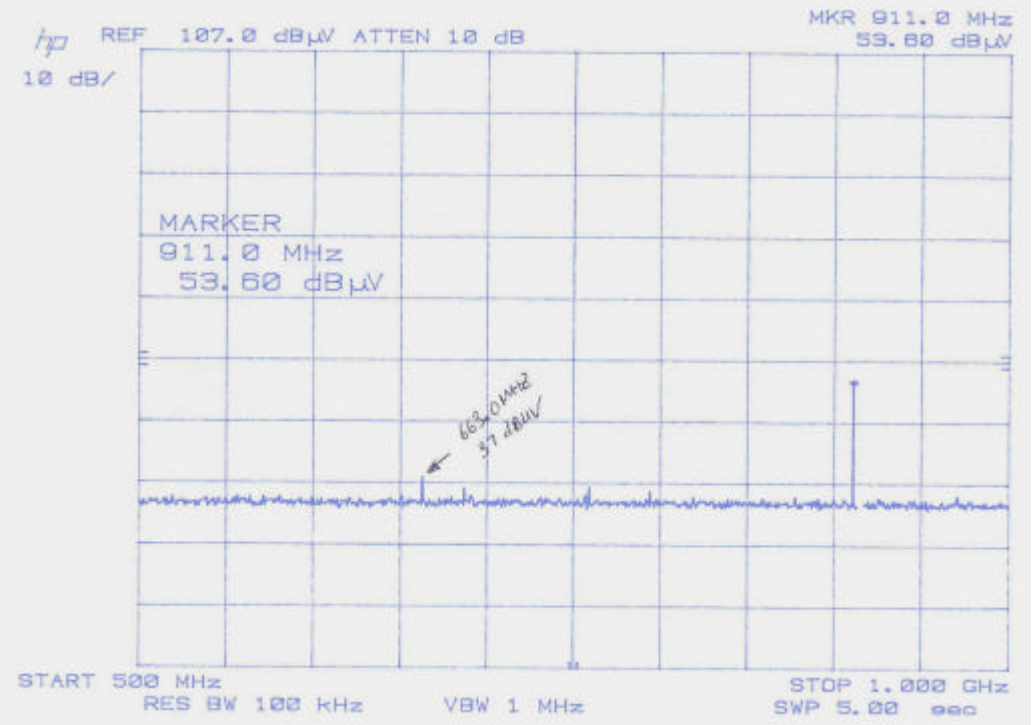
Average pulse width	$1.18(10^{-4})$ sec
Number of pulses in worse case 100 msec window	12

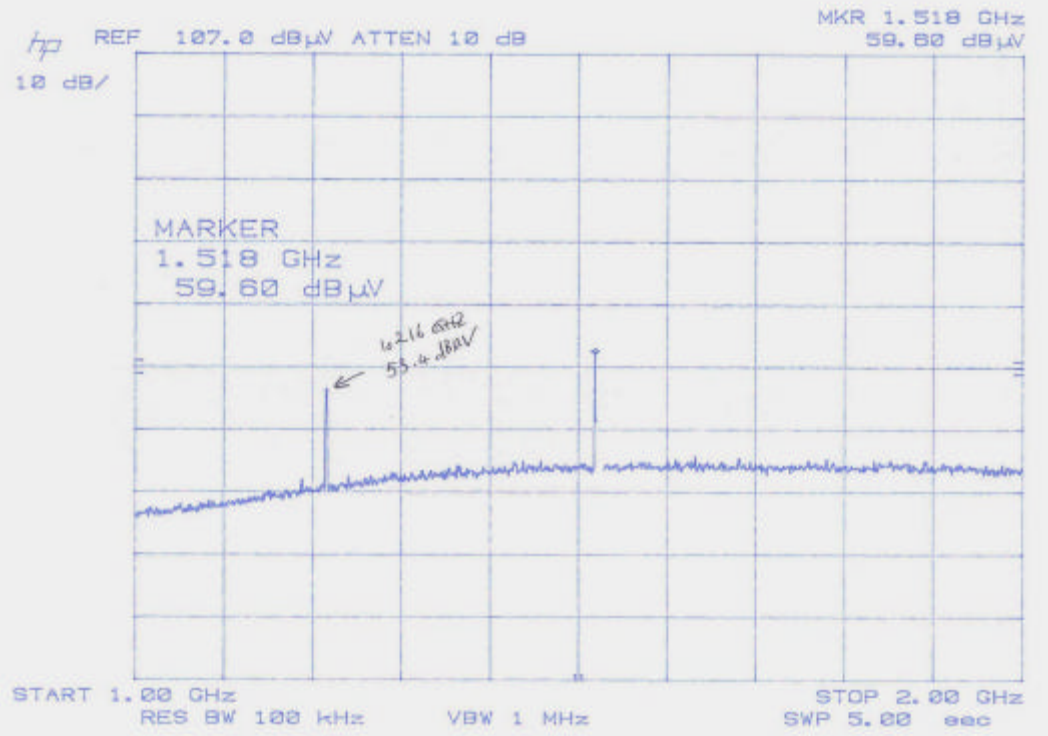
6.3.2 Frequency and Time Domain Plots

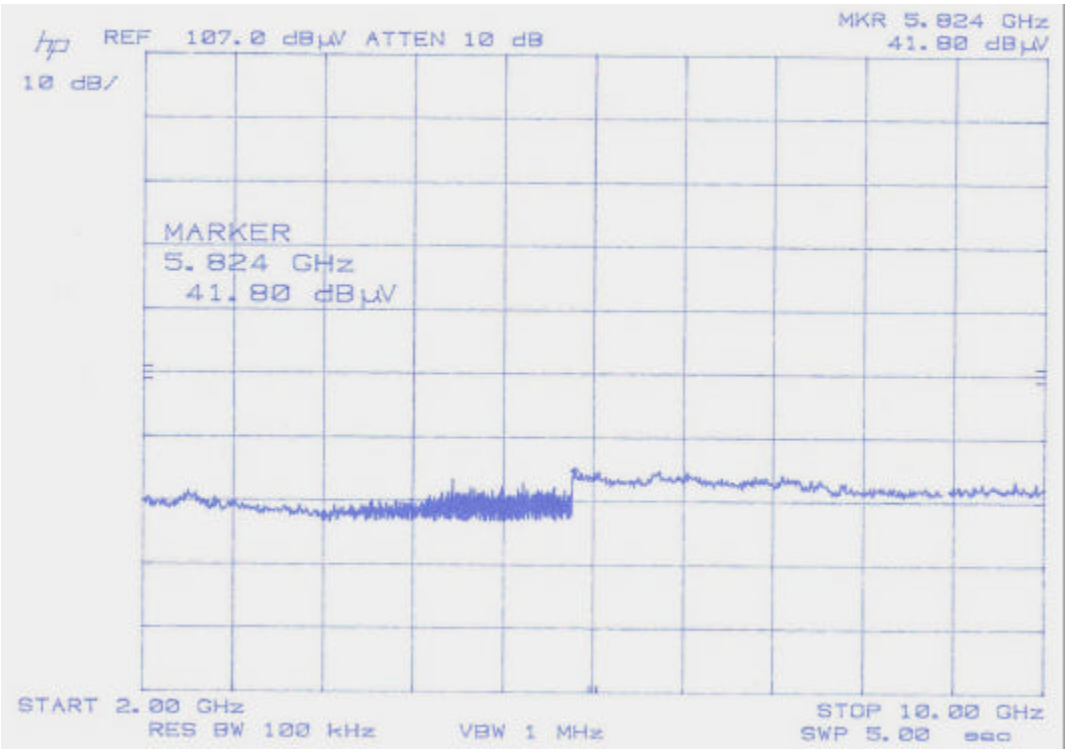


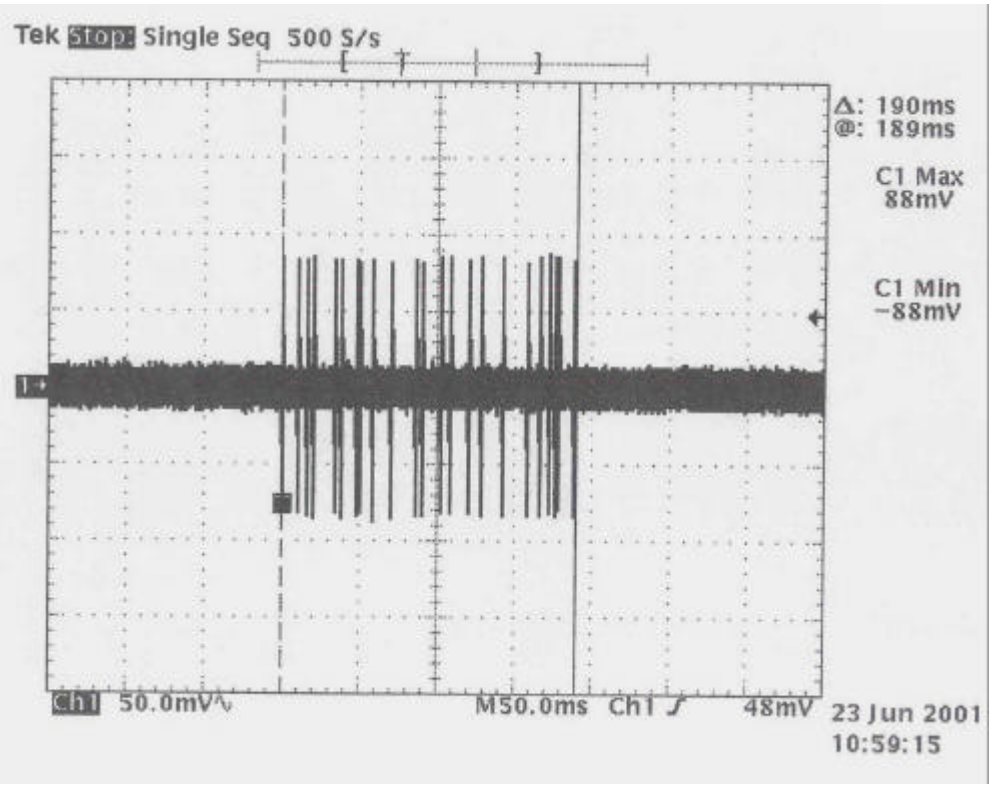



REF 107.0 dBµV ATTEN 10 dB
MKR 303.8 MHz
63.20 dBµV
10 dB/
MARKER
303.8 MHz
63.20 dBµV
START 200 MHz
RES BW 100 kHz
VBW 1 MHz
STOP 500 MHz
SWP 5.00 sec


REF 107.0 dBµV ATTEN 10 dB
MKR 911.0 MHz
53.60 dBµV
10 dB/
MARKER
911.0 MHz
53.60 dBµV
START 500 MHz
RES BW 100 kHz
VBW 1 MHz
STOP 1.000 GHz
SWP 5.00 sec


REF 107.0 dBµV ATTEN 10 dB
MKR 1.518 GHz
59.80 dBµV
10 dB/
MARKER
1.518 GHz
59.60 dBµV
START 1.00 GHz
RES BW 100 kHz
VBW 1 MHz
STOP 2.00 GHz
SWP 5.00 sec


REF 107.0 dBµV ATTEN 10 dB
MKR 5.824 GHz
41.80 dBµV
10 dB/
MARKER
5.824 GHz
41.80 dBµV
START 2.00 GHz
RES BW 100 kHz
VBW 1 MHz
STOP 10.00 GHz
SWP 5.00 sec


Tek Stop: Single Seq 500 S/s
Δ: 190ms
@: 189ms
C1 Max
88mV
C1 Min
-88mV
Ch1 50.0mV
M50.0ms Ch1 ƒ 48mV
23 Jun 2001
10:59:15