FCC Certification Test Report

FCC Certification Test Report for Transportation Safety Technologies, Inc. NVX-TST-RFT200

July 18, 2002

Prepared for:

Transportation Safety Technologies, Inc.
2400 Roosevelt Ave
Indianapolis, IN 46218

Prepared By:

Washington Laboratories, Ltd.
7560 Lindbergh Drive
Gaithersburg, Maryland 20879

FCC Certification Test Program

FCC Certification Test Report
for the
Transportation Safety Technologies, Inc.
RF Tek-200 Wireless Control System
NVX-TST-RFT200

July 18, 2002

WLL JOB# 7140

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Abstract

This report has been prepared on behalf of Transportation Safety Technologies, Inc. to support the attached Application for Equipment Authorization. The test report and application are submitted for a Periodic Intentional Radiator under Part 15.231 of the FCC Rules and Regulations. This Federal Communication Commission (FCC) Certification Test Report documents the test configuration and test results for a Transportation Safety Technologies, Inc. RF Tek-200 Wireless Control System.

Testing was performed on an Open Area Test Site (OATS) of Washington Laboratories, Ltd, 7560 Lindbergh Drive, Gaithersburg, MD 20879. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. Washington Laboratories, Ltd. has been accepted by the FCC and approved by NIST NVLAP (NVLAP Lab Code: 200066-0) as an independent FCC test laboratory.

The Transportation Safety Technologies, Inc. RF Tek-200 Wireless Control System complies with the limits for a Periodic Intentional Radiator device under Part 15.231 of the FCC Rules and Regulations.

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1 Introduction

1.1 Compliance Statement

The Transportation Safety Technologies, Inc. RF Tek-200 Wireless Control System complies with the limits for a Periodic Intentional Radiator device under Part 15.231 of the FCC Rules and Regulations.

1.2 Test Scope

Tests for radiated emissions were performed. All measurements were performed according to the 1992 version of ANSI C63.4. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:	Transportation Safety Technologies, Inc. 2400 Roosevelt Ave Indianapolis, IN 46218
Purchase Order Number:	040878-00
Quotation Number:	60029-A

1.4 Test Dates

Testing was performed from June 18, 2002 to June 20, 2002.

1.5 Test and Support Personnel

Washington Laboratories, LTD	Ken Gemmell
Customer	Clay Howell

1.6 Abbreviations

A	Ampere
Ac	alternating current
AM	Amplitude Modulation
Amps	Amperes
b/s	bits per second
BW	Bandwidth
CE	Conducted Emission
cm	centimeter
CW	Continuous Wave
dB	decibel
dc	direct current
EMI	Electromagnetic Interference
EUT	Equipment Under Test
FM	Frequency Modulation
G	giga - prefix for 10^9 multiplier
Hz	Hertz
IF	Intermediate Frequency
k	kilo - prefix for 10^3 multiplier
M	Mega - prefix for 10^6 multiplier
m	Meter
μ	micro - prefix for 10^{-6} multiplier
NB	Narrowband
LISN	Line Impedance Stabilization Network
RE	Radiated Emissions
RF	Radio Frequency
rms	root-mean-square
SN	Serial Number
S/A	Spectrum Analyzer
V	Volt

2 Equipment Under Test

2.1 EUT Identification & Description

The RF *Tek-200* 2-Function Wireless Control System was designed primarily for Tow Truck or Wrecker Truck vehicles. The basic purpose for this control system is to control the winch that pulls vehicles up and down on the Tow Truck flat bed. There are two parts to the RF *Tek-200* control system: The Hand Held Remote Transmitter, and the Vehicle Mounted Receiver. The Hand Held Remote Transmitter has two functions, both functions are momentary and only one button is used at a time. Each time a button is pressed the Remote will transmit a code to the receiver unit for control. The control data packet is continuously transmitted as long as a button is held down. Once the button is released the Remote is programmed to stop transmitting within 5 seconds.

A third function of the Remote is called E-Stop Mode. E-Stop mode is entered by pressing and holding any one of the buttons for ¾ of a second and then pressing the other button simultaneously. E-Stop mode is an emergency mode that will instruct the receiver to turn off all outputs and turn on the E-Stop relay output. E-Stop mode is indicated by the Red LEDs blinking back and forth on the Remote. Once E-Stop mode is entered the Remote will remember and stay in E-Stop Mode until the mode is canceled.

Table 1. Device Summary

ITEM	DESCRIPTION
Manufacturer:	Transportation Safety Technologies, Inc.
FCC ID Number	NVX-TST-RFT200
EUT Name:	Wireless Control System
Model:	RF Tek-200
FCC Rule Parts:	§15.231
Frequency Range:	433.9 MHz
Maximum Output Power:	<1mW
Modulation:	OOK
Necessary Bandwidth:	146 kHz
Keying:	Manual
Type of Information:	Control
Number of Channels:	1
Power Output Level	Fixed
Antenna Type	Integrated
Frequency Tolerance:	N/A
Interface Cables:	None
Power Source & Voltage:	9Vdc from battery

2.2 Test Configuration

The RF Tek-200 was configured in a constant transmit mode. Conducted emissions testing was not performed as the unit is battery powered.

2.3 Testing Algorithm

The RF Tek-200 was operated continuously by taping one of the two function buttons into a constant "On" mode.

Worst case emission levels are provided in the test results data.

2.4 Test Location

All measurements herein were performed at Washington Laboratories, Ltd. test center in Gaithersburg, MD. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. Washington Laboratories, Ltd. has been accepted by the FCC and approved by NIST NVLAP (NVLAP Lab Code: 200066-0) as an independent FCC test laboratory.

2.5 Measurements

2.5.1 References

ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation

ANSI C63.4 American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

Land Mobile FM or PM Communications Equipment Measurement and Performance Standards (ANSI/TIA/EIA-603-93)

2.6 Measurement Uncertainty

All results reported herein relate only to the equipment tested. For the purposes of the measurements performed by Washington Laboratories, the measurement uncertainty is ±2.3 dB. This has been calculated for a *worst-case situation* (radiated emissions measurements performed on an open area test site).

The following measurement uncertainty calculation is provided:

$$\text{Total Uncertainty} = (A^2 + B^2 + C^2)^{1/2}/(n-1)$$

where:

A = Antenna calibration uncertainty, in dB = 2 dB

B = Spectrum Analyzer uncertainty, in dB = 1 dB

C = Site uncertainty, in dB = 4 dB

n = number of factors in uncertainty calculation = 3

Thus, Total Uncertainty = $0.5\ (2^2 + 1^2 + 4^2)^{1/2} = \pm 2.3$ dB.

3 Test Equipment

Table 2 shows a list of the test equipment used for measurements along with the calibration information.

Table 2: Test Equipment List

Equipment	Serial Number	Date Calibrated	Calibration Due
Sunol Science, Inc. Biconical Log Periodic Antenna JB1 (Site 1)	A090501	9/21/01	9/21/02
Hewlett-Packard Spectrum Analyzer: HP 8568B (Site 1)	2928A04750	6/29/01	6/29/02
Hewlett-Packard Quasi-Peak Adapter: HP 85650A (Site 1)	3303A01786	6/29/01	6/29/02
Hewlett-Packard RF Preselector: HP 85685A (Site 1)	2817A00744	6/29/01	6/29/02
Solar Electronics LISN 8012-50-R-24-BNC	8379493	9/18/01	9/18/02
Solar Electronics LISN 8028-50-TS-24-BNC	N/A	9/18/01	9/18/02
Solar Electronics LISN 8028-50-TS-24-BNC	N/A	9/18/01	9/18/02
Hewlett-Packard Spectrum Analyzer: HP 8564E	3643A00657	4/11/01	4/18/03
Hewlett-Packard RF Pre-Amplifier: HP 8449B	3008A00385	9/24/01	9/24/02
ARA DRG-118/A Antenna	1010	11/28/01	11/28/02

4 Test Results

4.1 Duty Cycle Correction

Measurements may be adjusted where pulsed RF is utilized to find the average level associated with a quantity. This calculation is applied to limits for pulsed licensed and unlicensed devices.

On time = $N_1L_1 + N_2L_2 + \ldots + N_{N-1}L_{N-1} + N_NL_N$, where N_1 is number of type 1 pulses, L_1 is length of type 1 pulses, etc.

- For Licensed Transmitters basic formula can be stated as 20log[Duty Cycle]
- For Unlicensed Intentional Radiators under 47CFR Part 15, all duty cycle measurements compared to a 100 millisecond period
- i.e. duty cycle = on time/100 milliseconds or period, whichever is less
- Restating the basic formula:
    - Duty cycle = $(N_1L_1 + N_2L_2 + \ldots + N_{N-1}L_{N-1} + N_NL_N)/100$ or T, whichever is less

Where T is the period of the pulse train.

The following Figures show the plots of the modulated carrier. The spectrum analyzer was set to Zero Span and the video triggered to collect the pulse train of the modulation. Calculations of the duty cycle correction factor were obtained from time data provided by the plots.

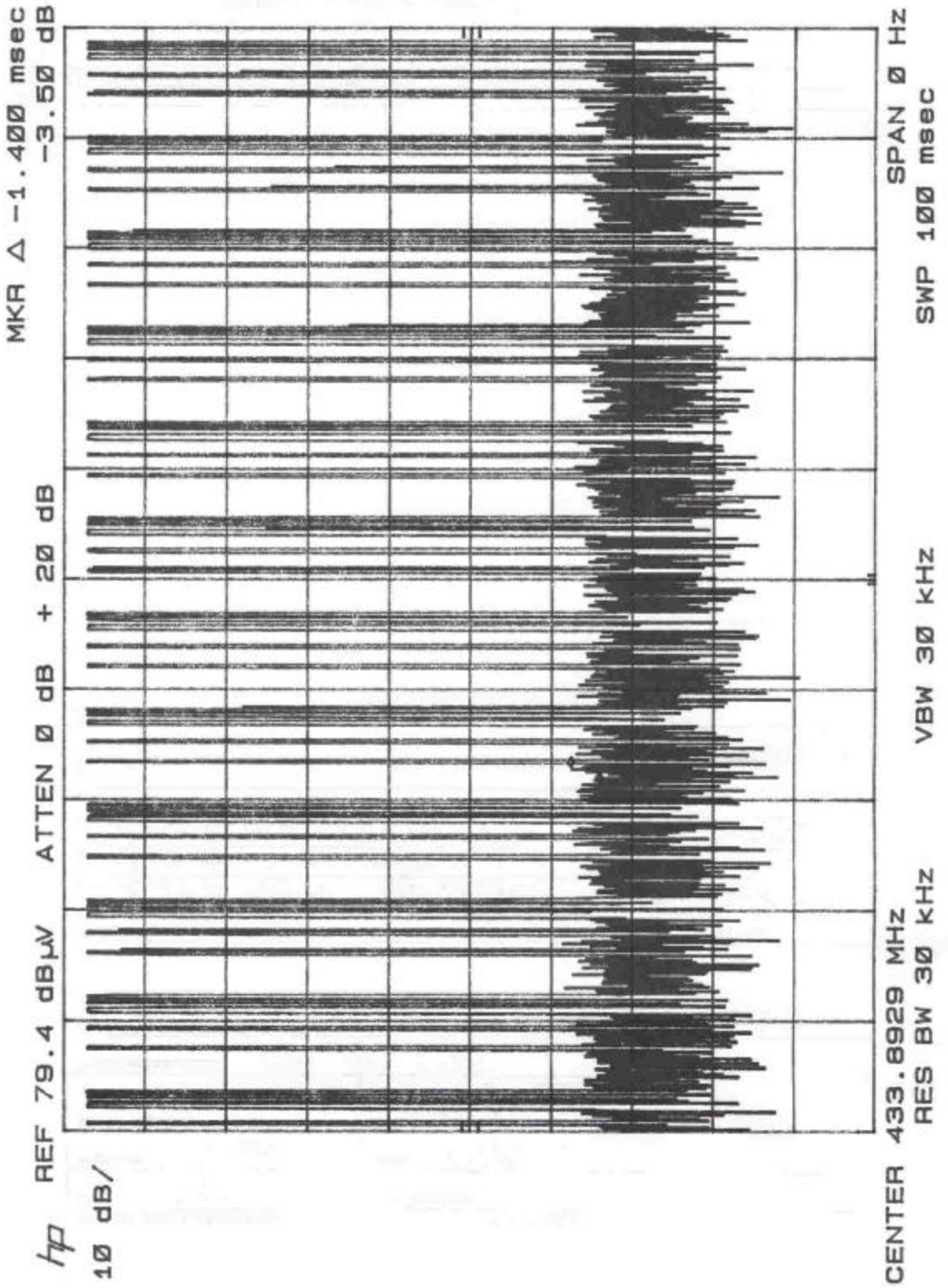

Figure 1. Duty Cycle Plot, Worst Case 100ms

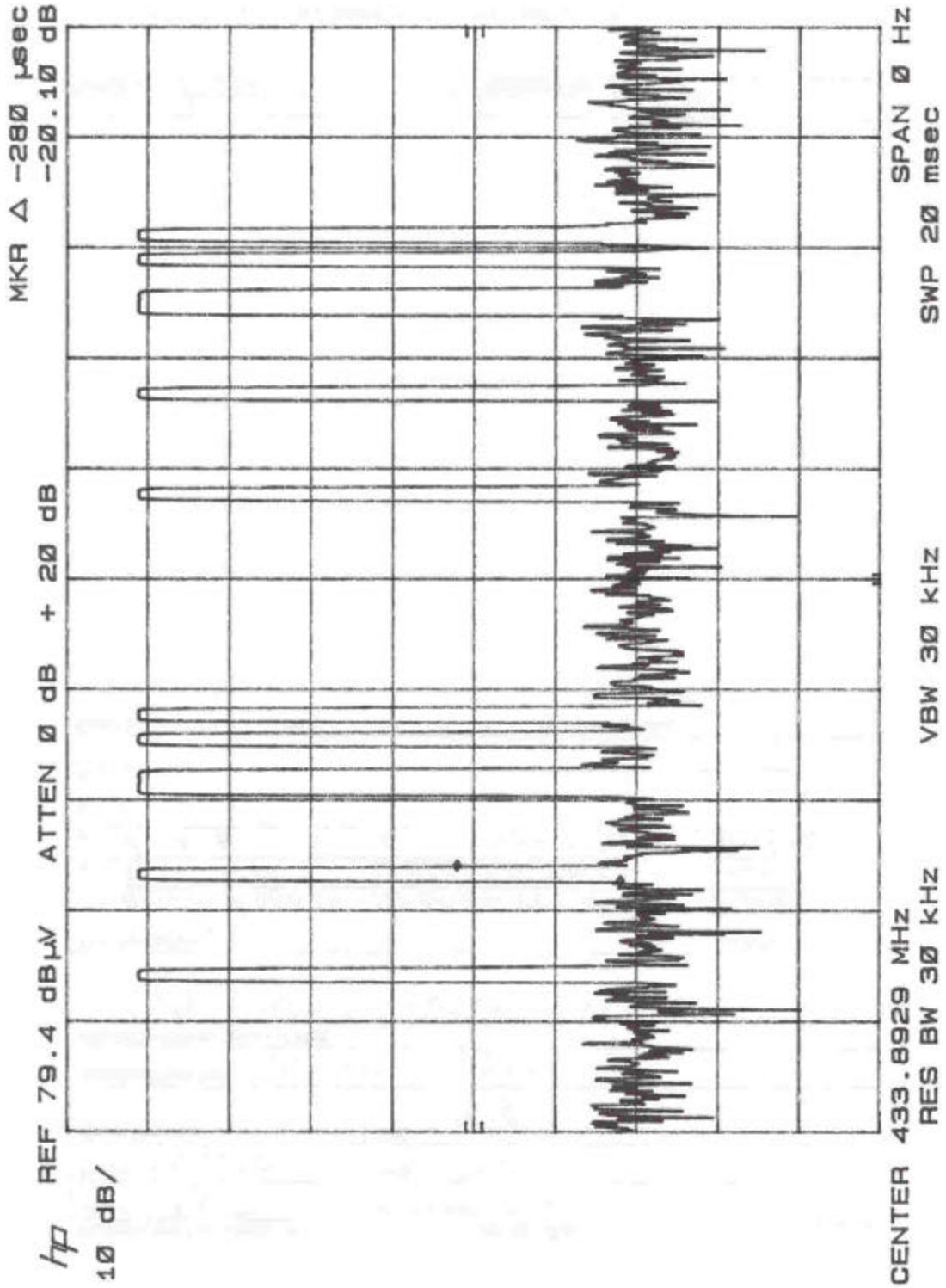

Figure 2. Duty Cycle Plots, Narrow Pulse Width

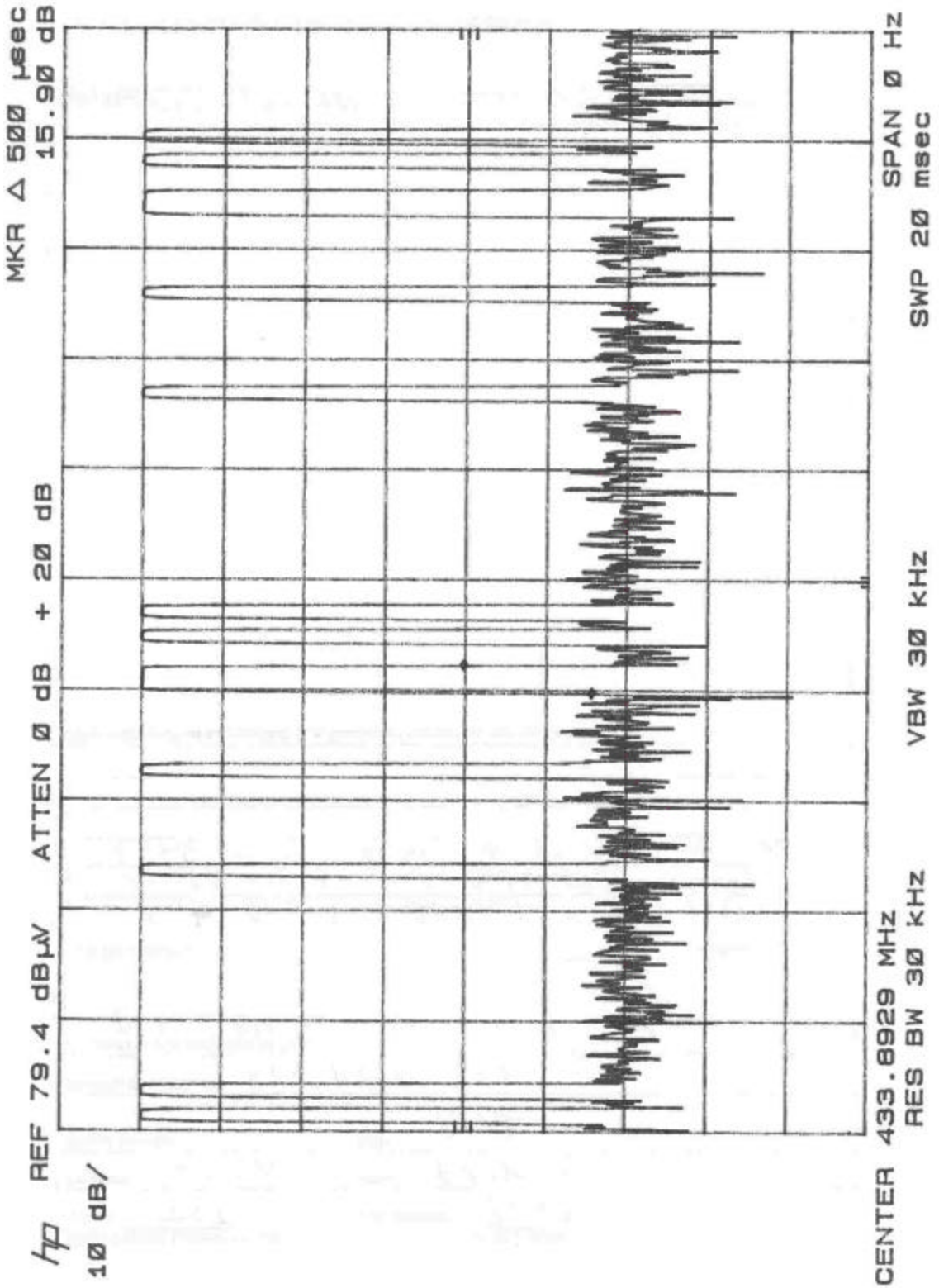

Figure 3. Duty Cycle Plot, Wide Pulse Width

From the data in Figure 2 and Figure 3, the following calculations are made.

On Time Per Code Group/100ms:

(12 x 500us) + (47 x 280us) = 19.16ms

The data are summarized in the following table.

Table 3. Duty Cycle Correction

Measurement Time	Total ON Time	Duty Cycle (%)	Duty Cycle (dB)
100ms	19.16ms	19.16	-14.35

4.2 RF Power Output: (FCC Part §2.1046)

N/A – Integral Antenna

4.3 Modulation Characteristics: (FCC Part §2.1047); Audio Frequency Response

N/A

4.4 Occupied Bandwidth: (FCC Part §2.1049)

Occupied bandwidth was performed by coupling the output of the EUT to the input of a spectrum analyzer.

FCC Part 15.231 states that the 20 dB bandwidth of the modulated carrier shall be as follows:

Frequency Range (MHz)	Occupied Bandwidth Limit
70-900 MHz	0.25%
> 900 MHz	0.5%

At full modulation, the occupied bandwidth was measured as shown in Figure 4

Results: Limit: 1.08475 MHz

Measured: 146 kHz

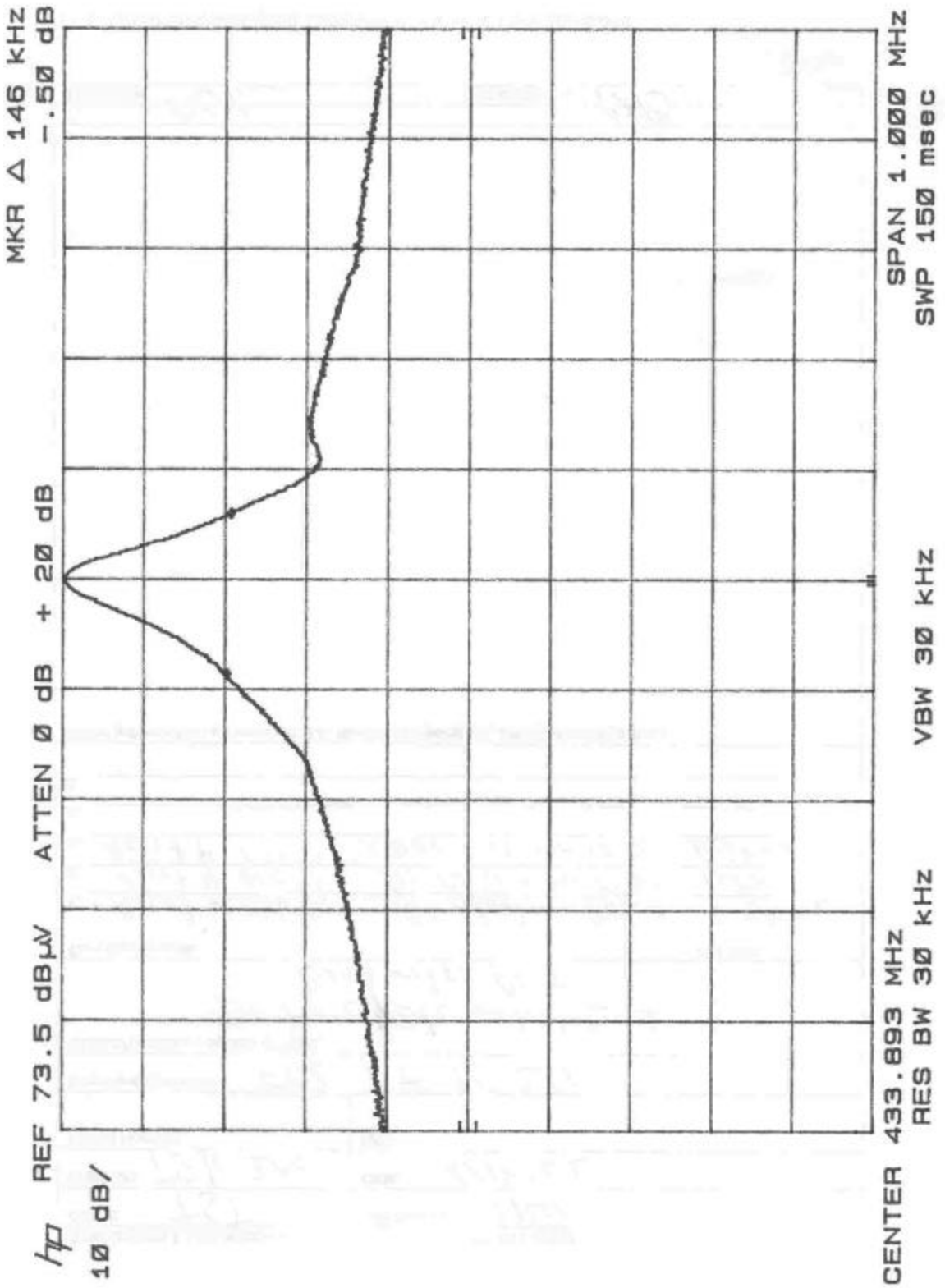

Figure 4. Occupied Bandwidth

4.5 Spurious Emissions at Antenna Terminals (FCC Part §2.1051

N/A

4.6 Radiated Spurious Emissions: (FCC Part §2.1053)

The EUT must comply with requirements for radiated spurious emissions. The limits are as shown in the following table.

Table 4. Radiated Spurious Emissions Limits

Frequency	Fundamental	Harmonic Level E-Field)
Fundamental	10995.8 uV/m	
Harmonics		1099.6 uV/m
FCC Mask		500 uV/m

4.6.1 Test Procedure

The EUT was placed on motorized turntable for radiated testing on a 3-meter open field test site. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. Receiving antennas were mounted on an antenna mast to determine the height of maximum emissions. The height of the antenna was varied between 1 and 4 meters. The peripherals were placed on the table in accordance with ANSI C63.4-1992. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured.

Table 5: Radiated Spurious Emission Test Data

CLIENT:	Transportation Safety	DATE:	6/18/02
TESTER:	K. Gemmell	JOB #:	7140
EUT:	Tek-200		
CONFIGURATION:	Continuous transmit mode, X - Orientation		
CLOCKS:	4 MHz 433 MHZ Transmitter		
Test Equipment/Limit:		**Test Requirements:**	
ANTENNA:	A_00028	TEST STANDARD:	FCC Part 15
CABLE:	CSITE2_3m	DISTANCE:	3m
LIMIT:	LFCC_3m_Class_B	CLASS:	B

Frequency (MHz)	Polarity H/V	Azimuth Degree	Ant. Hght (m)	SA Level (Peak) (dBuV)	Ant. Corr. (dB/m)	Cable Corr. (dB)	Duty Cycle Corr. (dB)	Corr. Level (dBuV/m)	Corr. Level (uV/m)	Limit (uV/m)	Margin dB
433.90	V	135.0	1.7	58.5	15.8	4.9	14.4	64.8	1739.2	10995.8	-16.0
433.90	H	270.0	1.0	70.9	15.8	4.9	14.4	77.2	7250.4	10995.8	-3.6
867.80	V	270.0	1.5	6.9	22.6	7.6	14.4	22.7	13.7	1099.6	-38.1
867.80	H	270.0	1.0	8.7	22.6	7.6	14.4	24.5	16.8	1099.6	-36.3
1301.70	V	180.0	1.0	50.9	27.7	2.3	14.4	32.5	42.3	500.0	-21.5
1301.70	H	180.0	1.0	48.5	27.7	2.3	14.4	30.1	32.1	500.0	-23.9
1735.60	V	0.0	1.0	50.4	30.7	2.4	14.4	35.1	56.6	1099.6	-25.8
1735.60	H	135.0	1.0	50.7	30.7	2.4	14.4	35.3	58.4	1099.6	-25.5
2169.50	V	180.0	1.0	49.9	32.9	2.7	14.4	37.2	72.2	1099.6	-23.7
2169.50	H	180.0	1.0	50.0	32.9	2.7	14.4	37.3	73.0	1099.6	-23.6
2603.40	V	0.0	1.0	46.2	34.8	3.1	14.4	35.7	61.0	1099.6	-25.1
2603.40	H	180.0	1.0	45.3	34.8	3.1	14.4	34.8	54.8	1099.6	-26.0
3037.30	V	180.0	1.0	45.9	36.2	3.4	14.4	37.1	71.7	1099.6	-23.7
3037.30	H	180.0	1.0	40.8	36.2	3.4	14.4	32.0	39.9	1099.6	-28.8
3471.20	V	180.0	1.0	46.9	36.8	3.6	14.4	38.9	88.0	1099.6	-21.9
3471.20	H	180.0	1.0	44.5	36.8	3.6	14.4	36.5	66.7	1099.6	-24.3
3905.10	V	180.0	1.0	41.4	37.3	3.8	14.4	34.1	50.6	500.0	-19.9
3905.10	H	90.0	1.0	41.7	37.3	3.8	14.4	34.4	52.4	500.0	-19.6
4339.00	V	180.0	1.0	45.1	37.6	3.9	14.4	38.2	81.3	1099.6	-22.6
4339.00	H	90.0	1.0	40.8	37.6	3.9	14.4	33.9	49.7	1099.6	-26.9

Table 6: Radiated Spurious Emission Test Data, Continued

CLIENT:	Transportation Safety	DATE:	6/18/02
TESTER:	K. Gemmell	JOB #:	7140
EUT:	Tek-200		
CONFIGURATION:	Continuous transmit mode, Y - Orientation		
CLOCKS:	4 MHz 433 MHZ Transmitter		
Test Equipment/Limit:		**Test Requirements:**	
ANTENNA:	A_00028	TEST STANDARD:	FCC Part 15
CABLE:	CSITE2_3m	DISTANCE:	3m
LIMIT:	LFCC_3m_Class_B	CLASS:	B

Frequency (MHz)	Polarity H/V	Azimuth Degree	Ant. Hght (m)	SA Level (Peak) (dBuV)	Ant. Corr. (dB/m)	Cable Corr. (dB)	Duty Cycle Corr (dB)	Corr. Level (dBuV/m)	Corr. Level (uV/m)	Limit (uV/m)	Margin dB
433.90	H	90.0	1.0	57.3	15.8	4.9	14.4	63.6	1514.8	10995.8	-17.2
433.90	V	0.0	1.2	71.3	15.8	4.9	14.4	77.6	7592.1	10995.8	-3.2
867.80	H	0.0	1.0	12.5	22.6	7.6	14.4	28.3	26.0	1099.6	-32.5
867.80	V	180.0	1.0	9.6	22.6	7.6	14.4	25.4	18.6	1099.6	-35.4
1301.70	V	270.0	1.0	49.4	27.7	2.3	14.4	31.0	35.6	500.0	-23.0
1301.70	H	45.0	1.0	46.0	27.7	2.3	14.4	27.6	24.0	500.0	-26.4
1735.60	V	270.0	1.0	51.9	30.7	2.4	14.4	36.6	67.3	1099.6	-24.3
1735.60	H	45.0	1.0	53.3	30.7	2.4	14.4	38.0	79.0	1099.6	-22.9
2169.50	V	0.0	1.0	49.2	32.9	2.7	14.4	36.5	66.8	1099.6	-24.3
2169.50	H	135.0	1.0	50.2	32.9	2.7	14.4	37.4	74.5	1099.6	-23.4
2603.40	V	180.0	1.0	43.5	34.8	3.1	14.4	33.0	44.5	1099.6	-27.8
2603.40	H	180.0	1.0	46.2	34.8	3.1	14.4	35.6	60.6	1099.6	-25.2
3037.30	V	180.0	1.0	45.9	36.2	3.4	14.4	37.1	71.7	1099.6	-23.7
3037.30	H	180.0	1.0	41.0	36.2	3.4	14.4	32.2	40.8	1099.6	-28.6
3471.20	V	180.0	1.0	46.7	36.8	3.6	14.4	38.7	86.3	1099.6	-22.1
3471.20	H	180.0	1.0	42.5	36.8	3.6	14.4	34.5	53.0	1099.6	-26.3
3905.10	V	180.0	1.0	41.7	37.3	3.8	14.4	34.4	52.6	500.0	-19.6
3905.10	H	0.0	1.0	40.0	37.3	3.8	14.4	32.7	43.1	500.0	-21.3
4339.00	V	0.0	1.0	44.2	37.6	3.9	14.4	37.4	73.8	1099.6	-23.5
4339.00	H	0.0	1.0	39.7	37.6	3.9	14.4	32.8	43.7	1099.6	-28.0

Table 7: Radiated Spurious Emission Test Data, Continued

CLIENT:	Transportation Safety	DATE:	6/18/02
TESTER:	K. Gemmell	JOB #:	7140
EUT:	Tek-200		
CONFIGURATION:	Continuous transmit mode, Z - Orientation		
CLOCKS:	4 MHz 433 MHZ Transmitter		
Test Equipment/Limit:		**Test Requirements:**	
ANTENNA:	A_00028	TEST STANDARD:	FCC Part 15
CABLE:	CSITE2_3m	DISTANCE:	3m
LIMIT:	LFCC_3m_Class_B	CLASS:	B

Frequency (MHz)	Polarity H/V	Azimuth Degree	Ant. Hght (m)	SA Level (Peak) (dBuV)	Ant. Corr. (dB/m)	Cable Corr. (dB)	Duty Cycle Corr (dB)	Corr. Level (dBuV/m)	Corr. Level (uV/m)	Limit (uV/m)	Margin dB
433.90	V	0.0	1.0	69.8	15.8	4.9	14.4	76.1	6387.9	10995.8	-4.7
433.90	H	90.0	1.0	58.9	15.8	4.9	14.4	65.2	1821.2	10995.8	-15.6
867.80	V	180.0	1.0	10.1	22.6	7.6	14.4	25.9	19.7	1099.6	-34.9
867.80	H	90.0	1.0	9.1	22.6	7.6	14.4	24.9	17.6	1099.6	-35.9
1301.70	V	225.0	1.0	50.1	27.7	2.3	14.4	31.7	38.5	500.0	-22.3
1301.70	H	180.0	1.0	44.5	27.7	2.3	14.4	26.1	20.2	500.0	-27.9
1735.60	V	0.0	1.0	49.9	30.7	2.4	14.4	34.6	53.4	1099.6	-26.3
1735.60	H	135.0	1.0	48.7	30.7	2.4	14.4	33.4	46.5	1099.6	-27.5
2169.50	V	180.0	1.0	48.7	32.9	2.7	14.4	36.0	63.1	1099.6	-24.8
2169.50	H	270.0	1.0	49.3	32.9	2.7	14.4	36.6	67.6	1099.6	-24.2
2603.40	V	0.0	1.0	44.9	34.8	3.1	14.4	34.4	52.3	1099.6	-26.4
2603.40	H	0.0	1.0	44.2	34.8	3.1	14.4	33.6	48.1	1099.6	-27.2
3037.30	V	135.0	1.0	45.9	36.2	3.4	14.4	37.1	71.7	1099.6	-23.7
3037.30	H	0.0	1.0	41.0	36.2	3.4	14.4	32.2	40.8	1099.6	-28.6
3471.20	V	180.0	1.0	47.1	36.8	3.6	14.4	39.1	89.7	1099.6	-21.8
3471.20	H	270.0	1.0	45.5	36.8	3.6	14.4	37.5	74.9	1099.6	-23.3
3905.10	V	180.0	1.0	41.7	37.3	3.8	14.4	34.4	52.6	500.0	-19.6
3905.10	H	90.0	1.0	43.0	37.3	3.8	14.4	35.7	60.9	500.0	-18.3
4339.00	V	0.0	1.0	44.2	37.6	3.9	14.4	37.4	73.8	1099.6	-23.5
4339.00	H	90.0	1.0	42.8	37.6	3.9	14.4	35.9	62.6	1099.6	-24.9

4.7 Frequency Stability: (FCC Part §2.1055)

N/A

5 Transmitter Environmental Assessment, Maximum Permissible Exposure (MPE)

Not applicable