CHOMERICS

Parker Seals

TEST SERVICES

EMC EVALUATION OF THE
TRAKUS
ELECTRONIC LOCAL AREA POSITIONING SYSTEM
(ELAPS)
IN ACCORDANCE WITH THE
FCC PART 15 SUBPART C
AND
FCC PART 15 SUBPART B

Prepared For: **TRAKUS**
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ATTENTION: MICHAEL FREY

Prepared By: **ROBERT FOSTER**
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Date: **JANUARY 23, 2001**

Test Report Number: **TR2899.01**

Test Technician or Engineer: _____
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CTS Approved Signatory: _____

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LIST OF DEFINITIONS/ABBREVIATIONS

AC	Alternating Current
BB	Broadband
BW	Bandwidth
cm	Centimeter
C.P.U.	Calibrate Prior to Use
dB	Decibel
DC	Direct Current
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ER	Electric Radiation
EUT	Equipment Under Test
GHz	Gigahertz
Hz	Hertz
I-face	Interface
kHz	Kilohertz
m	Meter
MHz	Megahertz
mm	Millimeter
mS	Millisecond
mV	Millivolt
MR	Magnetic Radiation
NB	Narrowband
N.C.R.	No Calibration Required
PLC	Power Line Conduction
PPS	Pulses Per Second
uF	Microfarad
uH	Microhenry
uS	Microsecond
uV	Microvolt
U.W.C.	Use With Calibrated Equipment

1.0 GENERAL

1.1 Introduction

1.1.1 Purpose

The purpose of this report is to document the performance of the Trakus Electronic Local Area Positioning System during a variety of radio-performance tests and record the test requirements and procedures used. At the request of Trakus, the tests were performed by Chomerics Test Service (CTS) of Woburn, Massachusetts. The assessment will determine the compliance or non-compliance to the requirements set by FCC Part 15 Subpart B and C.

Michael Frey from Trakus was present for testing. Testing was performed during the period of January 8 through 10, 2001 under purchase order number 3537-1063.

1.1.2 Requirements

The requirements for the sequence of tests performed on the Trakus Electronic Local Area Positioning System are as follows:

FCC Part 15 Subpart B Class B

The transceiver and system shall meet the FCC Part 15 Subpart B Class B radiated and conducted emissions limits as stated in 15.107 and 15.109.

Conducted Emissions Limits	
Frequency (MHz)	Limit dBuV
.450 to 30	250

Radiated Emissions Limits		
Frequency (MHz)	Field Strength (uV/meter)	Measurement Distance (meters)
30-88	100	3
88-216	150	3
216-960	200	3
960-2500	500	3

FCC Part 15 Subpart C 15.247 Bandwidth

For Direct Sequence systems, the minimum 6dB bandwidth shall be at least 500kHz

FCC Part 15 Subpart C 15.247 Output Power

For Direct Sequence systems, the maximum output power is 1 Watt.

FCC Part 15 Subpart C 15.247 Spurious

In any 100kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement.

FCC Part 15 Subpart C 15.247 Power Spectral Density

For direct sequence systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3kHz band during any interval of continuous transmission.

FCC Part 15 Subpart C 15.247 Processing Gain

The processing gain of a direct sequence system, shall be at least 10 dB. The processing gain represents the improvement to the received signal-to-noise ratio, after filtering to the information bandwidth, from the spreading/despreading function. The processing gain may be determined by the following methods:

1. As measured at the demodulated output of the receiver.
2. A measured using the CW jamming margin method.

FCC Part 15 Subpart C 15.249 Field strength of the Fundamental and Harmonics

Field Strength of Fundamental and Harmonics		
Frequency (MHz)	Fundamental (mV/meter)	Harmonics (uV/meter)
2400-2483.5	50	500

1.2 Administrative Data

1.2.1 Test Facility

Chomerics Test Facility is recognized under the National Voluntary Laboratory Accreditation Program (NVLAP) for NVLAP Codes 12/C01 and 12/R01. Tests within this report not conforming to 12/C01 and 12/R01 NVLAP Codes are not covered under Chomerics NVLAP accreditation.

Chomerics Test Facility operates under the current revision of Chomerics Quality Assurance (QA) Manual Document Number QA002.

The QA manual has been constructed to reflect a quality program in accordance with the requirements of the National Institute of Standards and Technology (NIST), ISO 9002, ISO Guide 25, NIST Handbook 150, EN 45001, MIL-I-45208A, MIL-STD-461D, 462D and Chomerics Quality Assurance Program (QAP).

The QA manual outlines and describes the procedures for establishing and maintaining the quality of analysis, research, inspection, and testing within Chomerics Test Service (CTS).

This report does not represent an endorsement by the U.S. Government.

The results and/or conclusions within this test report refer and/or apply only to the unit(s) tested as defined by this report.

Measurements performed for this test are traceable to the National Institute of Standards and Technology (NIST) based on the fact that all test equipment used for the measurements were previously calibrated using standards traceable to NIST.

No deviations, additions to, or exclusions from the test specification(s) were made.

The system amplitude accuracy for the measurements made during the radiated emission tests was ±3dB.

1.2.2 Equipment Calibration

The calibration of Chomerics test facility equipment is controlled under the current edition of Chomerics Laboratory Test Equipment Calibration Manual Document Number QA001.

The test equipment used throughout this test sequence conforms to laboratory calibration standards, MIL-STD-45662, traceable to the National Institute of Standards and Technology. The date of the next due scheduled calibration is listed in each test section for the applicable equipment.

All test equipment is calibrated in one year intervals

1.2.3 Personnel

The test personnel used to perform or supervise the tests are accredited by the National Association of Radio and Telecommunications Engineers, Inc. (NARTE) as Certified Electromagnetic Compatibility Engineers (N.C.E.) and Technicians (N.C.T.).

1.3 Test Set-up

1.3.1 Test Site Matrix

The test locations used for the emissions and immunity tests are as follows: (Refer to Section 1.3.2 for test site descriptions).

Test Performed	Test Site
Radiated Emission Subpart B	Open Area Test Site A
Conducted Emissions Subpart B/C	Open Area Test Site A
Bandwidth 15.247	Open Area Test Site A & Test Chamber B
Power Output 15.247	Test Chamber B
Spurious Emission 15.247	Test Chamber B
Power Spectral Density	Open Area Test Site A
Processing Gain	N/A
Field Strength Fundamental	Open Area Test Site A
Strength Harmonics	Open Area Test Site A

1.3.2 Test Site Descriptions

The following is a list of the test sites and descriptions of each. Refer to Section 1.3.1 for specific test sites used for testing.

Open Area Test Site A: Chomerics Open Area Test Site "A" if used for this test program is located in the lower parking lot attached to the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts (see Figure 1). Parking is permitted on one side of test site "A" at a discrete distance from the imaginary ellipse.

The Open Area Test Site A enclosure is a wooden structure measuring 56 x 30 x 25 feet in size with galvanized steel sheet metal used as the ground plane. The structure is sized to allow 3 meter measurements and is heated and/or air conditioned.

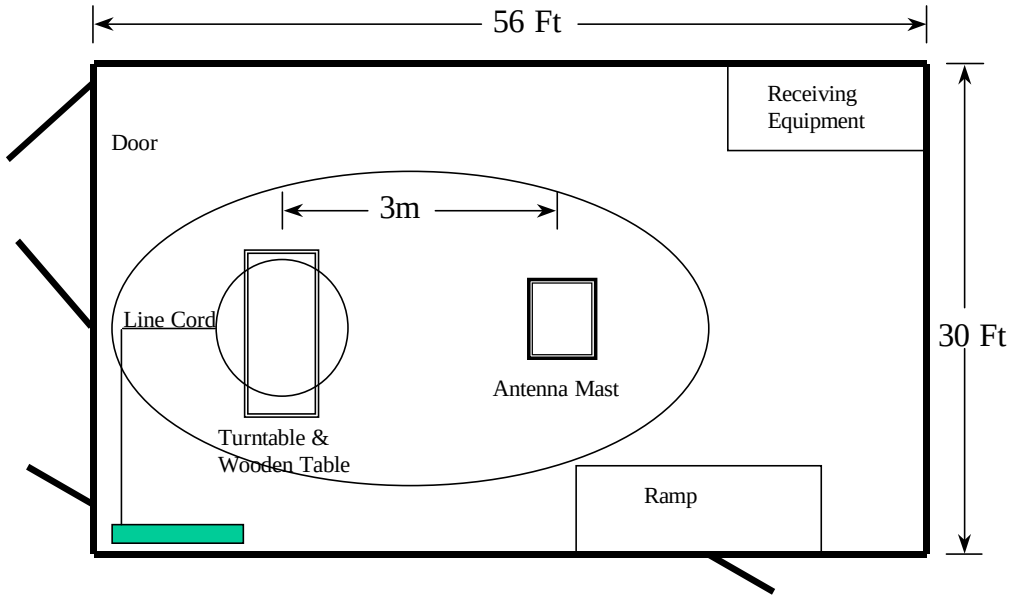
The structure used to support equipment under test is an EMCO 4 foot diameter motorized turntable. For tabletop equipment, a wooden table measuring 1.5 x 1 meter in size is positioned at the center of the turntable, at the proper height above the ground plane.

The area at the end of the Open Area Test Site “A” is the location for the test personnel and equipment to ensure they are outside the imaginary ellipse.

The available AC power within Open Area Test Site “A” is 120V 60Hz Single Phase 60Amps; 208V 60Hz Three Phase 60Amps; 208V 60Hz Single Phase 60Amps; 230V 50Hz Single Phase 50Amps.

This Site is listed with the Federal Communications Commissions (FCC).

OPEN AREA TEST SITE A
Figure 1



Key: = Power board

Open Area Test Site B: Chomerics Open Area Test Site "B" if used for this test program is located in the lower parking lot behind the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts (see Figure 2). Parking is permitted on one side of test site "B" at a discrete distance from the imaginary ellipse.

The Open Area Test Site “B” enclosure is a wooden structure measuring 56 x 30 x 25 feet in size with galvanized steel sheet metal used as the ground plane. The structure is sized to allow both 3 and 10 meter measurements and is heated and/or air conditioned.

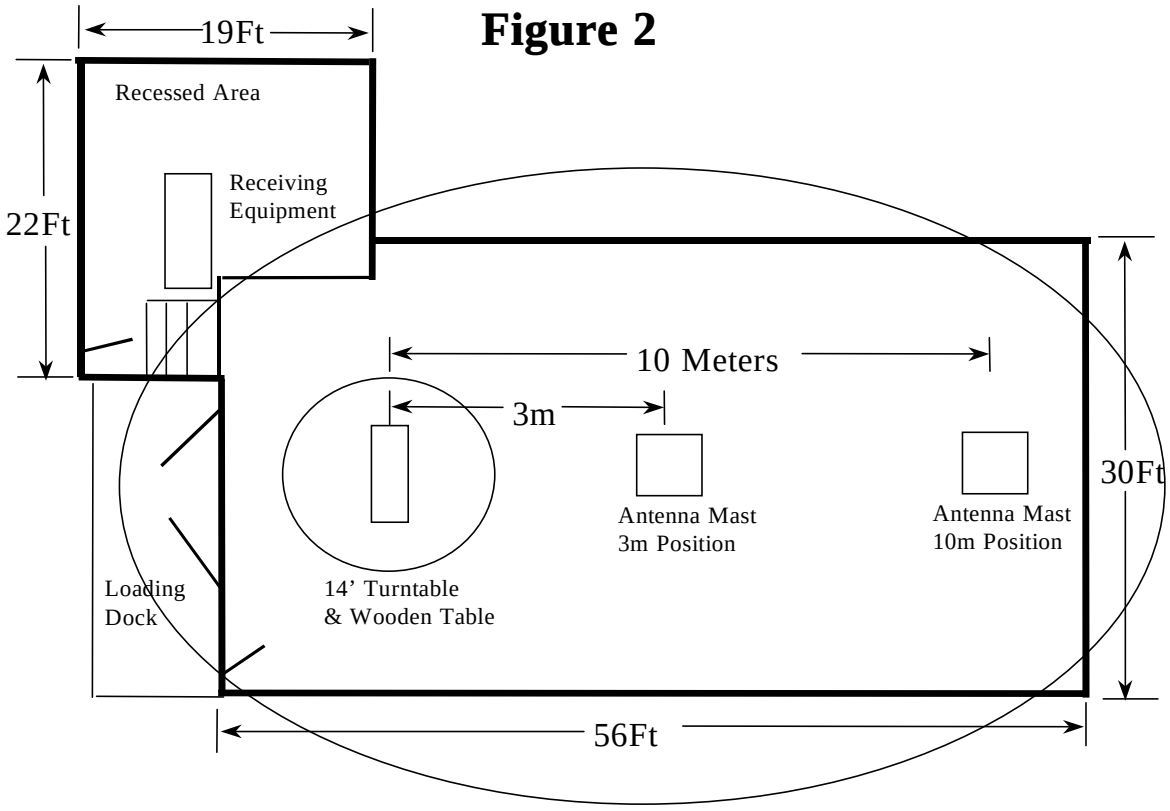
The structure used to support equipment under test is a 14 foot diameter motorized turntable. The sheet metal surface is flush with the ground plane. To ground the turntable, 175 copper fingers (1" x 1.5") are mounted around the outer edge of the turntable using machine screws. The spring fingers are equally spaced and provide a uniform interface between the turntable metal surface and ground plane. For tabletop equipment, a wooden table measuring 1.5 x 1 meter in size is positioned at the center of the turntable, at the proper height above the ground plane.

The addition at the end of the Open Area Test Site "B" is the location for the test personnel and equipment to ensure they are outside the imaginary ellipse.

The available AC power within Open Area Test Site "B" is 120V 60Hz Single Phase 60Amps; 208V 60Hz Three Phase 60Amps; 208V 60Hz Single Phase 60Amps; 230V 50Hz Single Phase 50Amps.

This site is listed with the Federal Communications Commissions (FCC).

OPEN AREA TEST SITE B
Figure 2



Test Chamber A: Chomerics Test Chamber A, if used for this test program, is located in the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts (see Figure 3). The shielded enclosures (test chambers) were manufactured and installed by Universal Shielding Corporation of Deer Park, New York. Attenuation tests have demonstrated that the shielded enclosures meet the attenuation requirements of MIL-STD-285 and NSA 65-6. The main test chamber is 22 x 10 x 10 feet in size with an adjacent enclosure that is 8 x 8 x 8 feet in size. The adjacent room, used for support equipment, and the main test chamber are connected together and referenced to the same single point ground.

When needed for tabletop equipment, a wooden table measuring 3 x 9 feet in size is positioned within the test chamber. When used for MIL-STD-461D tests the tabletop surface is covered with a copper sheet and grounded to the test chamber wall so that the resistance is less than 2.5 milliohms.

The power line filters supplying the power to the enclosures provide 100dB of attenuation from 10kHz to 10GHz. The adjacent room, used for support equipment, and the main test chamber have independent AC power obtained from independent AC power line filters.

The available AC power in Test Chamber A is 120V 60Hz Single Phase 100Amps; 120V 400Hz Three Phase 50Amps; 208V 60Hz Three Phase 100Amps; 208V 60Hz Single Phase 100Amps; 230V 50Hz Single Phase 50Amps.

Test Chamber B: Chomerics Test Chamber B, if used for this test program, is located in the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts (see Figure 3). The shielded enclosures (test chambers) were manufactured and installed by Universal Shielding Corporation of Deer Park, New York. Attenuation tests have demonstrated that the shielded enclosures meet the attenuation requirements of MIL-STD-285 and NSA 65-6.

The main test chamber is 22 x 10 x 10 feet in size with an adjacent enclosure that is 8 x 8 x 8 feet in size. The adjacent room, used for support equipment, and the main test chamber are connected together and referenced to the same single point ground.

Test Chamber B is lined with Rantec ferrite absorber tiles FT-100. All surfaces of the room are lined with FT-100. The floor is lined with removable tiles. This absorber material allows the test chamber to meets the 0-6dB field uniformity requirements of IEC 1000-4-3 and ENV50140.

There are two access panels between the main test chamber and the support room. The access panels are covered with absorber tiles. The absorber tiles can be removed from the access panels.

The power line filters supplying the power to the enclosures provide 100dB of attenuation from 10kHz to 10GHz. The adjacent rooms, used for support equipment, and the main test chamber have independent AC power obtained from independent AC power line filters.

The available AC power in Test Chamber B is 120V 60Hz Single Phase 30Amps; 208V 60Hz Three Phase 30Amps; and 230V 50Hz Single Phase 30Amps: A wooden table 3 x 6 feet in size is used for tabletop equipment.

Only one power line frequency is available in the chamber at a time, 50, 60 or 400 cycle, unless power is brought through an access panel.

Test Chamber C: Chomerics Test Chamber C, if used for this test program, is located in the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts (see Figure 3). The shielded enclosures (test chambers) were manufactured and installed by Universal Shielding Corporation of Deer Park, New York.

Attenuation tests have demonstrated that the shielded enclosures meet the attenuation requirements of MIL-STD-285 and NSA 65-6. The main test chamber is 16 x 20 x 10 feet in size with two adjacent enclosures on either side which are 8 x 8 x 8 and 8 x 12 x 10 feet in size, respectively.

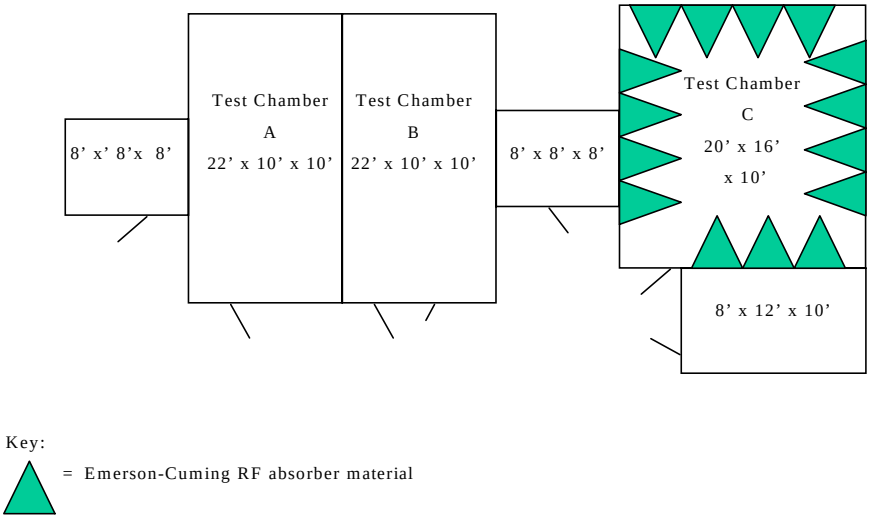
Test Chamber C is lined with Emerson-Cuming RF absorber material. This absorber material meets the following absorption specifications: 80MHz 6dB, 300MHz 30dB, 500MHz 35dB, 1GHz 40dB, and 3 to 24 GHz 50dB. Each of the two adjacent rooms used for support equipment and the main test chamber are connected together and referenced to the same single point ground.

When needed for tabletop equipment, a wooden table measuring 3 x 9 feet in size is positioned within the test chamber. When used for MIL-STD-461D tests, the tabletop surface is covered with a copper sheet and grounded to the test chamber wall so that the resistance is less than 2.5 milliohms. When used for radiated electromagnetic field tests, to some standards, the copper tabletop surface is removed.

The available AC power in Test Chamber C is 120V 60Hz AC Single Phase 60Amps; 230V 50Hz AC Single Phase 50Amps; 115V 400Hz AC Three Phase 30Amps (through access panel); 208V 60Hz AC Three Phase AC 30Amps (through access panel).

The power line filters supplying the power to the enclosures provide 100dB of attenuation from 10kHz to 10GHz. Each of the two adjacent rooms used for support equipment and the main test chamber has independent AC power obtained from independent AC power line filters.

Immunity Lab Layout
Figure 3



EC Lab A: Chomerics EC Lab A is located in the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts.

EC Lab A is a typical room measuring 20 x 16 feet with an aluminum sheet metal (8 x 12 feet in size) in the center of the floor for a ground plane. When needed for tabletop equipment, a wooden table (0.8 meters in height) is placed on the metal ground plane that extends at least 0.1m beyond all sides of the table. A removable 3 x 6 foot sheet of aluminum is placed on top of the wooden table when a horizontal coupling plane is required.

The appropriate connections, as needed for each test, are used to interconnect the table horizontal coupling plane, ground plane floor, test equipment, and earth ground.

The available AC power in the EC Lab A is 120V 60Hz AC Single Phase 60Amps; 230V 50Hz AC Single Phase 50Amps; and 208V 60Hz AC Three Phase AC 30Amps.

EC Lab A is equipped with air and water services for use with equipment that requires it.

The humidity in EC Lab A can be automatically controlled in the range of 20% to 60%.

TEST SERVICES

EC Lab B: Chomerics EC Lab B is located in the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts.

EC Lab B is a typical room measuring 12 x 14 feet with a copper sheet (6 x 8 feet in size) in the center of the floor for a ground plane. When needed for tabletop equipment, a wooden table (0.8 meters in height) is placed on the metal ground plane that extends at least 0.1m beyond all sides of the table. A removable 3 x 6 foot sheet of aluminum is placed on top of the wooden table when a horizontal coupling plane is required.

The appropriate connections, as needed for each test, are used to interconnect the table horizontal coupling plane, ground plane floor, test equipment, and earth ground.

The available AC power in the EC Lab B is 120V 60Hz AC Single Phase 60Amps, 230V 50Hz AC Single Phase 50Amps; and 208V 60Hz AC Three Phase AC 30Amps.

The humidity in EC Lab B can be automatically controlled in the range of 20% to 60%.

1.3.3 Equipment Under Test

A detailed description of the Equipment Under Test is located in Appendix B.

ISM Band Radio Link for ELAPS

The Tower Transceiver (TT) and Player Patch (PP) were developed as part of a microwave radio link operating in the Industrial, Scientific, & Medical (ISM) band for spread spectrum transmissions at 2.4 GHz to 2.485 GHz. The transceivers were developed for an Electronic Local Area Positioning System (ELAPS) which uses pairs of TT's as delta time of arrival (TOA) sensors to determine exact locations of multiple PP's within a defined viewing area. Multiple PP locations are determined based on TOA correlation data called Digital Signal Processing Records (DSPR's). Location, Velocity, and Acceleration (LVA) calculations are made from DSPR's and then grouped for each PP and used as statistics for real-time display and amassed in a database. The Trakus system will be owned and operated by Trakus personnel and will not be for sale to the consumer market. However, the digital data that is collected by the Trakus system will be sold to interested consumer markets (i.e. Television/Sports networks, gaming and internet companies etc.).

Current Applications

The immediate application is for the televised sports industry, starting in the National Hockey League. The Tower Transceivers are deployed around an ice rink to determine the LVA's of all athletes during an entire game. Eight to sixteen TT's are used to cover the area confined by the rink boards. TT's will be located as close to the boards as possible, positioned at a predetermined height above the ice. All skaters in the game will be equipped with a PP affixed in their helmets. PP's will be worn at all times by the athletes throughout the game and will periodically transmit signals back to the TT's so that TOA correlation data may be obtained. LVA's can then be produced by the Trakus system to determine the locations and speeds of the hockey players at all times during the game, total distances skated by hockey players, the force of a hit between two or more hockey players (such as in checking), as well as many other insightful statistics.

Other applications include football and soccer, both of which would utilize pairs of TT's around the playing field as TOA sensors to determine the LVA's of all players involved in the game. Eight to sixteen TT's will be spaced evenly around the playing field, positioned at a predetermined height above the ground.

2.0 SUMMARY

The terms "Passed" or "Failed" in this section are intended to guide the reader as to whether or not the EUT met the minimum Performance Criteria that can be interpreted from the FCC Parts 2, 15 and 90. The "Results" paragraph in each test section to follow, and the test data sheets, will outline specifically how the EUT performed during each test.

Radiated Emission Subpart B	Passed
Conducted Emissions Subpart B/C	Passed
Bandwidth 15.247	Passed
Power Output 15.247	Passed
Spurious Emission 15.247	Passed
Power Spectral Density	Passed
Processing Gain	Passed
Field Strength Fundamental	Passed
Field Strength Harmonics	Passed

2.1 Summary of Recommendations

The Trakus Electronic Local Area Positioning System will not require modifications in order to insure compliance with CFR 47 FCC Parts 15 Subpart B and C.

3.0 TESTS PERFORMED

3.1 FCC Part 15 Subpart B Radiated Emissions

3.1.1 Equipment Used

Equipment Used	Asset #	Serial #	Cal Date
Tektronix 496 Spectrum Analyzer	56	B010206	4/01
Hewlett Packard 8566B Spectrum Analyzer	47	2637A04064	7/01
Hewlett Packard 8566 Display Analyzer Main	46	2648A14289	7/01
Hewlett Packard 85685A RF Preselector	48	2648A00483	7/01
Rhode and Schwartz ESV Test Receiver	521	979531/031	1/01
Hewlett Packard 8447D Pre Amp	633	2805A03022	1/01
EMCO 3120 Tuned Dipole Antenna B1	477	56	1/01
EMCO 3121 Tuned Dipole Antenna B2	478	176	1/01
EMCO 3121 Tuned Dipole Antenna B3	479	728	1/01
EMCO 3109 Biconical Antenna	119	2414	1/01
EMCO 3146 Log Periodic Antenna	377	3380	1/01
Eaton 94626-1 Horn Antenna	334	145	1/01
EMCO 3115 Microwave Horn Antenna	376	2796	1/01
EMCO 3105 Microwave Horn Antenna	78	2118	1/01

3.1.2 Test Conditions

The Trakus Electronic Local Area Positioning System consists of two separate pieces of equipment the Tower Transceiver and Player Patch. Two separate radiated emissions test were performed one on the Tower Transceiver and one on the Player Patch.

An initial pre-scan was performed inside a semi-anechoic chamber. The pre-scan was performed from 30MHz to 25GHz. The pre-scan was performed on the Transceiver Tower and the Player Patch.

Radiated emissions testing were performed with the Transceiver Tower and the Player Patch set up on a wooden table above the turntable at a distance of 3 meters from a tuned dipole antenna within Open Area Test Site A.

The Tower Transceiver was configured to operate in the continuous mode of operation to maximize the emissions. The Tower Transceiver was set up and powered by 120V 60Hz for radiated emission tests. The worst case signals detected were recorded.

The Player Patch was configured to operate in the continuous mode of operation to maximize the emissions. The Player Patch was set up and powered by 120V 60Hz for radiated emission tests. The worst case signals detected were recorded.

3.1.3 Test Method

The test method of ANSI C63.4 was followed for Class B equipment. For the radiated emission measurements, a manual scan was performed from 30MHz to 25GHz. During this scan, the antenna, turntable and the EUT's cable positions were manipulated to maximize the emission levels in a given frequency band displayed on the spectrum analyzer.

3.1.4 Results

The Trakus Electronic Local Area Positioning System which consist of the Tower Transceiver and the Player Patch meets the FCC Part 15 Subpart B Class B requirements.

3.1.5 Test Data

RADIATED E FIELD EMISSION MEASUREMENTS

CUSTOMER: TRAKUS **DATE: 01/08/01**
EQUIPMENT: PLAYER PATCH **TEST NUMBER: 1**
TESTED BY: ROBERT FOSTER
OPERATING MODE: CONTINUOUS TRANSMIT **TEST SPEC: FCC PART 15 SUBPART B CLASS B**
BANDWIDTH: 100 KHZ (PEAK)/120 KHZ (QP) AND 1MHZ PEAK **PROCEDURE: ANSI C63.4**
FREQUENCY RANGE: 30MHZ – 25 GHZ **ANTENNA DISTANCE: 3 METERS**

FREQUENCY MHZ	PEAK MEASURED LEVEL -dBm	QUASI-PEAK MEASURED LEVEL dBuV	ANTENNA HEIGHT (METERS)	TURNTABLE AZIMUTH (DEGREES)	ANTENNA H/V	ANTENNA FAC/CABLE LOSS dB	FIELD LEVEL dBuV/m ✯	LIMIT dBuV/m (QP)
30*	-	10	2.5	0	V	0	10	40
100*	-	10	2	0	V	9.6	19.6	43.5
200*	-	10	1.5	0	V	16.7	36.7	43.5
400*	-	17	1.5	0	V	0.1	17.1	46
750*	-	17	1.5	0	V	5.6	22.6	46
1000*	-	17	1.5	0	V	10.2	27.2	53.9
560	-	36	1.2	0	H	3.6	39.6	46
4350	10	-	1.0	0	H	32.2	42.2	53.9
4890	18	-	1.0	0	H	32.2	50.4	53.9
No other signals detected to 25GHz								

✯All signals greater than 3dB from the limit are calculate to the nearest whole number.
✯Field Level (dBuV/m) = [107 – Measured level (dBm)] + Antenna Factor/Cable Loss (dB)
Ambient Temperature: 68°F Humidity: 25 % Atmospheric Pressure: 29.8″
NOTES: * = Noise floor of equipment.

FORM CTS-DS-001R

3.15 Test Data (continued)

RADIATED E FIELD EMISSION MEASUREMENTS

CUSTOMER: TRAKUS **DATE: 01/09/01**
EQUIPMENT: TOWER TRANSCEIVER **TEST NUMBER: 2**
TESTED BY: ROBERT FOSTER
OPERATING MODE: CONTINUOUS TRANSMIT **TEST SPEC: FCC PART 15 SUBPART B CLASS B**
BANDWIDTH: 100 KHZ (PEAK)/120 KHZ (QP) AND 1MHZ PEAK **PROCEDURE: ANSI C63.4**
FREQUENCY RANGE: 30MHZ – 25 GHZ **ANTENNA DISTANCE: 3 METERS**

FREQUENCY MHZ	PEAK MEASURED LEVEL -dBm	QUASI-PEAK MEASURED LEVEL dBuV	ANTENNA HEIGHT (METERS)	TURNTABLE AZIMUTH (DEGREES)	ANTENNA H/V	ANTENNA FAC/CABLE LOSS dB	FIELD LEVEL dBuV/m ✯	LIMIT dBuV/m (QP)
400	-	27	1.2	0	H	0.0	27	40
434	-	36	1.5	180	H	0.9	36.9	43.5
450	-	29	1.5	180	H	0.9	29.9	43.5
467	-	35	1.0	270	H	1.3	36.6	46
481	-	32	1.5	0	H	1.7	33.7	46
501	-	34	1.5	0	H	1.7	35.7	53.9
634	-	37	1.9	270	H	4.0	41.0	46
773	-	32	1.2	0	V	5.6	37.6	53.9
No other signals detected to 25GHz								

✯All signals greater than 3dB from the limit are calculate to the nearest whole number.
✯Field Level (dBuV/m) = [107 – Measured level (dBm)] + Antenna Factor/Cable Loss (dB)
Ambient Temperature: 68°F Humidity: 25 % Atmospheric Pressure: 29.8″
NOTES:

FORM CTS-DS-001R

3.1.6 Photographic Documentation

CUSTOMER: TRAKUS
EQUIPMENT: PLAYER PATCH
TESTED BY: ROBERT FOSTER

DATE: 01/08/01
TEST NUMBER: 1

Photograph Description: Radiated set-up

FORM CTS-PHOTO

CHOMERICS
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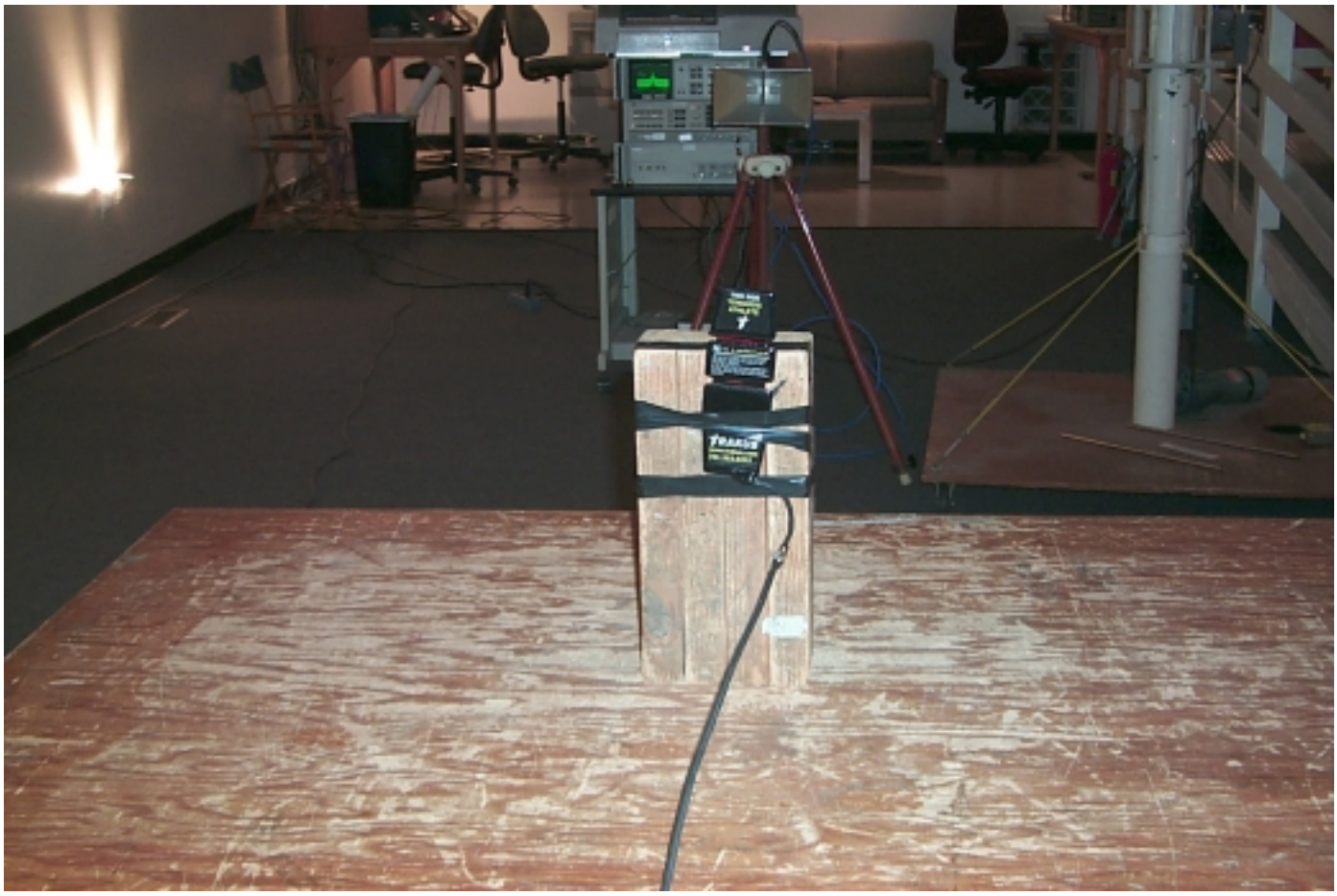
TEST SERVICES

Photographic Documentation

CUSTOMER: TRAKUS
EQUIPMENT: PLAYER PATCH
TESTED BY: ROBERT FOSTER

DATE: 01/08/01
TEST NUMBER: 1



Photograph Description: Radiated set-up

FORM CTS-PHOTO

CHOMERICS
Parker Seals

TEST SERVICES

Photographic Documentation

CUSTOMER: TRAKUS
EQUIPMENT: PLAYER PATCH
TESTED BY: ROBERT FOSTER

DATE: 01/08/01
TEST NUMBER: 1

Photograph Description: Radiated set-up

FORM CTS-PHOTO

CHOMERICS
Parker Seals

TEST SERVICES

Photographic Documentation

CUSTOMER: TRAKUS
EQUIPMENT: TRANSCEIVER TOWER
TESTED BY: ROBERT FOSTER

DATE: 01/09/01
TEST NUMBER: 2

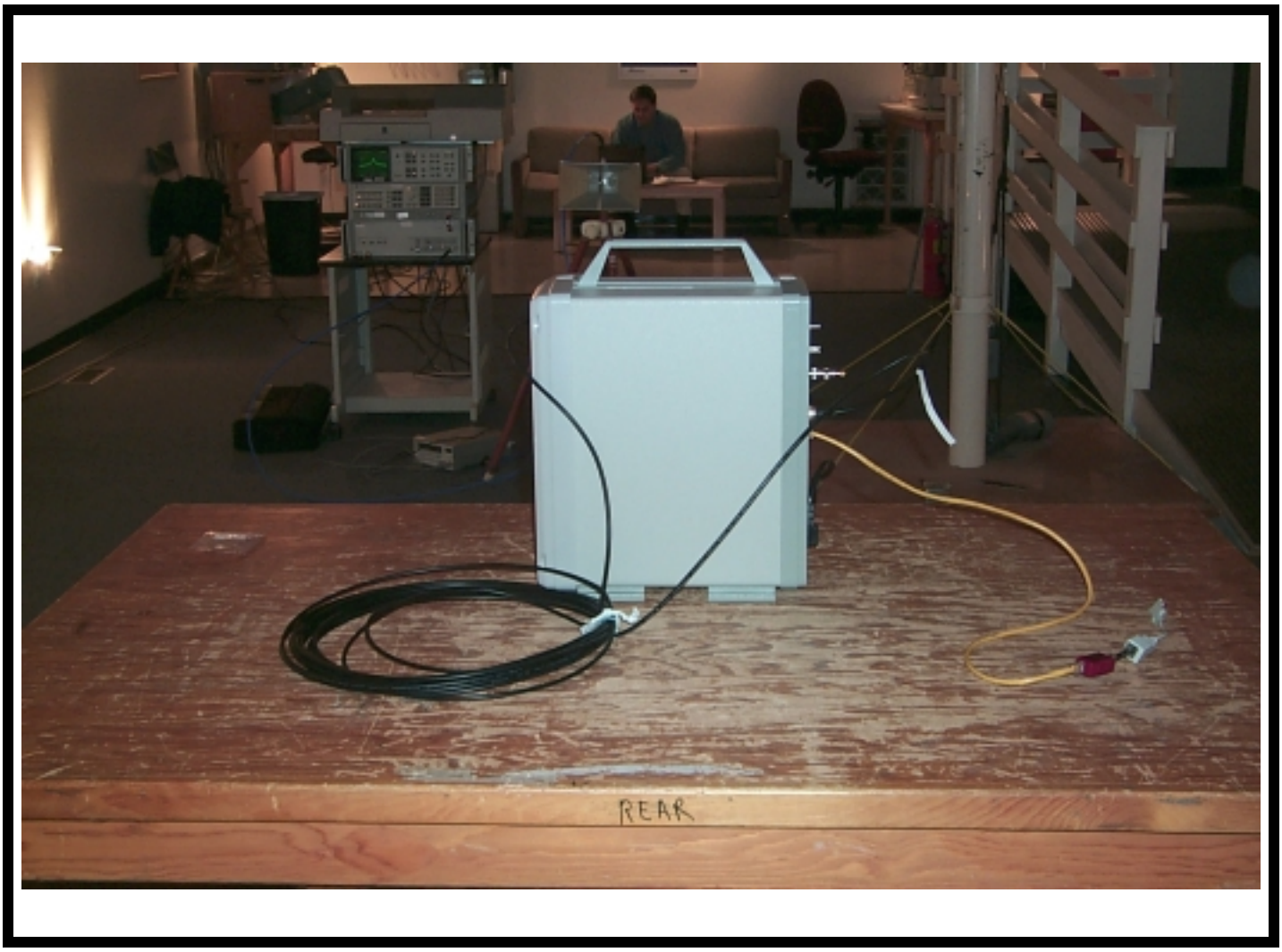
Photograph Description: Radiated set-up

FORM CTS-PHOTO

Photographic Documentation

CUSTOMER: TRAKUS
EQUIPMENT: TRANSCEIVER TOWER
TESTED BY: ROBERT FOSTER

DATE: 01/09/01
TEST NUMBER: 2



Photograph Description: Radiated set-up

FORM CTS-PHOTO

CHOMERICS
Parker Seals

TEST SERVICES

Photographic Documentation

CUSTOMER: TRAKUS
EQUIPMENT: TRANSCEIVER TOWER
TESTED BY: ROBERT FOSTER

DATE: 01/09/01
TEST NUMBER: 2

Photograph Description: Radiated set-up

FORM CTS-PHOTO

CHOMERICS
Parker Seals

TEST SERVICES

Photographic Documentation

CUSTOMER: TRAKUS
EQUIPMENT: TRANSCEIVER TOWER
TESTED BY: ROBERT FOSTER

DATE: 01/09/01
TEST NUMBER: 2

Photograph Description: Radiated set-up

FORM CTS-PHOTO

3.2 FCC Part 15 Subpart B and C Conducted Emissions

3.2.1 Equipment Used

Equipment Used	Asset #	Serial #	Cal Date
Tektronix 496 Spectrum Analyzer	56	B010206	4/01
Rhode and Schwartz ESH-2 Test Receiver	488	879575/006	1/01
EMCO 3810/2NM LISN	601	9612-1740	1/01

3.2.2 Test Conditions

Only one conducted emissions test was performed on the Trakus Electronic Local Area Positioning System. The conducted emissions test was performed on the Tower Transceiver. The Player Patch is exempt from conducted emissions because it is powered by 3 VDC.

Conducted emissions testing was performed with the Tower Transceiver placed on the table and the test receiver connected to the Line Impedance Stabilization Network (LISN).

The Trakus Tower Transceiver was configured to operate in the continuous Transmission mode of operation to maximize the emissions. The Tower Transceiver was set up and powered by 120V 60Hz for conducted emission tests. The worst case signals detected were recorded.

3.2.3 Test Method

The test method of ANSI C63.4 was followed for Class B equipment. A manual scan was performed from 450kHz to 30MHz with the Trakus Tower Transceiver powered through the Line Impedance Stabilization Network (LISN).

3.2.4 Results

The Trakus Tower Transceiver meets FCC Part 15 Subpart B and C conducted emissions requirements.

3.2.5 Test Data

CONDUCTED EMISSION MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: TOWER TRANSCEIVER
TESTED BY: ROBERT FOSTER
OPERATING MODE: CONTINUOUS TRANSMISSION
BANDWIDTH: 9 KHZ
FREQUENCY RANGE: 450 KHZ – 30 MHZ

DATE: 01/09/01
TEST NUMBER: 3
COUPLING DEVICE: EMCO LISN
TEST SPEC: FCC PART 15 SUBPART B AND C
PROCEDURE: ANSI C63.4
VOLTAGE: 110V AC 60HZ

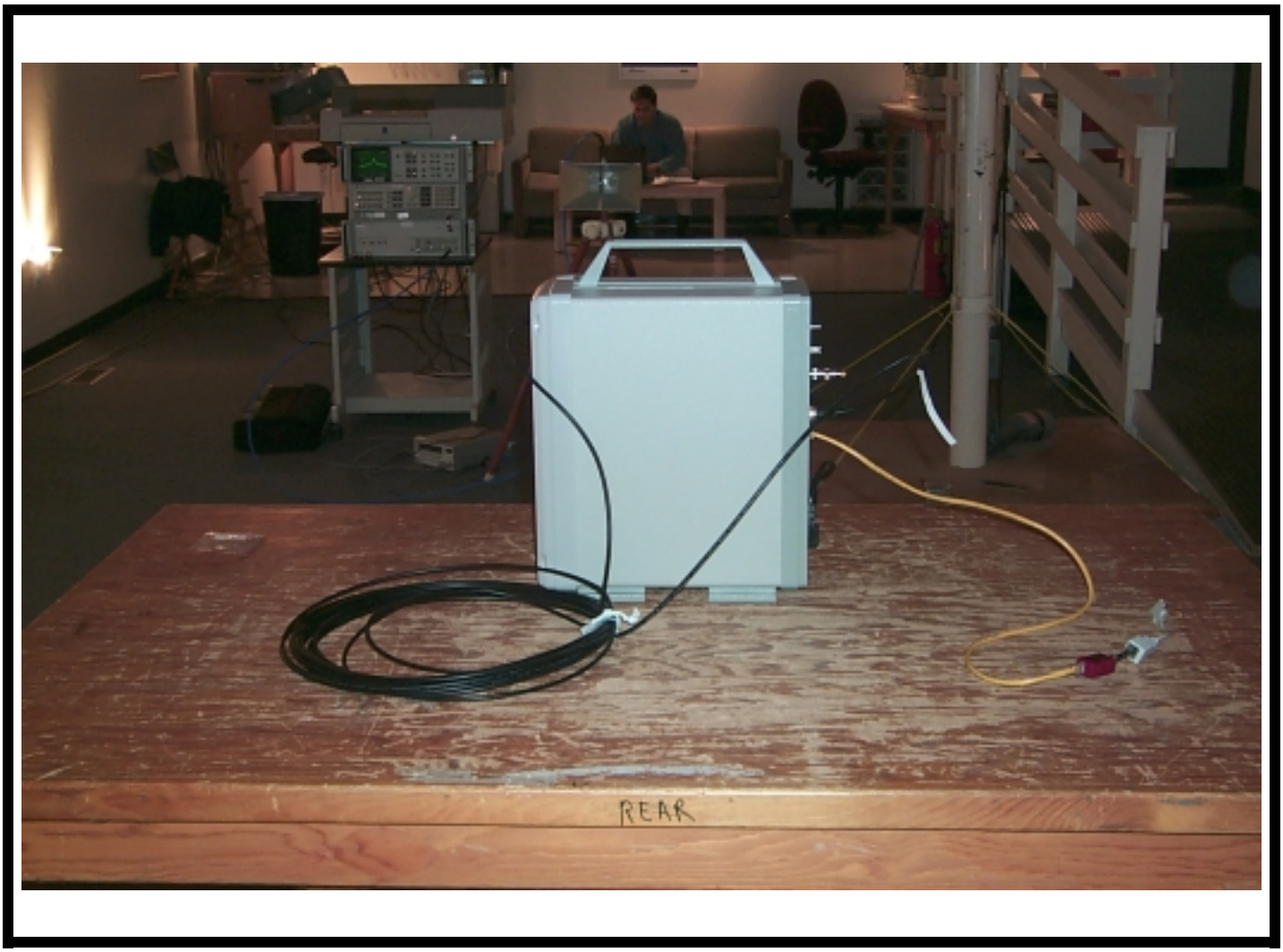
FREQUENCY MHz	PEAK MEASURED LEVEL dBuV				AVERAGE MEASURED LEVEL dBuV				QUASI-PEAK MEASURED LEVEL dBuV				LIMIT dBuV Quasi-Peak	
	AØ	BØ	CØ	NØ	AØ	BØ	CØ	NØ	AØ	BØ	CØ	NØ		
.450									10			10	48	
1									10			10	48	
2									10			10	48	
5									10			10	48	
10									10			10	48	
30									10			10	48	

✯All signals greater than 3dB from the limit are calculate to the nearest whole number.
✯Field Level (dBuV/m) = [107 – Measured level (dBm)] + Antenna Factor/Cable Loss (dB)
Ambient Temperature: 68°F Humidity: 25 % Atmospheric Pressure: 29.8″
NOTES:

FORM CTS-DS-002C

3.2.6 Photographic Documentation

CUSTOMER: TRAKUS
EQUIPMENT: TOWER TRANSCEIVER
TESTED BY: ROBERT FOSTER
OPERATING MODE: CONTINUOUS TRANSMISSION
DATE:01/09/01
TEST NUMBER:3
COUPLING DEVICE: EMCO LISN
TEST SPEC: FCC PART 15 SUBPART B AND C



Photograph Description: Conducted set-up

FORM CTS-PHOTO

3.3 FCC Part 15 Subpart C 15.247 Bandwidth

3.3.1 Equipment Used

Test Equipment	Asset #	Serial #	Cal Date
Hewlett Packard 8566B Spectrum Analyzer	47	2637A04064	7/01
Hewlett Packard 8566 Display Analyzer Main	46	2648A14289	7/01
Hewlett Packard 85685A RF Preselector	48	2648A00483	7/01
EMCO 3115 Microwave Horn Antenna	376	2796	1/01

3.3.2 Test Conditions

Two bandwidth tests were performed on the Trakus Electronic Local Area Positioning System, on the Player Patch and the Tower Transceiver.

Bandwidth measurements testing was performed with the Player Patch set up on a wooden table above the turntable at a distance of 3 meters from a tuned dipole antenna within Open Area Test Site A. The Player Patch was configured to operate in the continuous full power mode of operation. The Player Patch was set up and powered by 3V DC.

Bandwidth measurements testing was performed with the Tower Transceiver placed in an anechoic shielded chamber with the output connected to the spectrum analyzer. The Tower Transceiver was configured to operate in the continuous full power mode of operation. The Tower Transceiver was set up and powered by 120V 60Hz.

3.3.3 Test Method

The test method of “Guidance on Measurements for Direct Sequence Spread Spectrum Systems” Appendix C of Docket No. 96-8 FCC 97-114 was followed.

The bandwidth of the Player Patch was measured through an air interface. The Player Patch was placed on top of a wooden turntable 3 meters form a receiving antenna. The bandwidth of the Transceiver Tower was measured with the output of the transceiver directly connected to the input of the Spectrum Analyzer.

3.3.4 Results

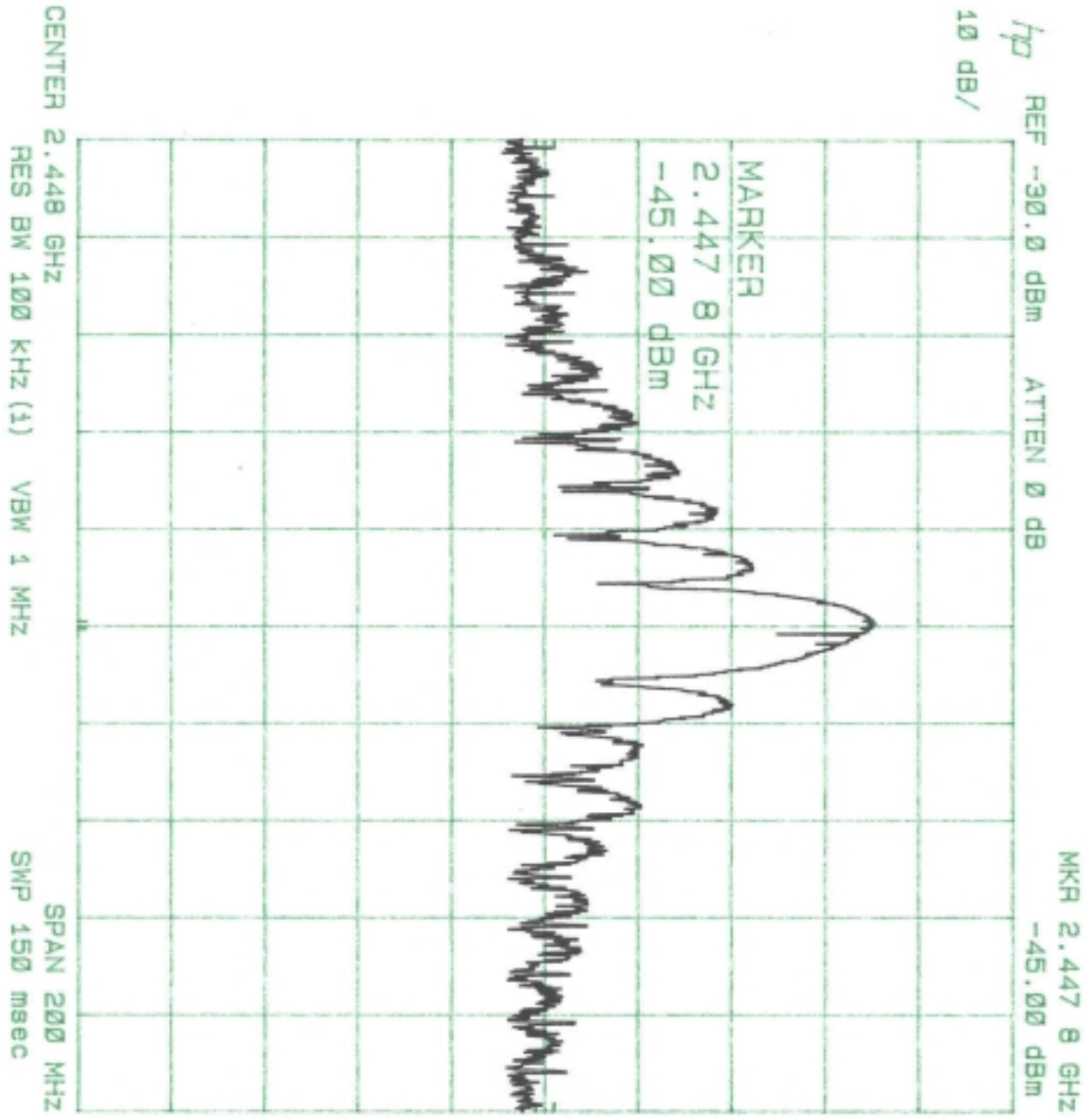
The Trakus Electronic Local Area Positioning System consisting of the Transmitter Tower and The Player Patch meets the bandwidth requirements of FCC Part 15 Subpart C 15.247 bandwidth requirements.

3.3.5 Test Data

BANDWIDTH MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: TOWER TRANSCEIVER
TESTED BY: ROBERT FOSTER
OPERATING MODE: CONTINUOUS TRANSMISSION

DATE: 01/09/01
TEST NUMBER: 4
PROCEDURE: 97-114

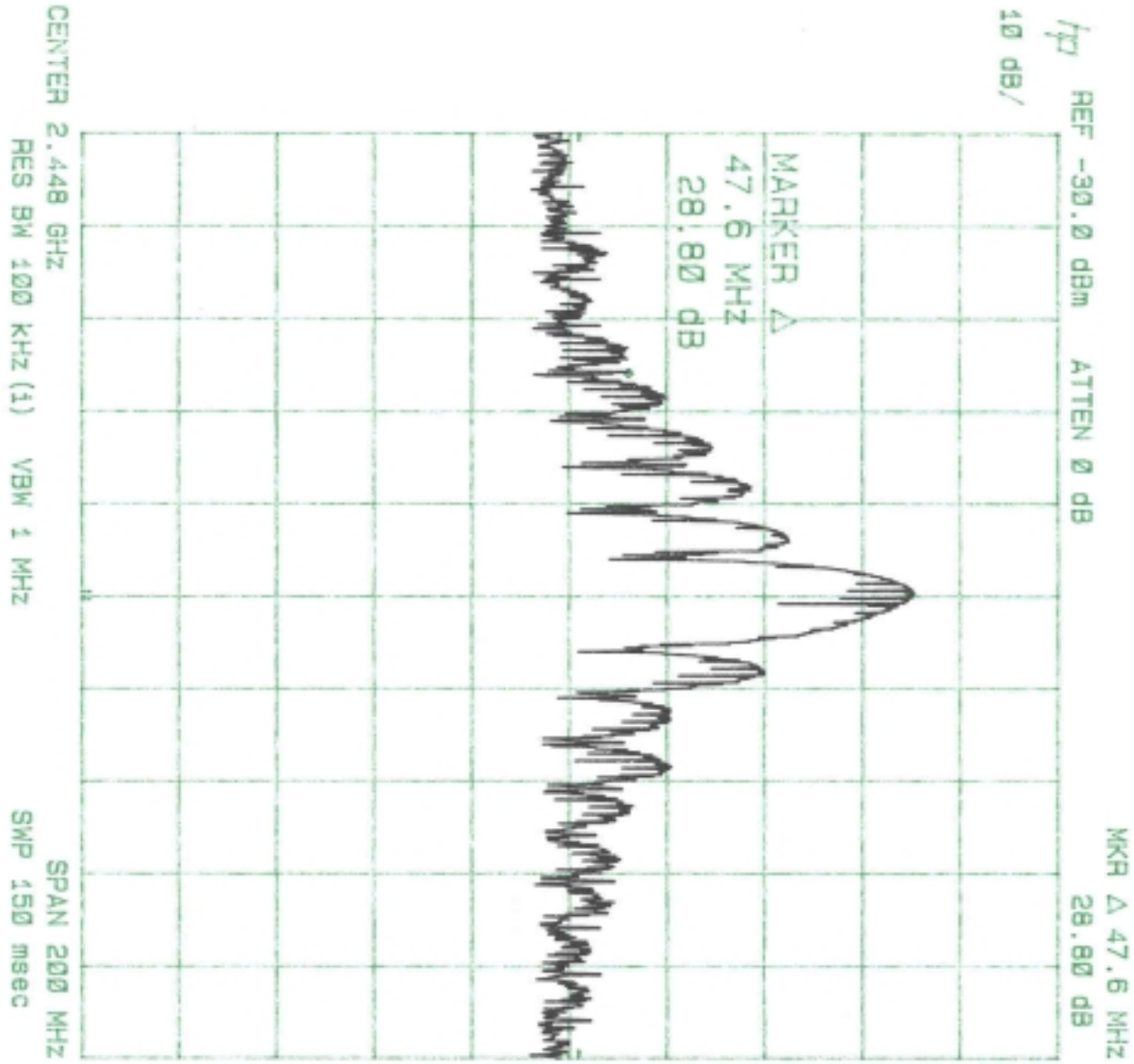


3.3.5 Test Data (continued)

BANDWIDTH MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: TOWER TRANSCEIVER
TESTED BY: ROBERT FOSTER
OPERATING MODE: CONTINUOUS TRANSMISSION

DATE: 01/09/01
TEST NUMBER: 4
PROCEDURE: 97-114

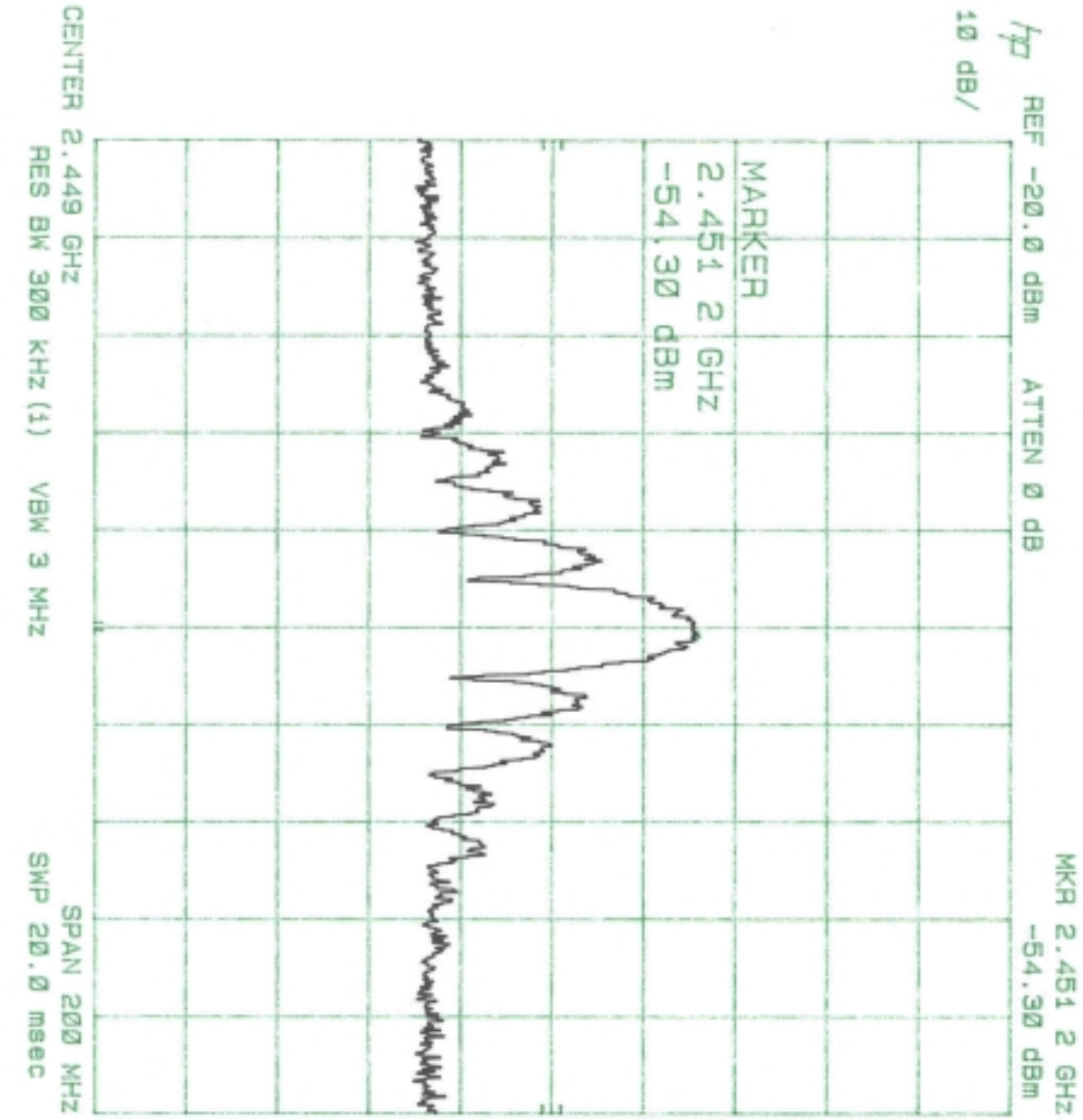


3.3.5 Test Data (continued)

BANDWIDTH MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: PLAYER PATCH
TESTED BY: ROBERT FOSTER
OPERATING MODE: CONTINUOUS TRANSMISSION

DATE: 01/09/01
TEST NUMBER: 4
PROCEDURE: 97-114

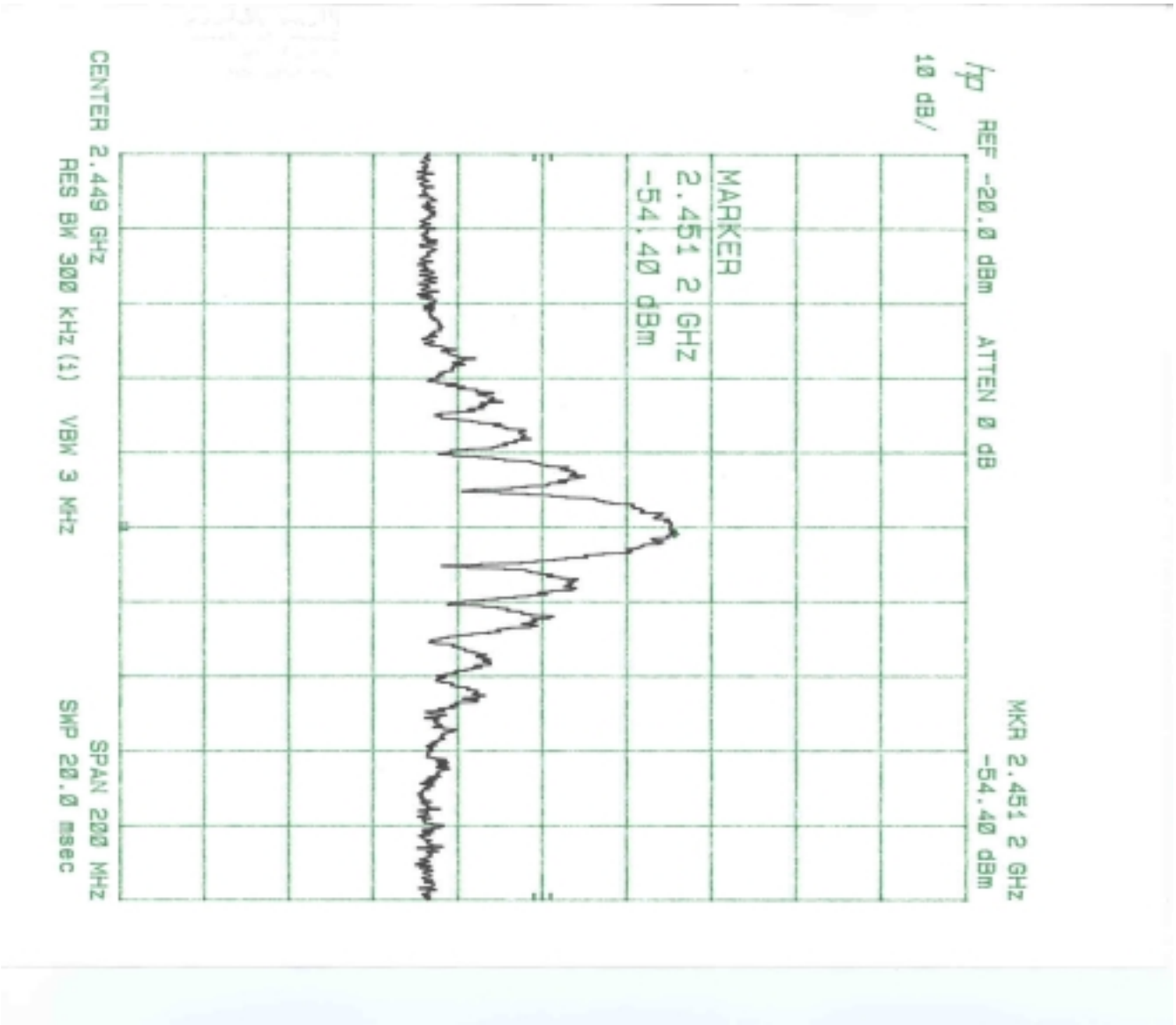


3.3.5 Test Data (continued)

BANDWIDTH MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: PLAYER PATCH
TESTED BY: ROBERT FOSTER
OPERATING MODE: CONTINUOUS TRANSMISSION

DATE: 01/09/01
TEST NUMBER: 4
PROCEDURE: 97-114



3.4 FCC Part 15 Subpart C Output Power

3.4.1 Equipment Used

Test Equipment	Asset #	Serial #	Cal Date
Hewlett Packard 8566B Spectrum Analyzer	47	2637A04064	7/01
Hewlett Packard 8566 Display Analyzer Main	46	2648A14289	7/01
Hewlett Packard 85685A RF Preselector	48	2648A00483	7/01

3.4.2 Test Conditions

Output Power tests was performed on the Trakus Electronic Local Area Positioning System, on the Tower Transceiver.

Output Power measurements testing was performed with the Tower Transceiver placed in an anechoic shielded chamber with the output connected to the spectrum analyzer.

The Tower Transceiver was configured to operate in the continuous full power mode of operation. The Tower Transceiver was set up and powered by 120V 60Hz.

3.4.3 Test Method

The test method of “Guidance on Measurements for Direct Sequence Spread Spectrum Systems” Appendix C of Docket No. 96-8 FCC 97-114 was followed.

The Output Power of the Transceiver Tower was measured with the output of the transceiver directly connected to the in put of the Spectrum Analyzer.

3.4.4 Results

The Trakus Electronic Local Area Positioning System consisting of the Transmitter Tower and The Player Patch meets the Output Power requirements of FCC Part 15 Subpart C 15.247 bandwidth requirements.

3.4.5 Test Data

OUTPUT POWER MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: TOWER TRANSCEIVER
TESTED BY: ROBERT FOSTER
OPERATING MODE: CONTINUOUS TRANSMIT

DATE: 01/09/01
TEST NUMBER: 5
TEST SPEC: FCC PART 15 SUBPART C
TEST PROCEDURE: FCC 97-114

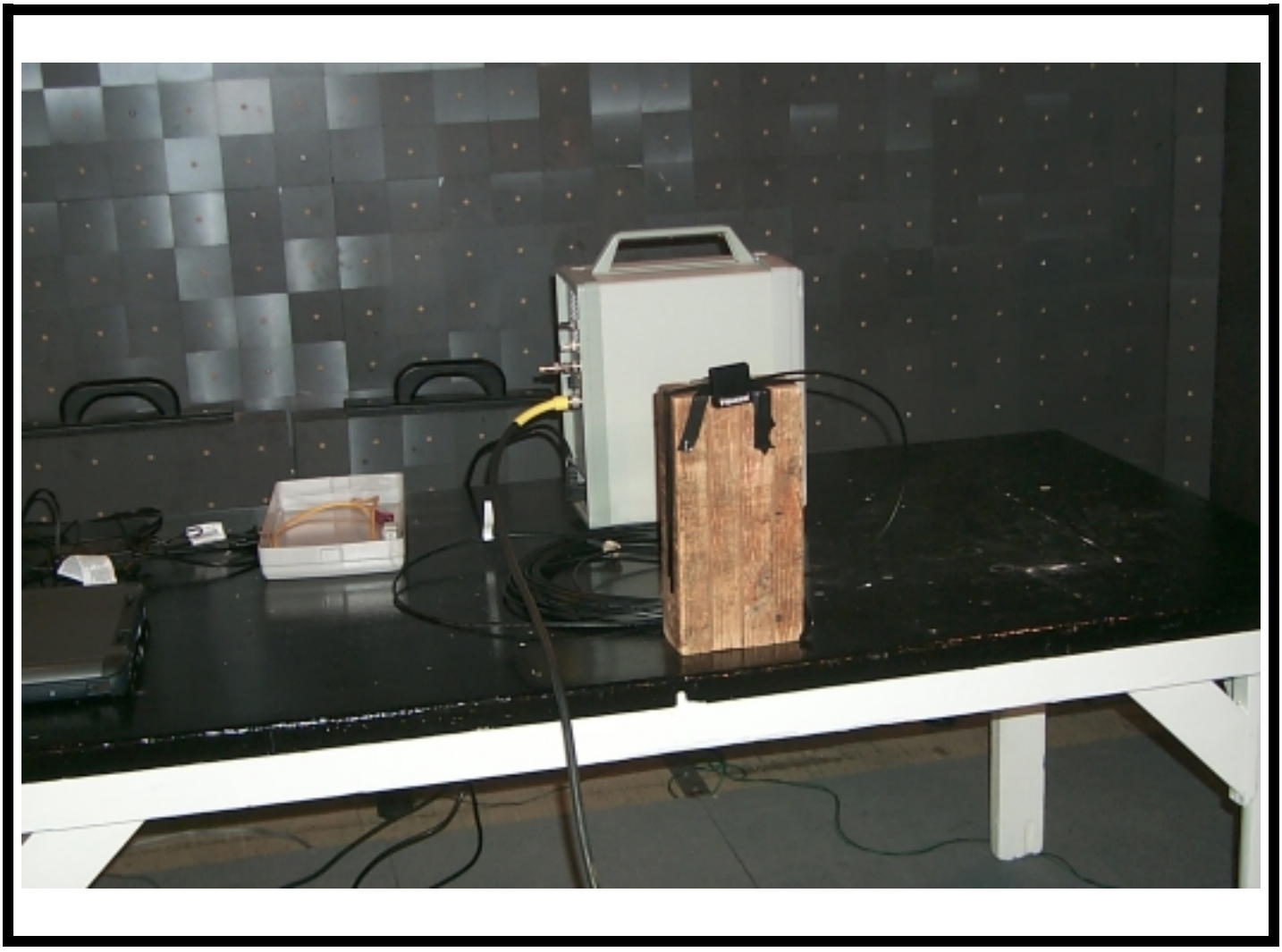
FREQUENCY MHz	PEAK MEASURED LEVEL dBm	CABLE LOSS dB	FIELD LEVEL dBuV	LIMIT dBuV
2450*	14	1.5	122.5	137
2450^	17	1.5	125.5	138

NOTES: *= Measured with 1MHz BW
^= Measured with 3MHz BW

FORM CTS-DS-001R

3.4.6 Photographic Documentation

CUSTOMER: TRAKUS **DATE:01/09/01**
EQUIPMENT: TOWER TRANSCEIVER **TEST NUMBER: 5**
TESTED BY: ROBERT FOSTER
OPERATING MODE: CONTINUOUS TRANSMISSION



Photograph Description: Conducted set-up

FORM CTS-PHOTO

3.5 FCC Part 15 Subpart C 15.247 Spurious Emissions

3.5.1 Equipment Used

Test Equipment	Asset #	Serial #	Cal Date
Hewlett Packard 8566B Spectrum Analyzer	47	2637A04064	7/01
Hewlett Packard 8566 Display Analyzer Main	46	2648A14289	7/01
Hewlett Packard 85685A RF Preselector	48	2648A00483	7/01
EMCO 3115 Microwave Horn Antenna	376	2796	1/01

3.5.2 Test Conditions

Two Spurious Emissions tests were performed on the Trakus Electronic Local Area Positioning System, on the Tower Transceiver and Player Patch.

Spurious Emissions measurements testing was performed with the Tower Transceiver placed in an anechoic shielded chamber with the output connected to the spectrum analyzer. The Tower Transceiver was configured to operate in the continuous full power mode of operation. The Tower Transceiver was set up and powered by 120V 60Hz.

Spurious Emissions measurement testing was performed with the Player Patch placed in an anechoic shielded chamber with an air measurement. The Player Patch was configured to operate in the continuous full power mode of operation. The Player Patch was set up and powered by 3VDC.

3.5.3 Test Method

The test method of "Guidance on Measurements for Direct Sequence Spread Spectrum Systems" Appendix C of Docket No. 96-8 FCC 97-114 was followed.

The Spurious of the Transceiver Tower was measured with the output of the transceiver directly connected to the in put of the Spectrum Analyzer.

The Spurious Player Patch was measured by placing a receive antenna three meters from the Player Patch and making air measurements.

3.5.4 Results

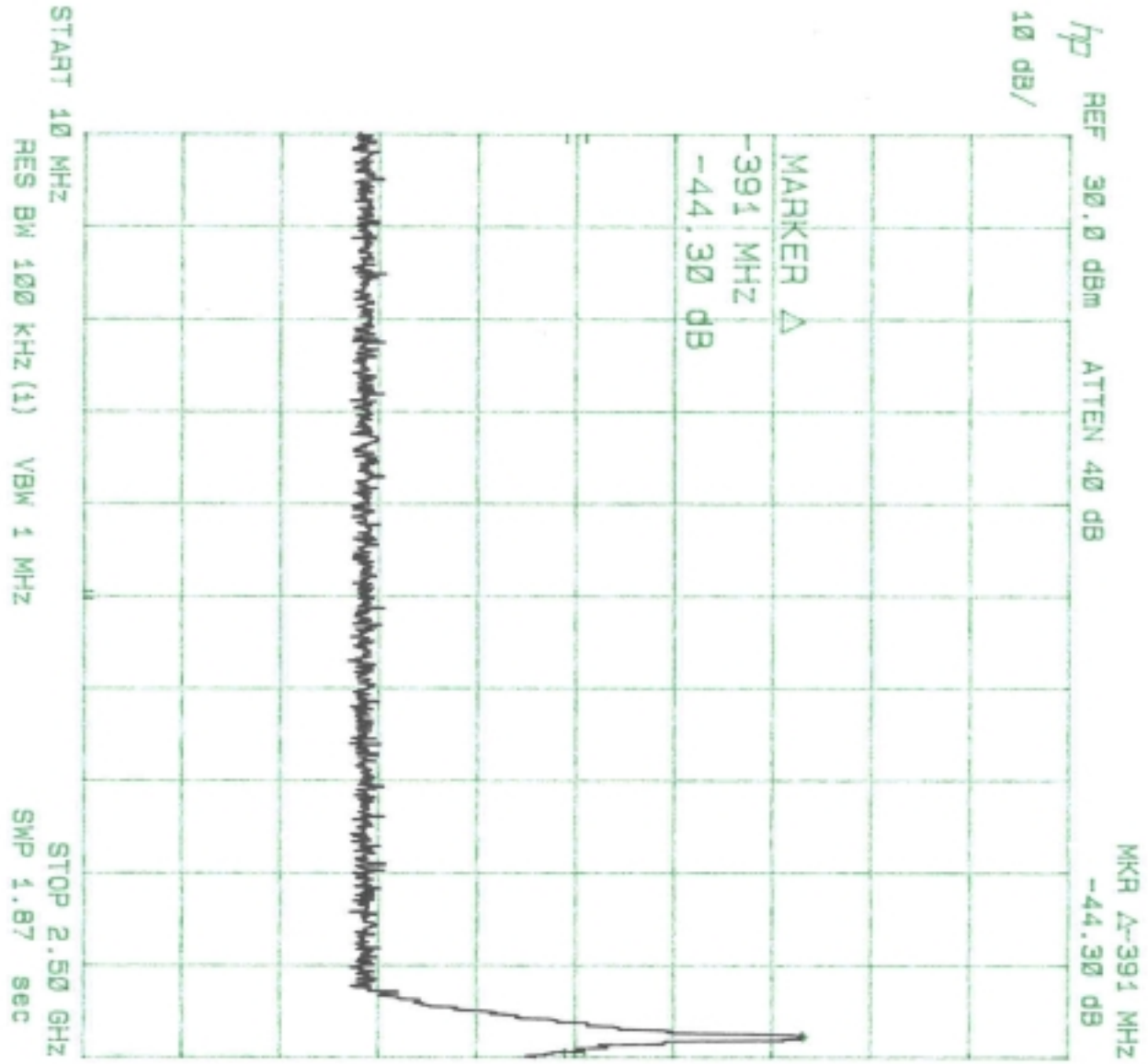
The Trakus Electronic Local Area Positioning System consisting of the Transmitter Tower and The Player Patch meets the spurious requirements of FCC Part 15 Subpart C 15.247.

3.5.5 Test Data

SPURIOUS MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: TOWER TRANSCEIVER
TESTED BY: ROBERT FOSTER
OPERATING MODE: SPURIOUS

DATE: 01/09/01
TEST NUMBER: 6
PROCEDURE: 97-114

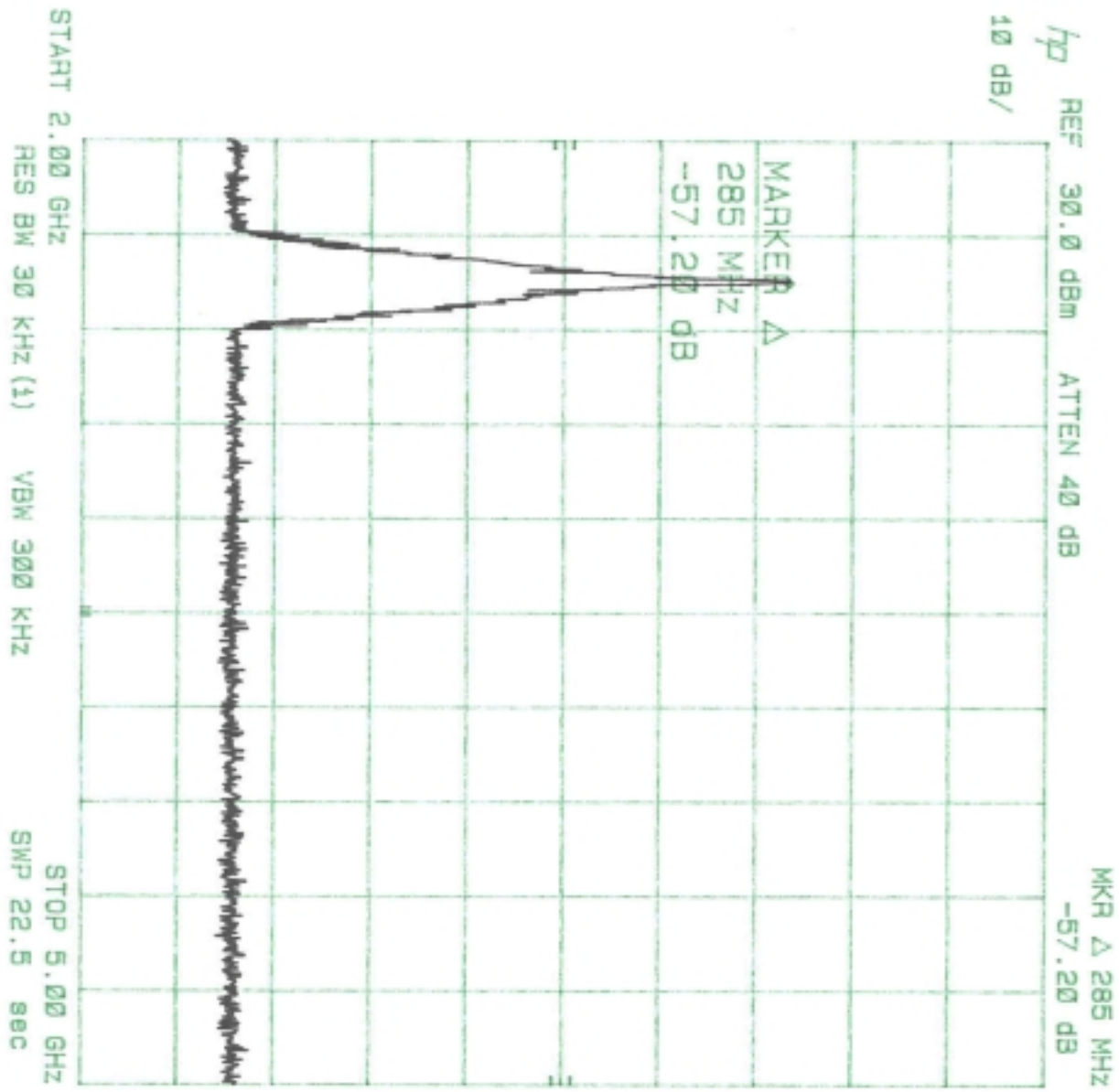


3.5.5 Test Data (continued)

SPURIOUS MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: PLAYER PATCH
TESTED BY: ROBERT FOSTER
OPERATING MODE: SPURIOUS

DATE: 01/09/01
TEST NUMBER: 6
PROCEDURE: 97-114

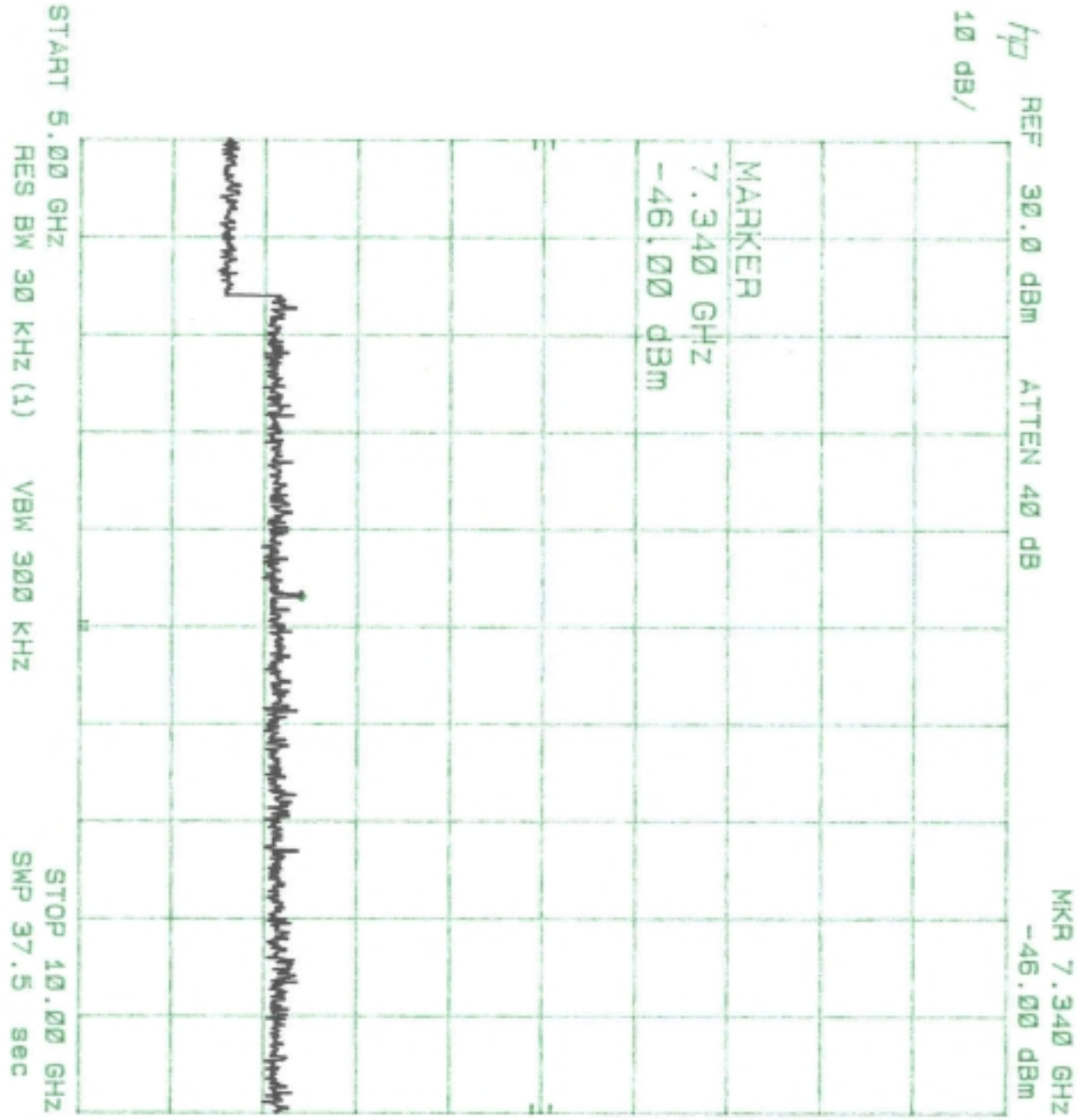


3.5.5 Test Data (continued)

SPURIOUS MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: PLAYER PATCH
TESTED BY: ROBERT FOSTER
OPERATING MODE: SPURIOUS

DATE: 01/09/01
TEST NUMBER: 6
PROCEDURE: 97-114

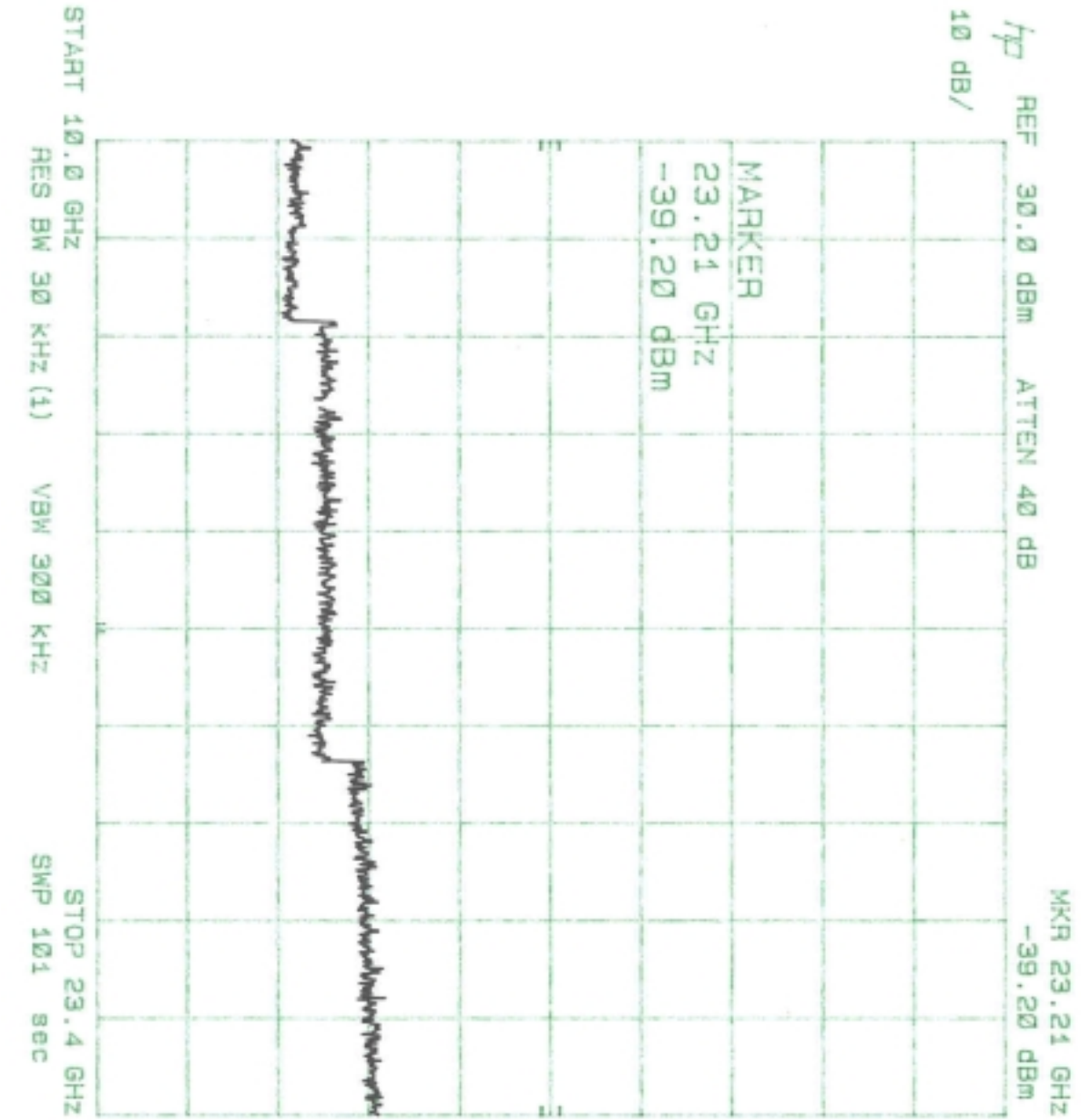


3.5.5 Test Data (continued)

SPURIOUS MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: TOWER TRANSCEIVER
TESTED BY: ROBERT FOSTER
OPERATING MODE: SPURIOUS

DATE: 01/09/01
TEST NUMBER: 6
PROCEDURE: 97-114

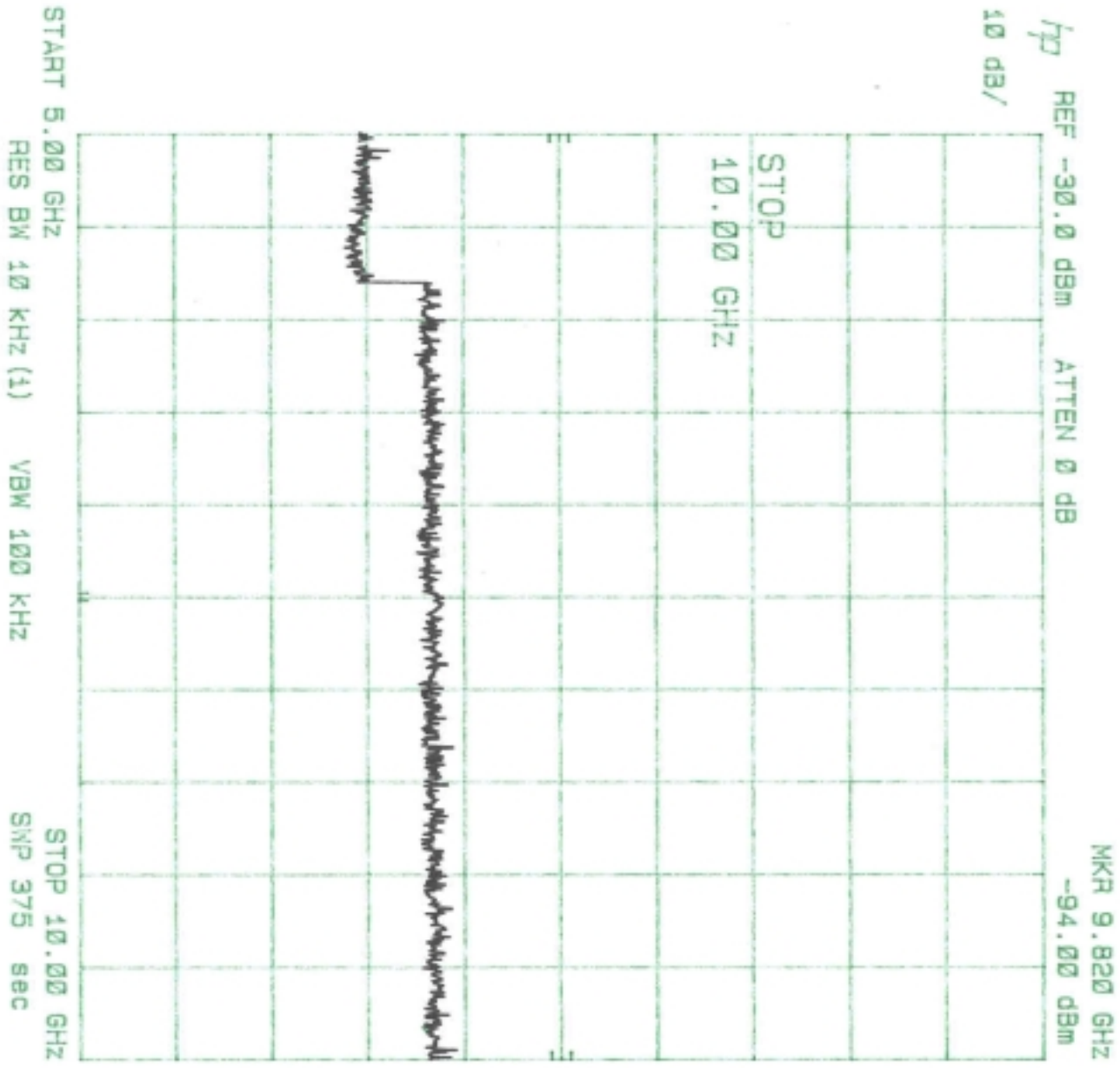


3.5.5 Test Data (continued)

SPURIOUS MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: PLAYER PATCH
TESTED BY: ROBERT FOSTER
OPERATING MODE: SPURIOUS

DATE: 01/09/01
TEST NUMBER: 6
PROCEDURE: 97-114

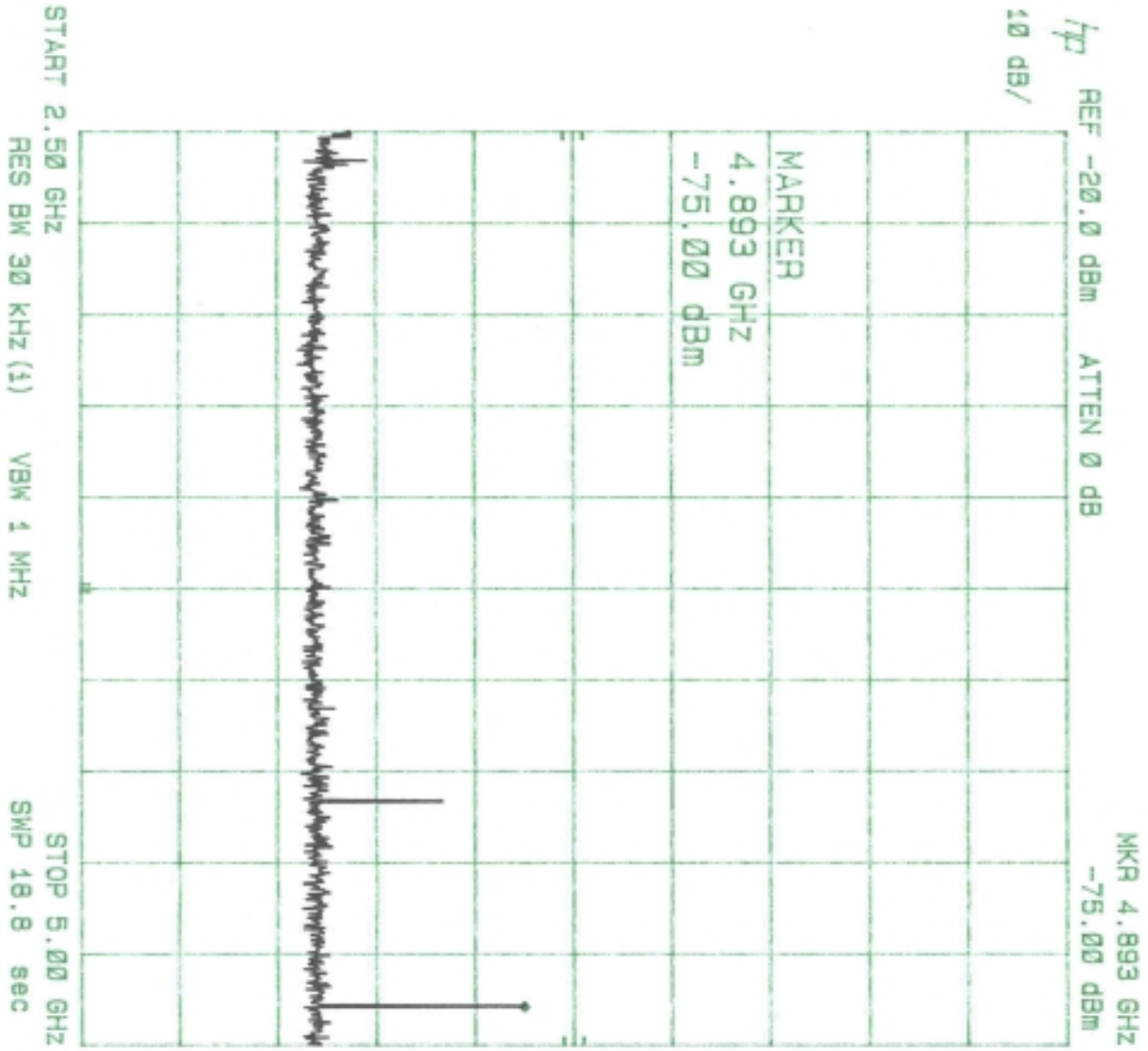


3.5.5 Test Data (continued)

SPURIOUS MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: PLAYER PATCH
TESTED BY: ROBERT FOSTER
OPERATING MODE: SPURIOUS

DATE: 01/09/01
TEST NUMBER: 6
PROCEDURE: 97-114

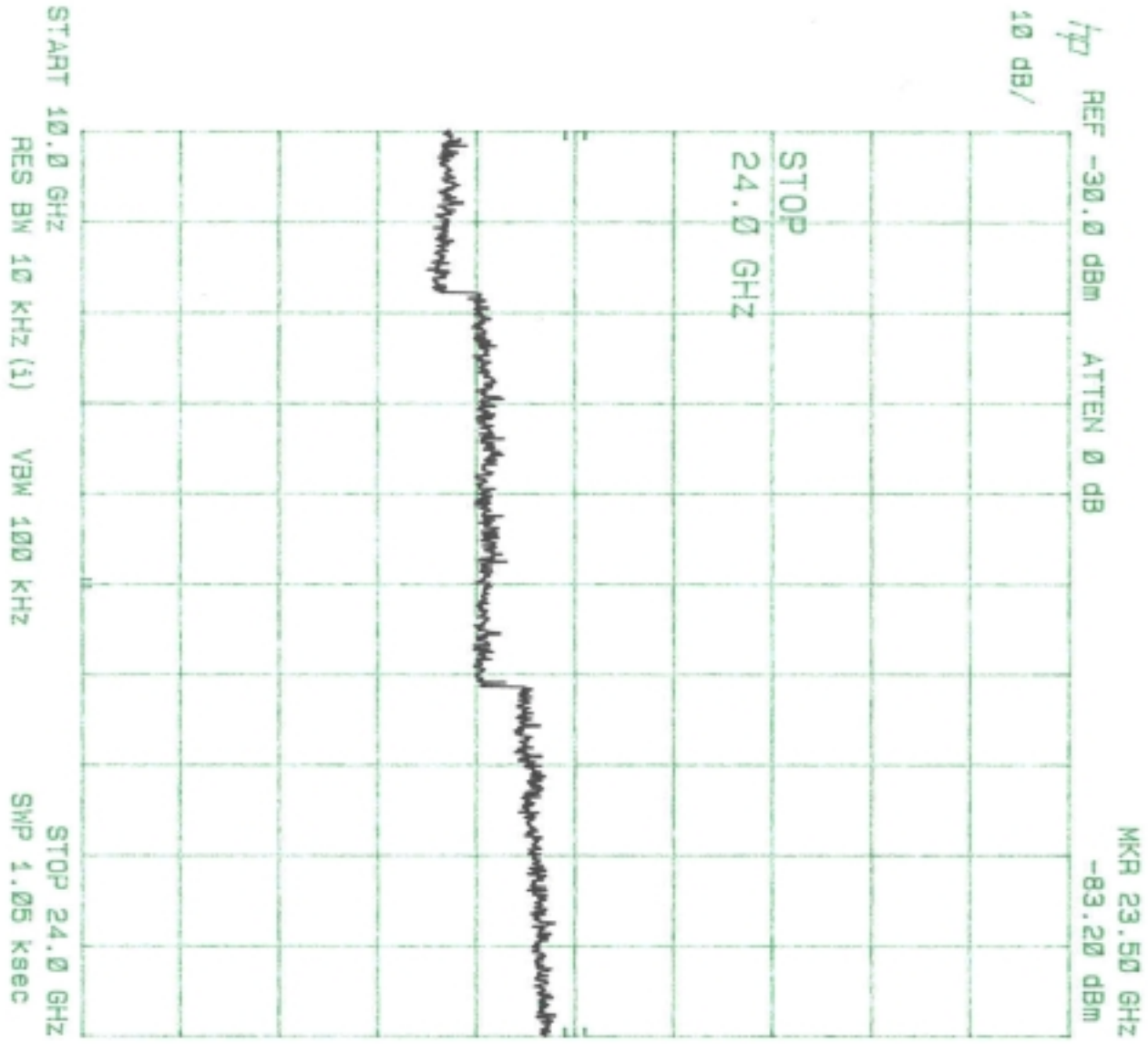


3.5.5 Test Data (continued)

SPURIOUS MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: PLAYER PATCH
TESTED BY: ROBERT FOSTER
OPERATING MODE: SPURIOUS

DATE: 01/09/01
TEST NUMBER: 6
PROCEDURE: 97-114



3.6 FCC Part 15 Subpart C 15.247 Power Spectral Density

3.6.1 Equipment Used

Test Equipment	Asset #	Serial #	Cal Date
Hewlett Packard 8566B Spectrum Analyzer	47	2637A04064	7/01
Hewlett Packard 8566 Display Analyzer Main	46	2648A14289	7/01
Hewlett Packard 85685A RF Preselector	48	2648A00483	7/01

3.6.2 Test Conditions

Power Spectral Density tests were performed on the Trakus Electronic Local Area Positioning System, on the Tower Transceiver.

Power Spectral Density measurements testing was performed with the Tower Transceiver placed in an anechoic shielded chamber with the output connected to the spectrum analyzer.

The Tower Transceiver was configured to operate in the continuous full power mode of operation. The Tower Transceiver was set up and powered by 120V 60Hz.

3.6.3 Test Method

The test method of "Guidance on Measurements for Direct Sequence Spread Spectrum Systems" Appendix C of Docket No. 96-8 FCC 97-114 was followed.

The Spurious of the Transceiver Tower was measured with the output of the transceiver directly connected to the in put of the Spectrum Analyzer.

3.6.4 Results

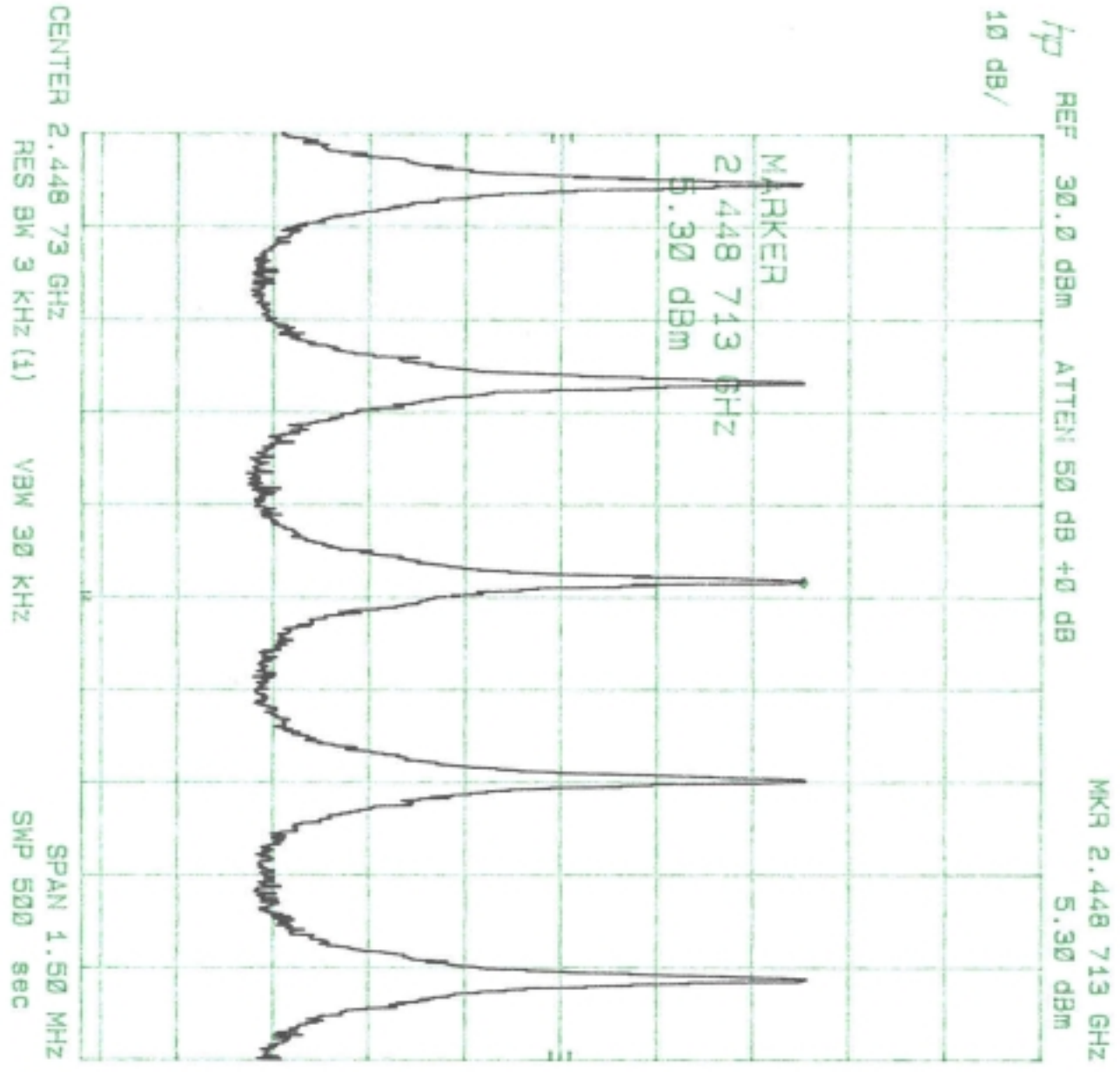
The Trakus Electronic Local Area Positioning System consisting of the Transmitter Tower and the Player Patch meets the spurious requirements of FCC Part 15 Subpart C 15.247.

3.6.5 Test Data

POWER SPECTRAL DENSITY MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: PLAYER PATCH
TESTED BY: ROBERT FOSTER
OPERATING MODE: SPURIOUS

DATE: 01/09/01
TEST NUMBER: 7
PROCEDURE: 97-114

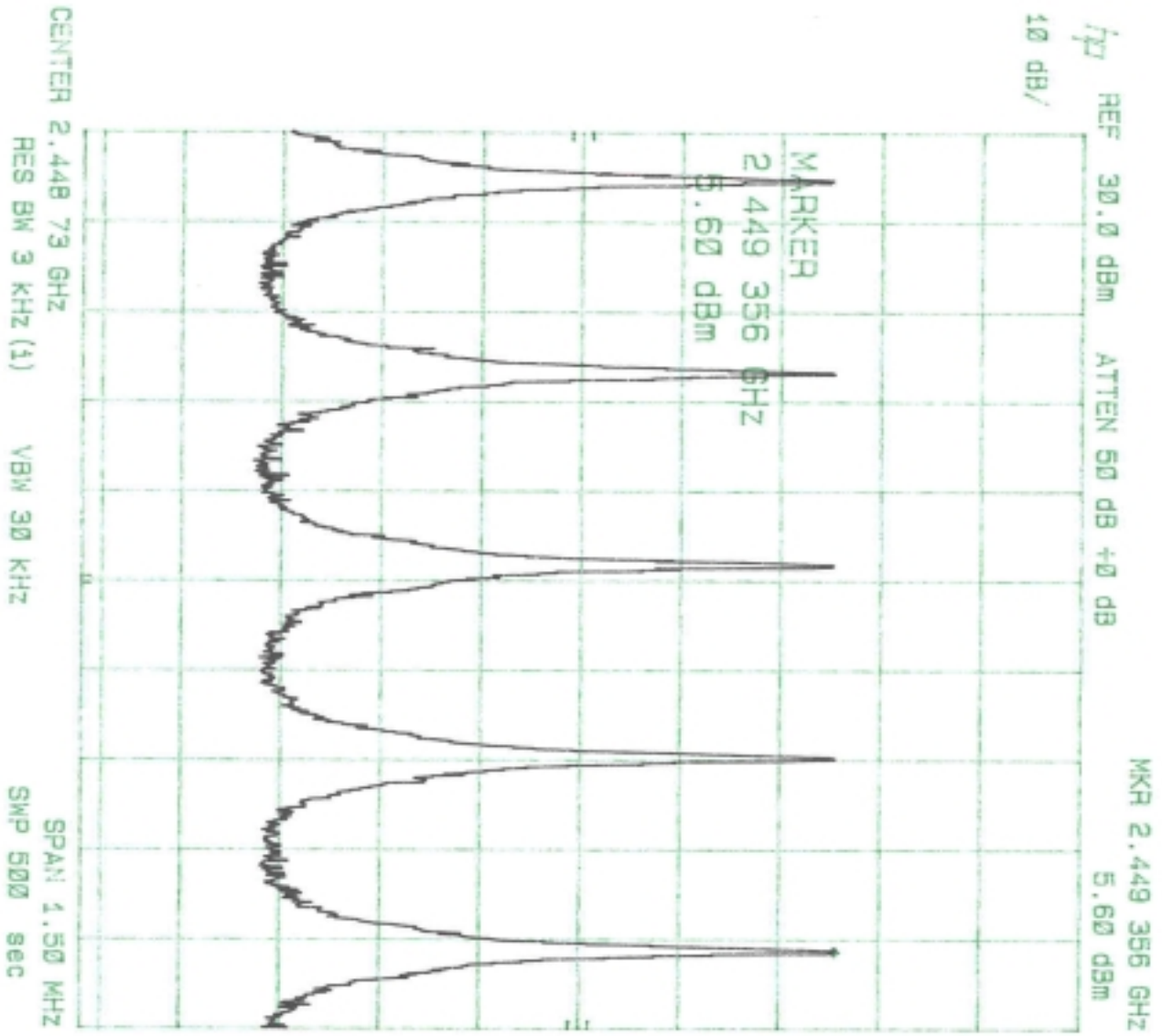


3.6.5 Test Data (continued)

POWER SPECTRAL DENSITY MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: PLAYER PATCH
TESTED BY: ROBERT FOSTER
OPERATING MODE: SPURIOUS

DATE: 01/09/01
TEST NUMBER: 7
PROCEDURE: 97-114



3.7 FCC Part 15 Subpart C Field Strength of Fundamental

3.7.1 Equipment Used

Equipment Used	Asset #	Serial #	Cal Date
Tektronix 496 Spectrum Analyzer	56	B010206	4/01
Hewlett Packard 8566B Spectrum Analyzer	47	2637A04064	7/01
Hewlett Packard 8566 Display Analyzer Main	46	2648A14289	7/01
Hewlett Packard 85685A RF Preselector	48	2648A00483	7/01
EMCO 3115 Microwave Horn Antenna	376	2796	1/01

3.7.2 Test Conditions

The Trakus Electronic Local Area Positioning System consists of two separate pieces of equipment the Tower Transceiver and Player Patch. Two separate field strength of fundamental tests were performed one on the Tower Transceiver and one on the Player Patch.

Radiated emissions testing were performed with the Transceiver Tower and the Player Patch set up on a wooden table above the turntable at a distance of 3 meters from a tuned dipole antenna within Open Area Test Site A.

The Tower Transceiver was configured to operate in the continuous mode of operation to maximize the emissions. The Tower Transceiver was set up and powered by 120V 60Hz for radiated emission tests.

The Player Patch was configured to operate in the continuous mode of operation to maximize the emissions. The Player Patch was set up and powered by 120V 60Hz for radiated emission tests.

3.7.3 Test Method

The test method of ANSI C63.4 was followed, for the field strength of the fundamental emission measurements. A manual scan was performed. During this scan, the antenna, turntable and the EUT' were manipulated to maximize the emission level.

3.7.4 Results

The Trakus Electronic Local Area Positioning System which consist of the Tower Transceiver and the Player Patch meets the FCC Part 15 Subpart C field strength fundamental.

3.7.5 Test Data

FIELD STRENGTH OF THE FUNDAMENTAL

CUSTOMER: TRAKUS
EQUIPMENT: TRANSCEIVER TOWER
TESTED BY: ROBERT FOSTER
OPERATING MODE: CONTINUOUS TRANSMIT
ANTENNA DISTANCE: 3 METERS

DATE: 01/09/01
TEST NUMBER: 8
PROCEDURE: ANSI C63.4 & FCC 97-114
TEST SPEC: FCC PART 15 SUBPART C

FREQUENCY MHz	PEAK MEASURED LEVEL -dBm	QUASI-PEAK MEASURED LEVEL dBuV	ANTENNA HEIGHT (METERS)	TURNTABLE AZIMUTH (DEGREES)	ANTENNA H/V	ANTENNA FAC/CABLE LOSS dB	FIELD LEVEL dBuV/m ✯	LIMIT dBuV/m (QP)
2450*	47	-	1.0	0	H	32.2	92.2	93.9
2450^	50	-	1.0	0	H	32.2	89.2	93.9

✯All signals greater than 3dB from the limit are calculate to the nearest whole number.
✯Field Level (dBuV/m) = [107 – Measured level (dBm)] + Antenna Factor/Cable Loss (dB)
Ambient Temperature: 68°F Humidity: 25 % Atmospheric Pressure: 29.8″
NOTES: * = 3MHz BW
^ = 1MHz BW

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3.7.5 Test Data (continued)

FIELD STRENGTH OF THE FUNDAMENTAL

CUSTOMER: TRAKUS **DATE: 01/09/01**
EQUIPMENT: PLAYER PATCH **TEST NUMBER: 8**
TESTED BY: ROBERT FOSTER **PROCEDURE: ANSI C63.4 & FCC 97-114**
OPERATING MODE: CONTINUOUS TRANSMIT **TEST SPEC: FCC PART 15 SUBPART C**
ANTENNA DISTANCE: 3 METERS

FREQUENCY MHz	PEAK MEASURED LEVEL -dBm	QUASI-PEAK MEASURED LEVEL dBuV	ANTENNA HEIGHT (METERS)	TURNTABLE AZIMUTH (DEGREES)	ANTENNA H/V	ANTENNA FAC/CABLE LOSS dB	FIELD LEVEL dBuV/m ✯	LIMIT dBuV/m (QP)
2450*	46	-	1.0	0	H	32.2	91.2	93.9
2450^	49	-	1.0	0	H	32.2	90.2	93.9

✯All signals greater than 3dB from the limit are calculate to the nearest whole number.
✯Field Level (dBuV/m) = [107 – Measured level (dBm)] + Antenna Factor/Cable Loss (dB)
Ambient Temperature: 68°F Humidity: 25 % Atmospheric Pressure: 29.8″
NOTES: * = 3MHz BW
^ = 1MHz BW

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3.7.6 Photographic Documentation

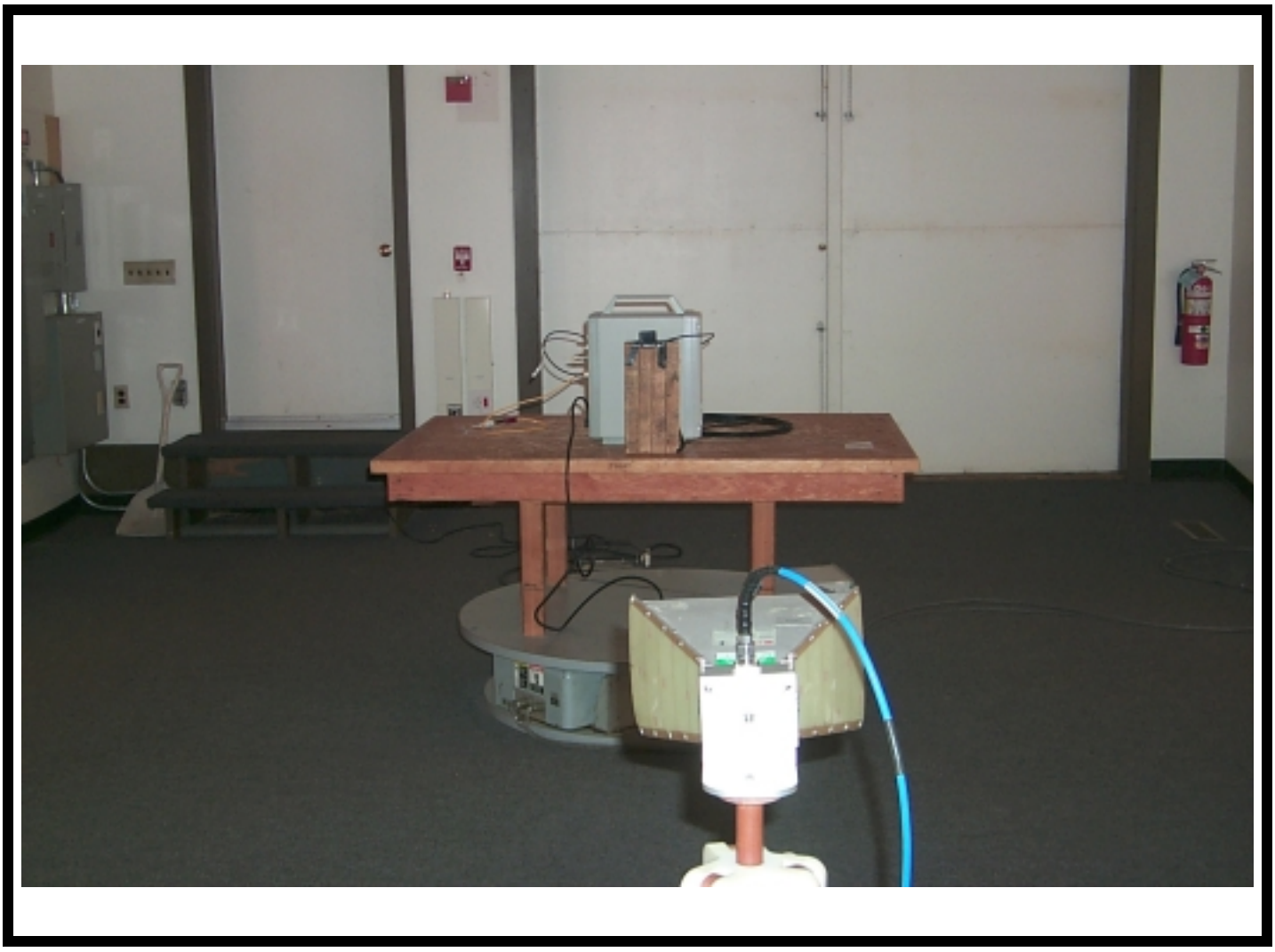
CUSTOMER: TRAKUS **DATE: 01/09/01**
EQUIPMENT: PLAYER PATCH **TEST NUMBER: 8**
TESTED BY: ROBERT FOSTER

Photograph Description: Set-up

FORM CTS-PHOTO

3.7.6 Photographic Documentation (continued)

CUSTOMER: TRAKUS **DATE: 01/09/01**
EQUIPMENT: TRANSCEIVER TOWER **TEST NUMBER: 8**
TESTED BY: ROBERT FOSTER



Photograph Description: Set-up

FORM CTS-PHOTO

3.8 FCC Part 15 Subpart C Field Strength Harmonics

3.8.1 Equipment Used

Equipment Used	Asset #	Serial #	Cal Date
Tektronix 496 Spectrum Analyzer	56	B010206	4/01
Hewlett Packard 8566B Spectrum Analyzer	47	2637A04064	7/01
Hewlett Packard 8566 Display Analyzer Main	46	2648A14289	7/01
Hewlett Packard 85685A RF Preselector	48	2648A00483	7/01
Eaton 94626-1 Horn Antenna	334	145	1/01
EMCO 3115 Microwave Horn Antenna	376	2796	1/01

3.8.2 Test Conditions

The Trakus Electronic Local Area Positioning System consists of two separate pieces of equipment the Tower Transceiver and Player Patch. Two separate radiated emissions test were performed one on the Tower Transceiver and one on the Player Patch.

Field Strength of harmonics emissions testing were performed with the Transceiver Tower and the Player Patch set up on a wooden table above the turntable at a distance of 3 meters from a tuned dipole antenna within Open Area Test Site A. The Tower Transceiver was configured to operate in the continuous mode of operation to maximize the emissions. The Tower Transceiver was set up and powered by 120V 60Hz for radiated emission tests. The worst case signals detected were recorded. The Player Patch was configured to operate in the continuous mode of operation to maximize the emissions. The Player Patch was set up and powered by 3VDC for radiated emission tests. The worst case signals detected were recorded.

3.8.3 Test Method

The test method of ANSI C63.4 was followed. A manual scan was performed from 30MHz to 25GHz. During this scan, the antenna, turntable and the EUT's cable positions were manipulated to maximize the emission levels in a given frequency band displayed on the spectrum analyzer.

3.8.4 Results

The Trakus Electronic Local Area Positioning System which consist of the Tower Transceiver and the Player Patch meets the FCC Part 15 Subpart C Harmonics Field Strength requirements.

3.8.5 Test Data

RADIATED E FIELD EMISSION MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: PLAYER PATCH
TESTED BY: ROBERT FOSTER
OPERATING MODE: CONTINUOUS TRANSMIT
FREQUENCY RANGE: 30MHZ – 25 GHZ

DATE: 01/09/01
TEST NUMBER: 9
TEST PROCEDURE: ANSI C63.4 & FCC 97-114
TEST SPEC: FCC PART 15 SUBPART C

FREQUENCY MHZ	PEAK MEASURED LEVEL -dBm	QUASI-PEAK MEASURED LEVEL dBuV	ANTENNA HEIGHT (METERS)	TURNTABLE AZIMUTH (DEGREES)	ANTENNA H/V	ANTENNA FAC/CABLE LOSS dB	FIELD LEVEL dBuV/m ✯	LIMIT dBuV/m (QP)
No harmonic emissions were detected								

✯All signals greater than 3dB from the limit are calculate to the nearest whole number.
✯Field Level (dBuV/m) = [107 – Measured level (dBm)] + Antenna Factor/Cable Loss (dB)
Ambient Temperature: 68°F Humidity: 25 % Atmospheric Pressure: 29.8″

FORM CTS-DS-001R

3.8.5 Test Data (continued)

RADIATED E FIELD EMISSION MEASUREMENTS

CUSTOMER: TRAKUS
EQUIPMENT: TRANSCEIVER TOWER
TESTED BY: ROBERT FOSTER
OPERATING MODE: CONTINUOUS TRANSMIT
FREQUENCY RANGE: 30MHZ – 25 GHZ

DATE: 01/09/01
TEST NUMBER: 9
TEST PROCEDURE: ANSI C63.4 & FCC 97-114
TEST SPEC: FCC PART 15 SUBPART C

FREQUENCY MHZ	PEAK MEASURED LEVEL -dBm	QUASI-PEAK MEASURED LEVEL dBuV	ANTENNA HEIGHT (METERS)	TURNTABLE AZIMUTH (DEGREES)	ANTENNA H/V	ANTENNA FAC/CABLE LOSS dB	FIELD LEVEL dBuV/m ✯	LIMIT dBuV/m (QP)
No harmonic emissions were detected								

✯All signals greater than 3dB from the limit are calculate to the nearest whole number.
✯Field Level (dBuV/m) = [107 – Measured level (dBm)] + Antenna Factor/Cable Loss (dB)
Ambient Temperature: 68°F Humidity: 25 % Atmospheric Pressure: 29.8″

FORM CTS-DS-001R

3.8.6 Photographic Documentation

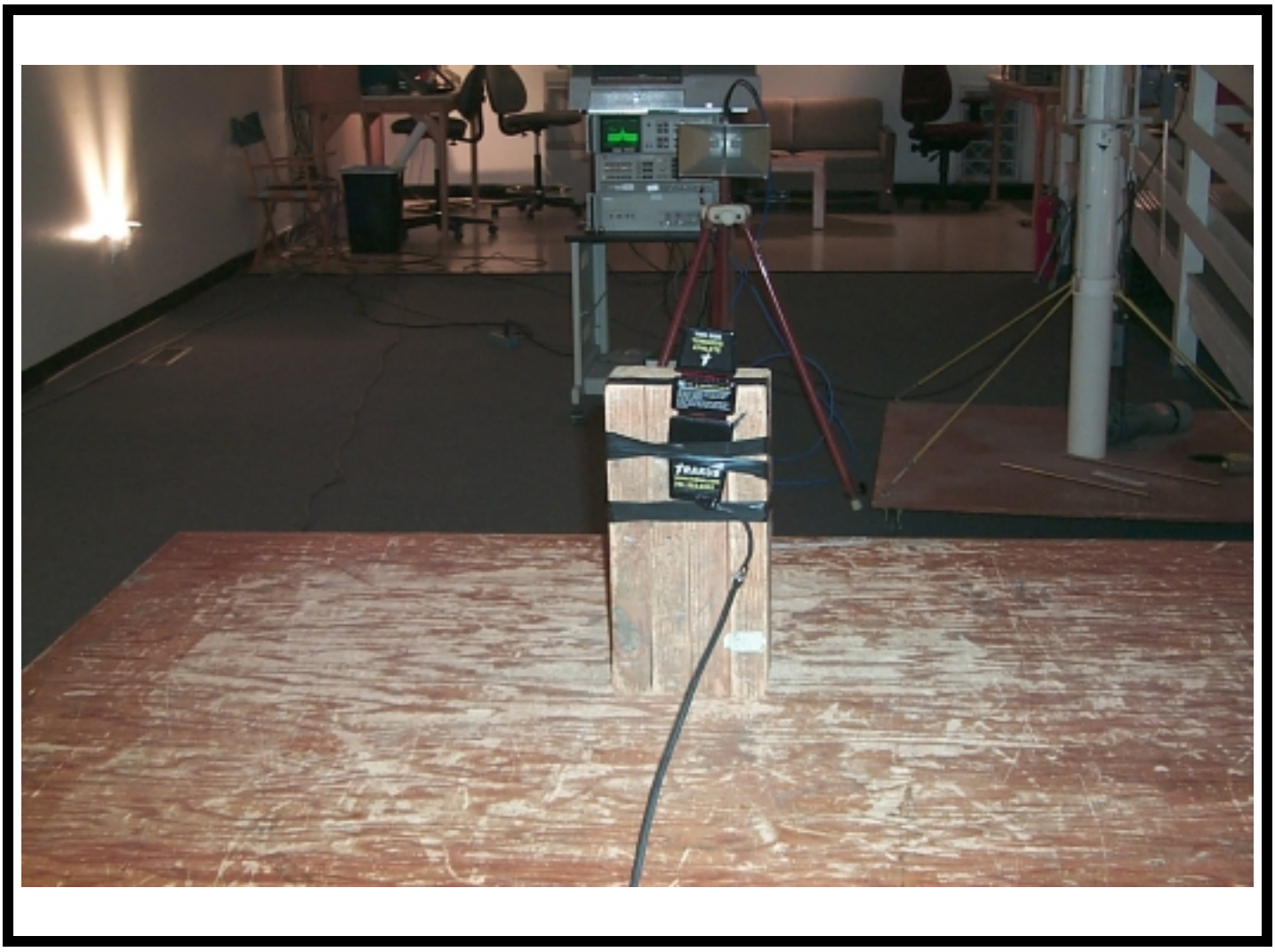
CUSTOMER: TRAKUS **DATE: 01/09/01**
EQUIPMENT: PLAYER PATCH **TEST NUMBER: 9**
TESTED BY: ROBERT FOSTER

Photograph Description: Set-up

FORM CTS-PHOTO

3.8.6 Photographic Documentation (continued)

CUSTOMER: TRAKUS **DATE: 01/09/01**
EQUIPMENT: PLAYER PATCH **TEST NUMBER: 9**
TESTED BY: ROBERT FOSTER



Photograph Description: Set-up

FORM CTS-PHOTO

3.8.6 Photographic Documentation (continued)

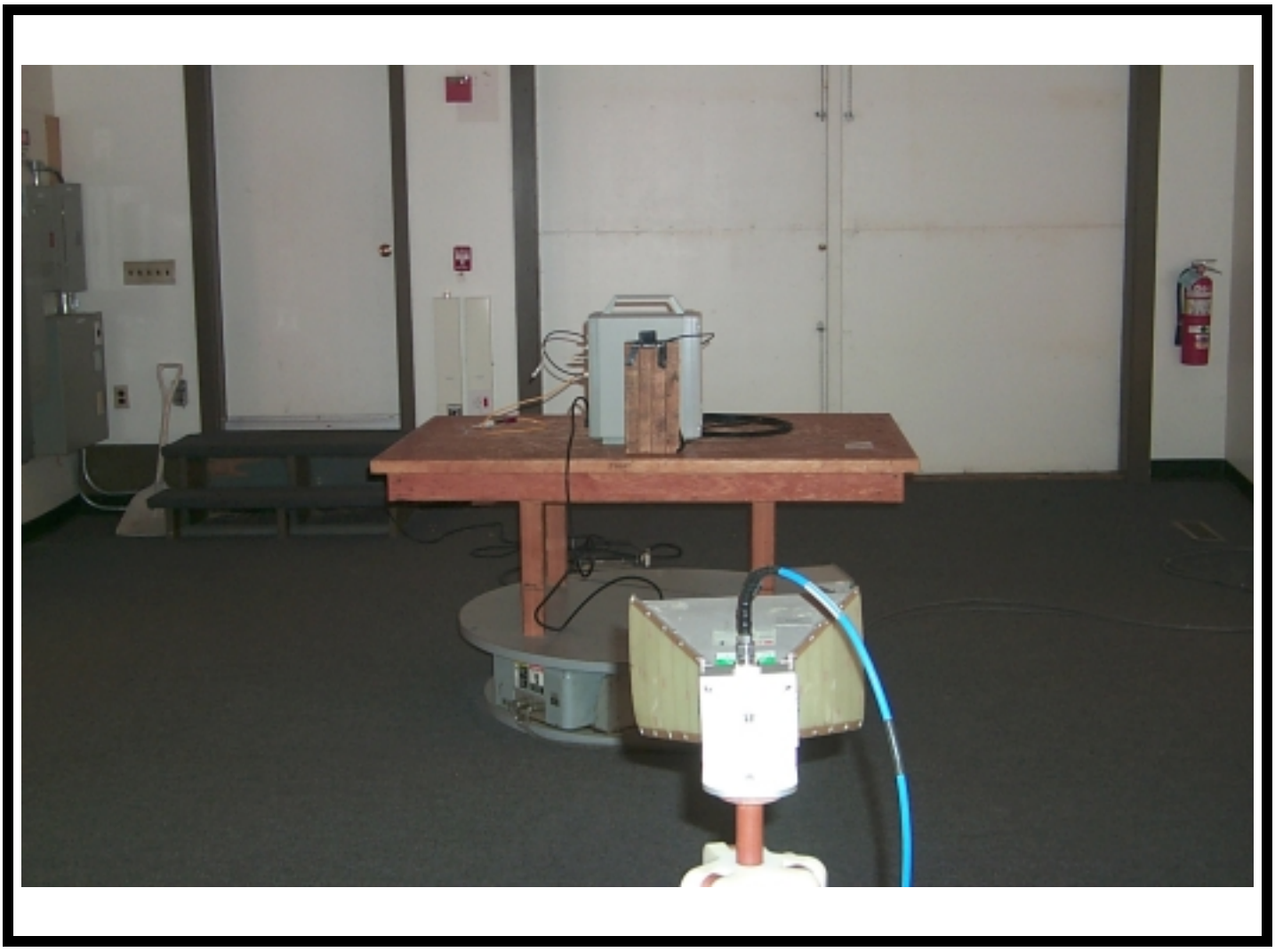
CUSTOMER: TRAKUS **DATE: 01/09/01**
EQUIPMENT: PLAYER PATCH **TEST NUMBER: 9**
TESTED BY: ROBERT FOSTER

Photograph Description: Set-up

FORM CTS-PHOTO

3.8.6 Photographic Documentation (continued)

CUSTOMER: TRAKUS **DATE: 01/09/01**
EQUIPMENT: TRANSCEIVER TOWER **TEST NUMBER: 9**
TESTED BY: ROBERT FOSTER

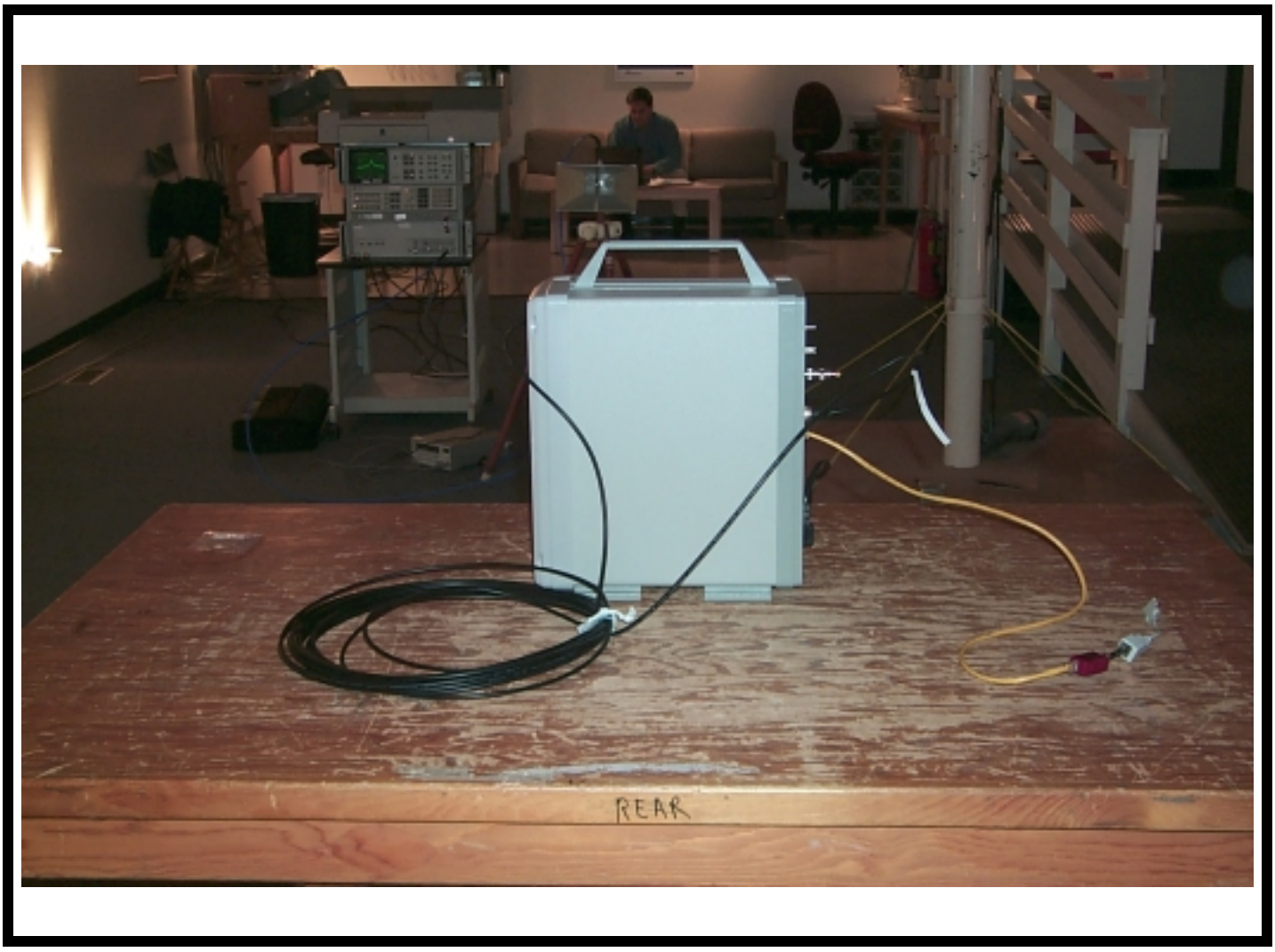


Photograph Description: Set-up

FORM CTS-PHOTO

3.8.6 Photographic Documentation (continued)

CUSTOMER: TRAKUS **DATE: 01/09/01**
EQUIPMENT: TRANSCEIVER TOWER **TEST NUMBER: 9**
TESTED BY: ROBERT FOSTER



Photograph Description: Set-up

FORM CTS-PHOTO

3.8.6 Photographic Documentation (continued)

CUSTOMER: TRAKUS **DATE: 01/09/01**
EQUIPMENT: TRANSCEIVER TOWER **TEST NUMBER: 9**
TESTED BY: ROBERT FOSTER

Photograph Description: Set-up

FORM CTS-PHOTO

3.8.6 Photographic Documentation (continued)

CUSTOMER: TRAKUS **DATE: 01/09/01**
EQUIPMENT: TRANSCEIVER TOWER **TEST NUMBER: 9**
TESTED BY: ROBERT FOSTER

Photograph Description: Set-up

FORM CTS-PHOTO

APPENDIX A

TEST LOG

TEST LOG

CUSTOMER: TRAKUS **PROGRAM: FCC CERTIFICATION**
EQUIPMENT: ELAPS **TESTED BY: ROBERT FOSTER**

	Date	Comments
Pre-Test Checklist	01/08/01	Test Plan/Procedure: ANSI C63.4 & FCC 97-114 Test Specification: FCC Part 15 Subpart B & C Chomerics Procedure: CHO TPEC T1, T2 EUT Power Requirement Verified: Tower Transceiver: 120V/60Hz Single phase Player Patch: 120V/60Hz Single Phase and 3V DC EUT Functional Operational Check: [X] Pass [ ] Fail Environmental: Bonding/Grounding: X Safety Issues: X

	Date	Test #	Test Type	Test Equipment Calibrated	Test Performed Properly – Data Accepted	EUT Set-up Check/ Operational Check	EUT Pass/ Fail
In-Process Test Checklist	01/08/01	1	Rad Emis Subpart B	Yes	Yes	Yes	Pass
	01/09/01	2	Rad emis Subpart B	Yes	Yes	Yes	Pass
	01/09/01	3	Cond Emis Subpart B & C	Yes	Yes	Yes	Pass
	01/09/01	4	Bandwidth Subpart C	Yes	Yes	Yes	Pass
	01/09/01	5	Power Output Subpart C	Yes	Yes	Yes	Pass
	01/09/01	6	Spurious Subpart C	Yes	Yes	Yes	Pass
	01/09/01	7	Power Spectral Density Subpart C	Yes	Yes	Yes	Pass
	01/09/01	8	Field Strength of Fundamental Subpart C	Yes	Yes	Yes	Pass
	01/09/01	9	Field Strength Harmonics Subpart C	Yes	Yes	Yes	Pass

Post Test Checklist	Date: 01/09/01	EUT Functional Operation Check: [X] Pass [ ] Fail	_____ _____ Test Engineer/Tech Approved Signatory

FORM CTS-010

APPENDIX B

CUSTOMER SUPPLIED EQUIPMENT DESCRIPTION

Transceiver Functional Description Document

Functional Descriptions

General

ISM Band Radio Link for ELAPS

The Tower Transceiver (TT) and Player Patch (PP) were developed as part of a microwave radio link operating in the Industrial, Scientific, & Medical (ISM) band for spread spectrum transmissions at 2.4 GHz to 2.485 GHz. The transceivers were developed for an Electronic Local Area Positioning System (ELAPS) which uses pairs of TT's as delta time of arrival (ΔTOA) sensors to determine exact locations of multiple PP's within a defined viewing area. Multiple PP locations are determined based on TOA correlation data called Digital Signal Processing Records (DSPR's). Location, Velocity, and Acceleration (LVA) calculations are made from DSPR's and then grouped for each PP and used as statistics for real-time display and amassed in a database. The Trakus system will be owned and operated by Trakus personnel and will not be for sale to the consumer market. However, the digital data that is collected by the Trakus system will be sold to interested consumer markets (i.e. Television/Sports networks, gaming and internet companies etc.).

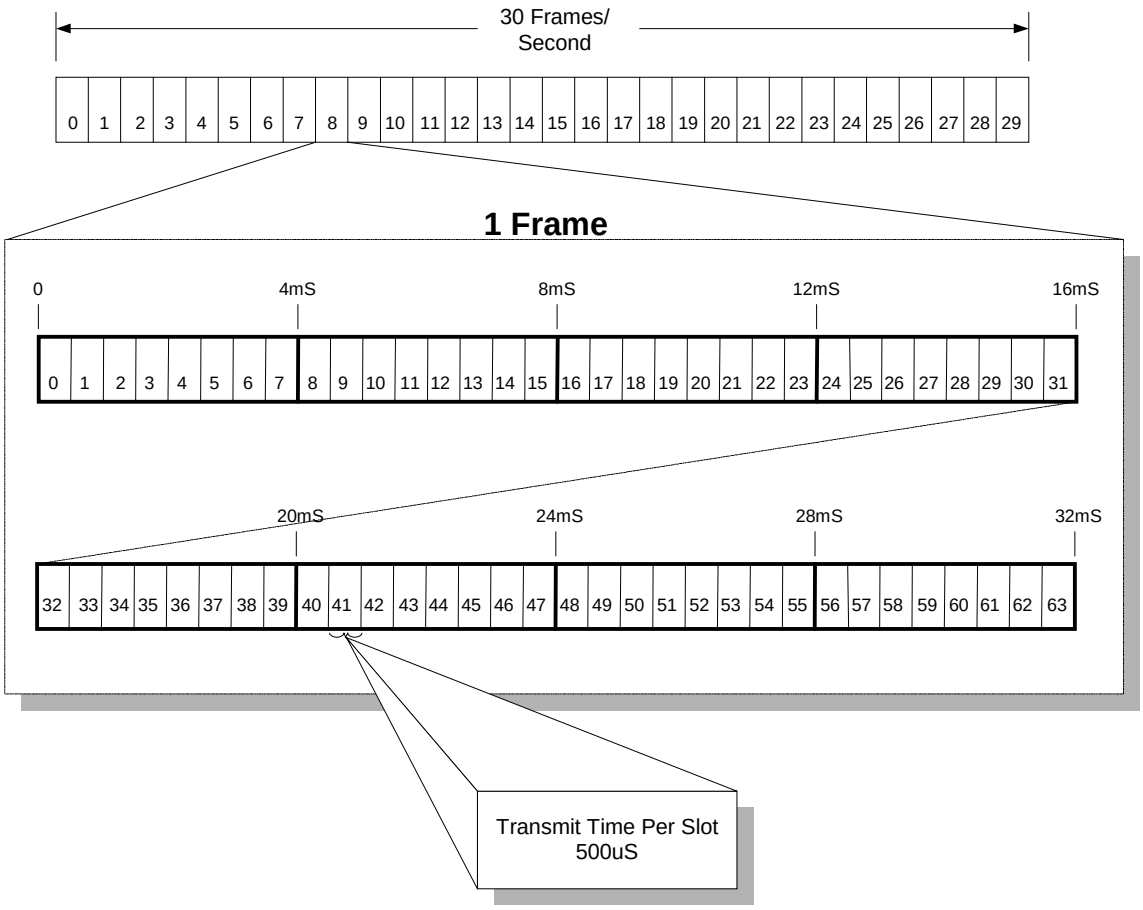
Current Applications

The immediate application is for the televised sports industry, starting in the National Hockey League. The Tower Transceivers are deployed around an ice rink to determine the LVA's of all athletes during an entire game. Eight to sixteen TT's are used to cover the area confined by the rink boards. TT's will be located as close to the boards as possible, positioned at a predetermined height above the ice. All skaters in the game will be equipped with a PP affixed in their helmets. PP's will be worn at all times by the athletes throughout the game and will periodically transmit signals back to the TT's so that TOA correlation data may be obtained. LVA's can then be produced by the Trakus system to determine the locations and speeds of the hockey players at all times during the game, total distances skated by hockey players, the force of a hit between two or more hockey players (such as in checking), as well as many other insightful statistics.

Other applications include football and soccer, both of which would utilize pairs of TT's around the playing field as ΔTOA sensors to determine the LVA's of all players involved in the game. Eight to sixteen TT's will be spaced evenly around the playing field, positioned at a predetermined height above the ground.

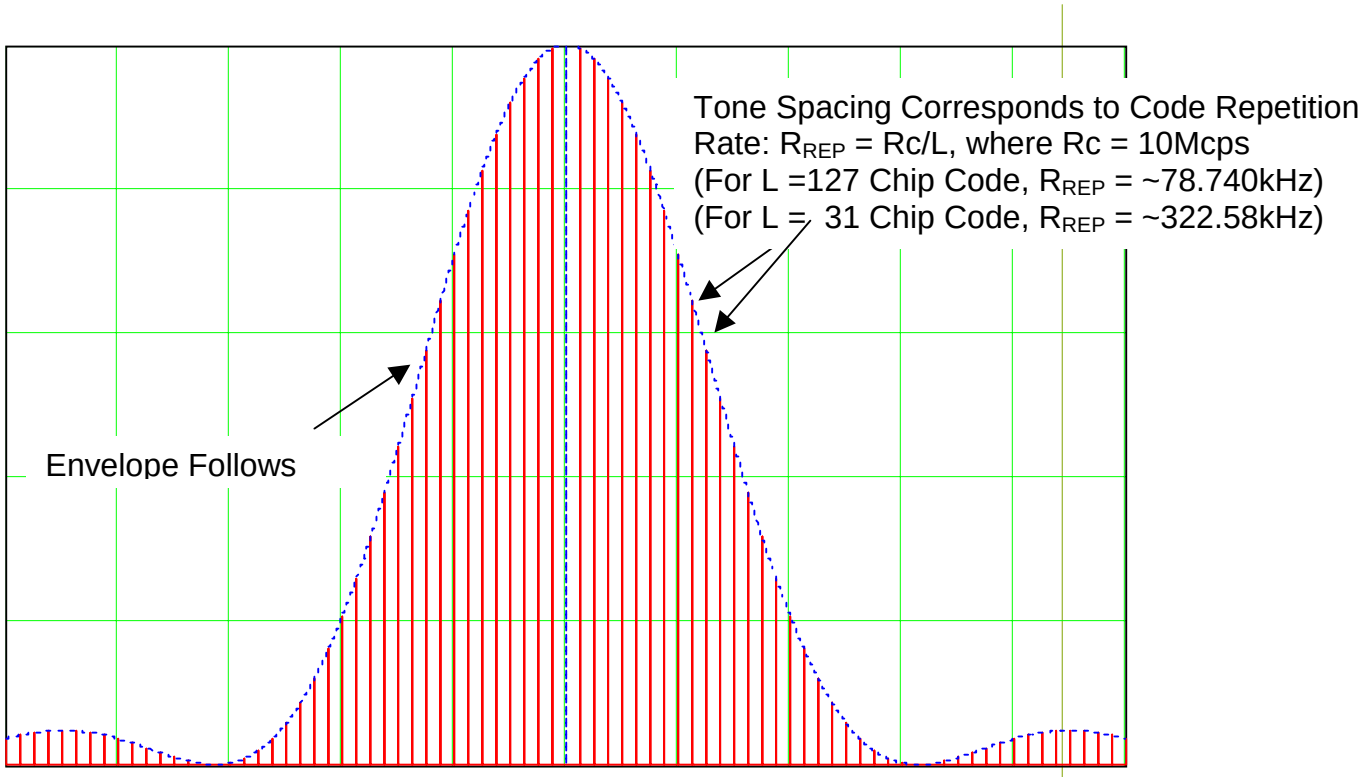
TDMA

ELAPS utilizes Time Division Multi-Access (TDMA) to track multiple objects in real-time. Each player on the field is given a time division SLOT in which to transmit. The players each transmit a Pseudo-Random Noise (PRN) code by phase modulating an ISM band carrier frequency (currently 2.450 GHz). This transmission is referred to as a Direct Sequence Spread Spectrum (DSSS), and complies with FCC regulations for transmission in the ISM band. The update rate, referred to as the frame rate, for TOA's from each player is approximately $1/30^{th}$ of a second. 64 time divisions fit within one frame and are referred to as SLOTS. Currently the available transmission time per SLOT is ~500µs. SLOTs 1 through 63 are designated for TT DSSS signal reception (Refer to the TDMA timing diagram shown below). For the master TT in the Trakus system, SLOT 0 is designated for back channel transmission. The back channel transmission is performed to synchronize all PP clocks with the master TT timing schedule. If the back channel sync code is not received by the PP after 15 consecutive timing frames, the PP is designed to enter a SLEEP mode. The PP's and TT's are software configurable and can be programmed to operate in many different modes. For testing purposes the units can be operated in a constant transmit and/or receive test mode. While in the test mode the PP will not be allowed to enter the SLEEP mode and will remain in either constant mode to simplify the testing process. The programmed test mode also offers the flexibility of not having to form a communication link between the two transceivers and therefore they can be tested independently.



TDMA Timing Diagram

PRN codes are sample sequences that are represented by a series of "ones" and "zeros" arranged in a specific pattern (or code). Each sample of one or zero in a PRN code is referred to as a chip. The chip rate for the PRN codes used in the transceivers is 10MChip/s (0.1usec/chip). The chip rate is 1/4 the transceiver's clock which is approximately 40 MHz. A single PRN code modulation of the carrier frequency is referred to as an epoch, and its length is based on the length of the PRN code, namely the number of chips in the sequence. Currently the TT's and the PP's use different length codes. For the back channel transmission the TT transmits in time SLOT 0 with an epoch length of 31 chips, with an epoch rate of 3.1μs (or ~322.6kHz). Therefore, 160 epochs will be transmitted in the allotted time (~500μs). For the remaining 63 time SLOTs each PP will transmit an epoch length of 127 chips. Each player will therefore transmit 39 epochs at an epoch rate of 12.7μs (or 78.740kHz) within their designated TDMA slot. The figure below shows the power spectral density of a typical spread spectrum waveform. As seen in the figure, the envelope of the waveform follows a $sinc^2(x)$ function. The spectral lines, or tones that are seen are generate by the repetitive nature of the PRN code. When longer PRN codes are used the closer the spectral lines become. Likewise, when shorted codes are used the spectral lines spacing is increased.



Power Spectral Density of SS Signal

Processing Gain

The processing gain of a spread spectrum system is often determined by:

$$G_p := 10 \cdot \log\left(\frac{R_c}{R_b}\right)$$

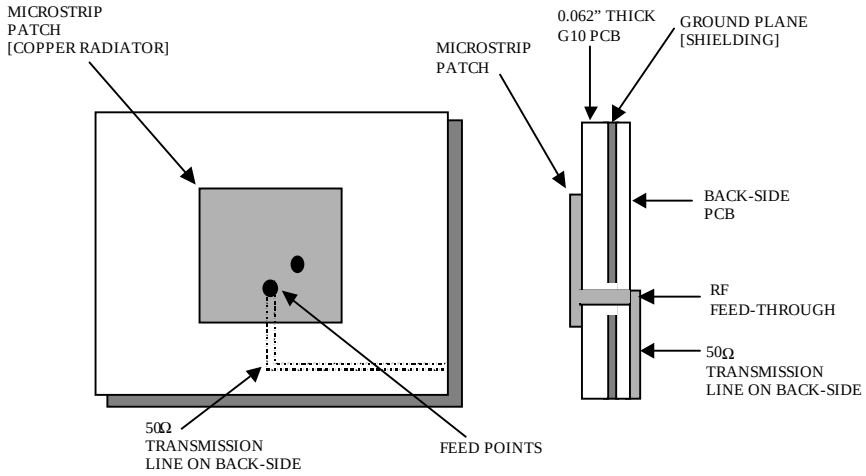
Where Rc is the code rate and Rb is the desired data rate. The Trakus system was designed to use PRN code inversion as a method of determining what logic value was transmitted. An inverted code would correspond to a logic "1" and a logic "0" would correspond to a non-inverted code. Therefore, the maximum data rate of the system is determined by the length of the PRN code and the number of epochs transmitted per time slot. As mentioned previously, the PP and the TT's use different PRN code lengths. However, both systems use a maximum chip rate of 10Mcps. The table below shows the PRN code length, the number of epochs transmitted per time slot, the maximum allowable data rate per given slot, and the processing gain for each receiver.

System Type	RX Code Length	Epochs per Slot	Max Data Rate	Processing Gain
Player Patch	31	160	322kbps	14.92dB
Tower Transceiver	127	39	78kbps	21.07dB

Microwave Antenna

A microstrip patch design is utilized for the antenna radiator because of its low profile and ease of construction. A rectangular copper radiator is generated via printed circuit board artwork. Dual feed points are used in order to generate the circularly polarized (CP) electric fields that needed for transmission and reception. The feed points are centered on the patch and are fed by 50 Ω transmission lines. Refer to the Patch Antenna Diagram.

Patch Antenna Diagram

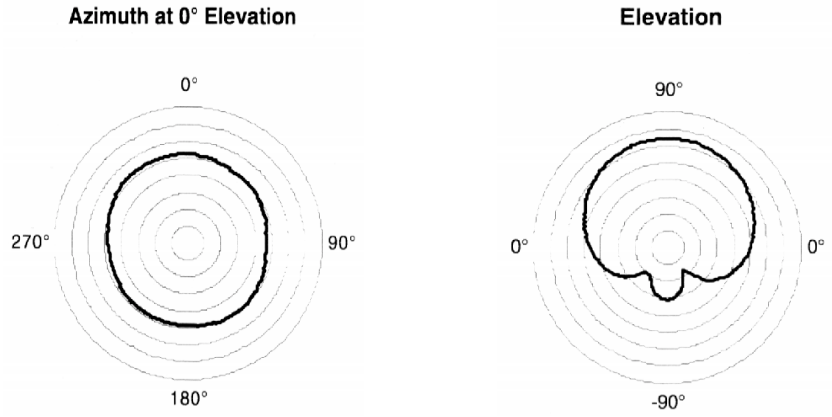


The antenna must be located 12' to 20' above the playing surface for current applications, and is therefore separate from the TT circuitry, being fed through a 50' low-loss coaxial cable. The cable has 8 dB of loss at 2.45 GHz, or 0.16 dB/ft. The antenna itself can handle power levels up to 1,000 dBm at full duty cycle but will actually radiate only 10-20 dBm for approximately 1/64th of the time.

The sense of the antenna's circular polarization is right-hand, designated RHCP. Circularly polarized electric fields have natural multi-path rejection qualities since transmitted signals that bounce once off the ground or surrounding objects will reverse their polarity sense. (i.e. RHCP electric fields transform to LHCP after bouncing once off the ground.) Cross-polarization isolation of the microwave antenna is better than 25 dB from RHCP to LHCP.

The patch antenna pattern demonstrates the antenna's ability to radiate or receive power in a given direction relative to its orientation. The RHCP microstrip patch antenna's power pattern is given below. The radiation pattern is nearly omni-directional in the antenna's radiated half-space (in azimuth). No radiated power is directed behind TT's (towards fans) or towards players' heads in helmets for PP configurations due to the ground plane shielding below the radiator on the backside of the PCB (elevation roll-off).

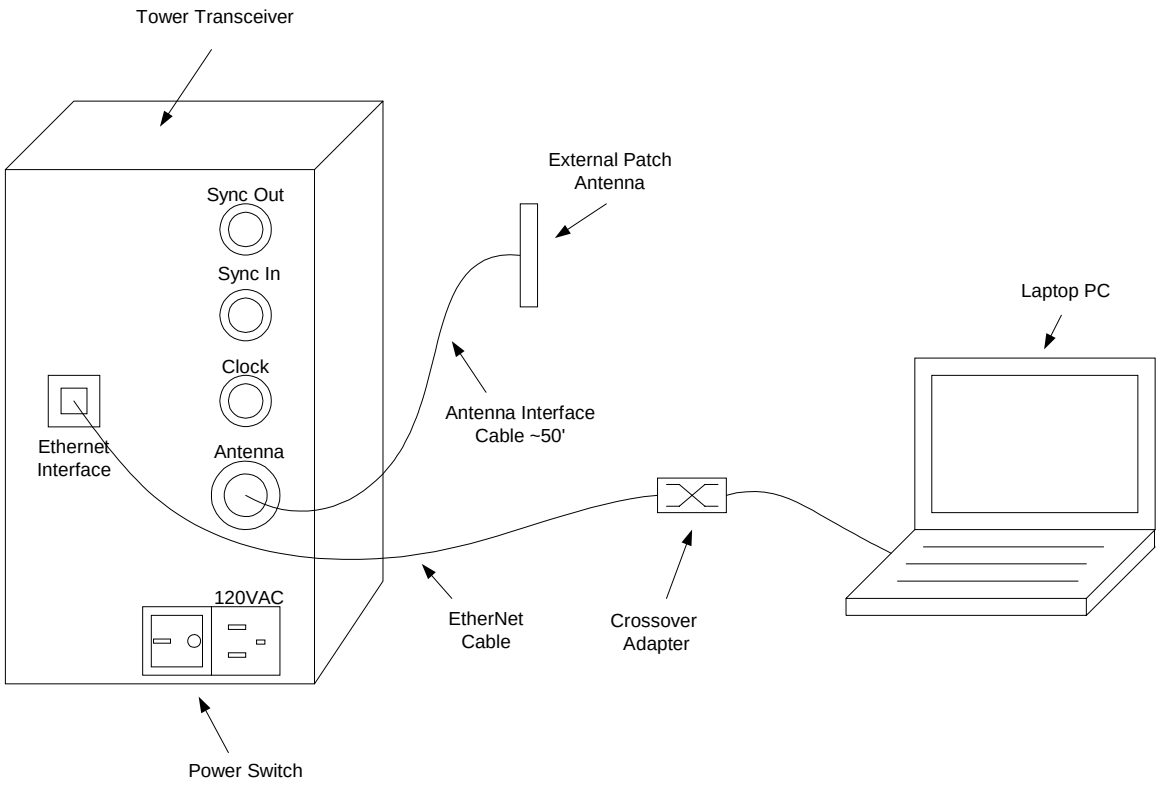
Patch Antenna Patterns



Operational Instructions

Tower Transceiver

Connect the antenna and power cables to the transceiver as shown in the TT connectivity figure. Push the power switch to the "ON" position and allow 2-3 minutes for the unit to boot-up. After the TT has successfully completed its boot-up cycle, the transceiver will wakeup and will immediately begin TDMA operation as stated above.

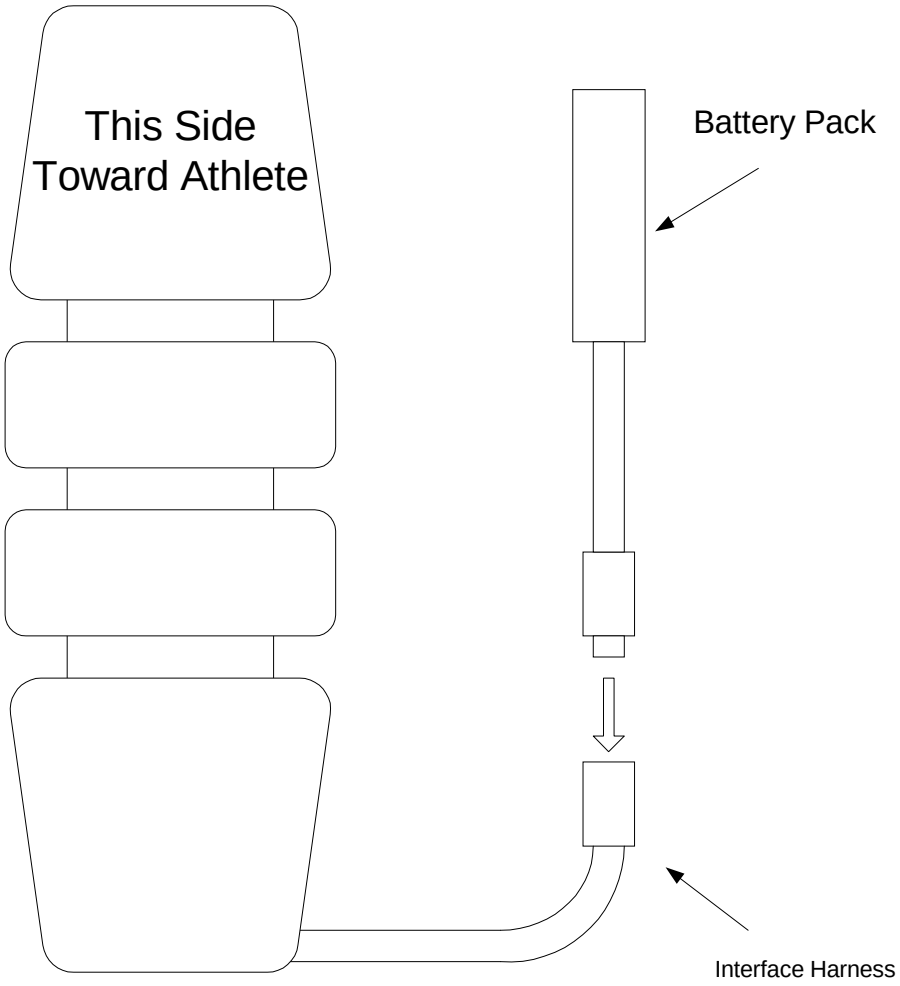


Tower Transceiver Connectivity Diagram

Player Patch

Be sure to start with a fully charged battery pack. Connect the battery harness to the PP interface harness as shown in the PP connectivity figure. When the battery connection is made the PP transceiver will wakeup and will immediately begin TDMA operation as stated above.

The marking on the tiles indicates the direction of the radiated RF energy. The RF energy is directed away from the label “This Side Toward Athlete” and should exhibit a far field radiation pattern that is consistent with the patch patterns shown above (note: Far Field Zone is ~2” from the radiator).



Player Patch Connectivity Diagram