PCTEST Engineering Laboratory, Inc.

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CERTIFICATE OF COMPLIANCE

SPORTS SENSORS INC.
P.O. Box 46198
Cincinnati, OH 45246-0198
Attn: Telemachos Manolatos, Vice President

Dates of Tests: February 16-17, 1999
Test Report S/N: TX.990216128.NVE
Test Site: PCTEST Lab, Columbia, MD

FCC ID	**NVE360**
APPLICANT	**SPORTS SENSORS INC.**

FCC Rule Part(s):	**§ 15.249 Subpart C – Intentional Radiator**
Classification:	**Low Power Transceiver – Rx Verified (DXT)**
EUT Type:	**Wireless Sports Radar Transceiver**
Freq. Range:	**5.725 GHz ~ 5.875 GHz**
Operating Freq.:	**5.8 GHz**
Model Name:	***GLOVE RADAR™***

This device has been shown to be capable of compliance with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified is ANSI C63.4-1992 with the following remarks (Note Codes):

- (#37) This device has shown to be in compliance with the new rules under Docket 87-389 and is not affected by Section 15.37 transition rule.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

PCTEST certifies that no party to this application has been denied the FCC benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C. 853(a)

Randy Ortlanez
President & Chief Engineer

Lab Code 100431-0

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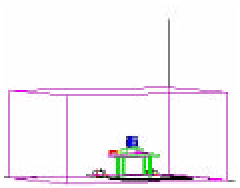
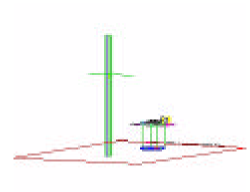
MEASUREMENT REPORT





Scope - Measurement and determination of electromagnetic emissions (EME) of radio frequency devices including intentional and/or unintentional radiators for compliance with the technical rules and regulations of the Federal Communications Commission.

Company Name:	**SPORTS SENSORS INC.**
Address:	**P.O. Box 46198**
	Cincinnati, OHIO 45246-0198
Attention:	**Telemachos J. Manolatos – Vice President**

- FCC ID: **NVE360**
- Model Name: ***GLOVE RADAR™***
- EUT Type: Mini Sports Radar
- Equipment Class: DXT (Low Power Transceiver – Rx Verified)
- Application Type: Transmitter Certification
- Frequency Range: 5.725 – 5.875 GHz
- Operating Frequency: 5.8 GHz
- FCC Rule Part(s): § 15.249 Subpart C (Intentional Radiator)
- Dates of Tests: February 16-17, 1999
- Place of Tests: PCTEST Lab, Columbia, MD U.S.A.
- Test Report S/N: TX.990216128.NVE

1.1 INTRODUCTION

The measurement procedure described in Section 15.249 of FCC Rules, and American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9kHz to 40GHz (ANSI C63.4-1992) was used in determining radiated and conducted emissions emanating from **SPORTS SENSORS INC. *GLOVE RADAR*™ Mini Sports Radar Transceiver FCC ID: NVE360.**

These measurement tests were conducted at ***PCTEST Engineering Laboratory, Inc.*** facility in New Concept Business Park, Guilford Industrial Park, Columbia, Maryland. The site address is 6660-B Dobbin Road, Columbia, MD 21045. The test site is one of the highest points in the Columbia area with an elevation of 390 feet above mean sea level. The site coordinates are 39° 11'15" N latitude and 76° 49'38" W longitude. The facility is 1.5 miles North of the FCC laboratory, and the ambient signal and ambient signal strength are approximately equal to those of the FCC laboratory. There are no FM or TV transmitters within 15 miles of the site. The detailed description of the measurement facility was found to be in compliance with the requirements of § 2.948 according to ANSI C63.4 on October 19, 1992.

1.2 PCTEST Location

The map at right shows the location of the PCTEST Lab, its proximity to the FCC Lab, the Columbia vicinity area, the Baltimore-Washington International (BWI) airport, and the city of Baltimore, and the Washington, D.C. area. (see Figure1).

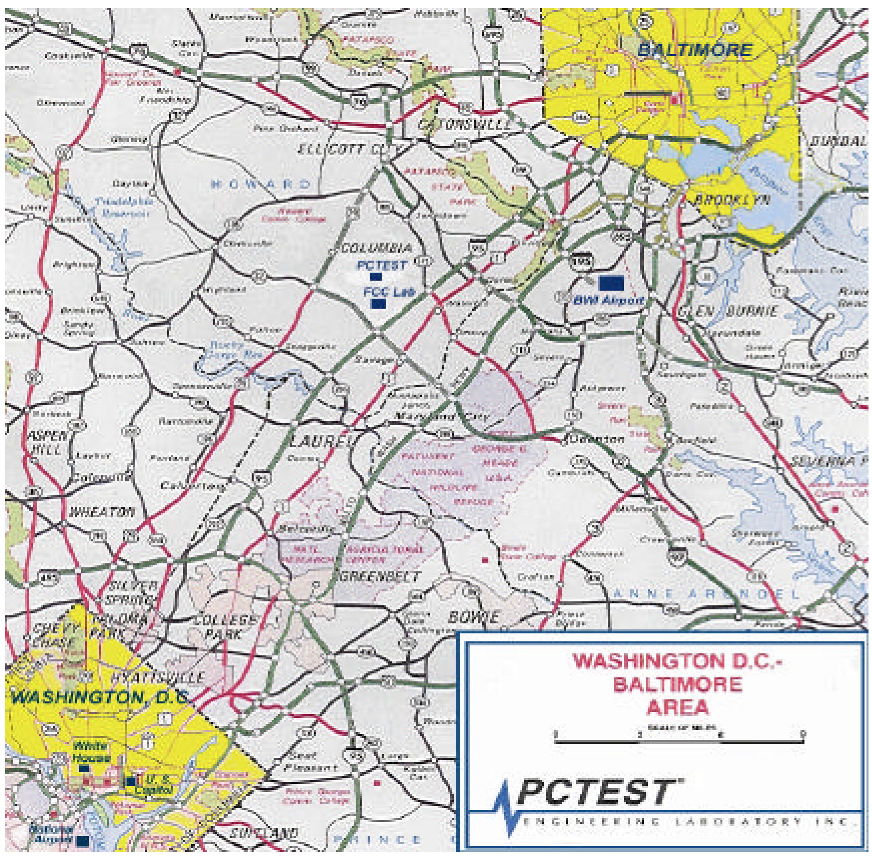


Figure 1. Map of the Greater Baltimore and Metropolitan Washington, D.C. area.

2.1 Product Information

2.2 Equipment Description

The Equipment Under Test (EUT) is the **SPORTS SENSORS INC. (Model: *GLOVE RADAR*™) Mini Sports Radar Transceiver FCC ID: NVE360.** The EUT is a radar velocity sensor which attaches to a baseball or softball glove to measure the speed of the ball just before it is caught.

- **Tx Frequency Range:** **5.725 ~ 5.875 GHz**
- **Tx Operating Frequency:** **5.8 GHz**
- **Modulation:** **Phase**
- **RF Output Power:** **.361mW**
- **Power Supply:** **(1) 3V 160mAh Lithium Battery**
- **Dimensions (LxWxH):** **3 1/2 x 2 1/2 x 1 1/8 inches**
- **Weight:** **3 oz**

2.3 EMI Suppression Device(s)

EMI suppression device(s) added and/or modified during testing:

- none

3.1 Description of Tests

3.2 Conducted Emissions (not applicable)

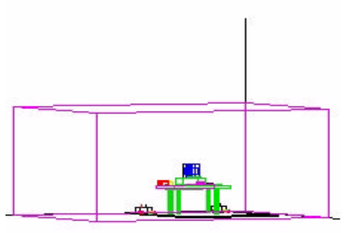


Figure 2. Shielded Enclosure Line-Conducted Test Facility

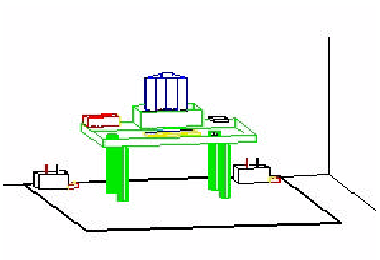


Figure 3. Line Conducted Emission Test Set-Up

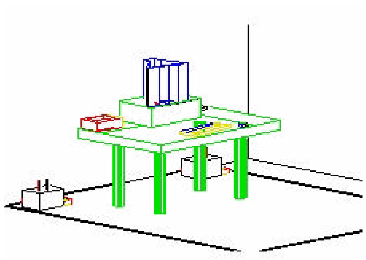


Figure 4. Wooden Table & Bonded LISNs

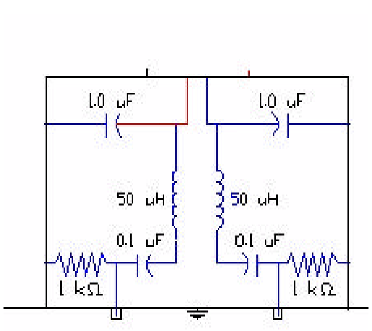


Figure 5. LISN Schematic Diagram

The line-conducted facility is located inside a 16'x20'x10' shielded enclosure. It is manufactured by Ray Proof Series 81 (see Figure 2). The shielding effectiveness of the shielded room is in accordance with MIL-Std-285 or NSA 65-6. A 1m. x 1.5m. wooden table 80cm. high is placed 40cm. away from the vertical wall and 1.5m away from the side wall of the shielded room (see Figure 3). Solar Electronics and EMCO Model 3725/2 (10kHz-30MHz) 50Ω/50µH Line-Impedance Stabilization Networks (LISNs) are bonded to the shielded room (see Figure 4). The EUT is powered from the Solar LISN and the support equipment is powered from the EMCO LISN. Power to the LISNs are filtered by a high-current high-insertion loss Ray Proof power line filters (100dB 14kHz-10GHz). The purpose of the filter is to attenuate ambient signal interference and this filter is also bonded to the shielded enclosure. All electrical cables are shielded by braided tinned copper zipper tubing, with an inner diameter of 1/2". If the EUT is a DC-powered device, power will be derived from the source power supply it normally will be powered from and this supply lines will be connected to the Solar LISN. LISN schematic diagram is shown in Figure 5. All interconnecting cables more than 1 meter were shortened by non-inductive bundling (serpentine fashion) to a 1-meter length. Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The RF output of the LISN was connected to the spectrum analyzer to determine the frequency producing the maximum EME from the EUT. The spectrum was scanned from 450kHz to 30MHz with 20 msec. sweep time. The frequency producing the maximum level was reexamined using EMI/ Field Intensity Meter and Quasi-Peak adapter. The detector function was set to CISPR quasi-peak mode. The bandwidth of the receiver was set to 10 kHz. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each EME emission. Each emission was maximized by: switching power lines; varying the mode of operation or resolution; clock or data exchange speed; scrolling H pattern to the EUT and/or support equipment, and powering the monitor from the floor mounted outlet box and the computer aux AC outlet, if applicable; whichever determined the worst-case emission. Photographs of the worst-case emission can be seen in Attachment I. Each EME reported was calibrated using the HP8640B signal generator.

3.1 Description of Tests (continued)

3.3 Radiated Emissions

Preliminary measurements were made indoors at 1 meter using broadband antennas, broadband amplifier, and spectrum analyzer to determine the frequency producing the maximum EME. Appropriate precaution was taken to ensure that all EME from the EUT were maximized and investigated. The system configuration, clock speed, mode of operation or video resolution, turntable azimuth with respect to the antenna were noted for each frequency found. The spectrum was scanned from 30 to 200 MHz using biconical antenna and from 200 to 1000 MHz using log-spiral antenna. Above 1 GHz, linearly polarized double ridge horn antennas were used.

Final measurements were made outdoors at 3-meter test range using Roberts™ Dipole antennas or horn antenna (see Figure 6). The test equipment was placed on a wooden and plastic bench situated on a 1.5 x 2 meter area adjacent to the measurement area (see Figure 7). Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. Each frequency found during pre-scan measurements was re-examined and investigated using EMI/Field Intensity Meter and Quasi-Peak Adapter. The detector function was set to CISPR quasi-peak mode and the bandwidth of the receiver was set to 100kHz or 1 MHz depending on the frequency or type of signal.

The half-wave dipole antenna was tuned to the frequency found during preliminary radiated measurements. The EUT, support equipment and interconnecting cables were re-configured to the set-up producing the maximum emission for the frequency and were placed on top of a 0.8-meter high non-metallic 1 x 1.5 meter table (see Figure 8). The EUT, support equipment, and interconnecting cables were re-arranged and manipulated to maximize each EME emission. The turntable containing the system was rotated; the antenna height was varied 1 to 4 meters and stopped at the azimuth or height producing the maximum emission. Each emission was maximized by: varying the mode of operation or resolution; clock or data exchange speed; scrolling H pattern to the EUT and/or support equipment; powering the monitor from the floor mounted outlet box and the computer aux AC outlet if applicable, and changing the polarity of the antenna; whichever determined the worst-case emission. Photographs of the worst-case emission can be seen in Attachment I. Each EME reported was calibrated using the HP8640B signal generator. The Theoretical Normalized Site Attenuation Curves for both horizontal and vertical polarization are shown in Figure 9 according to ANSI C63.4.

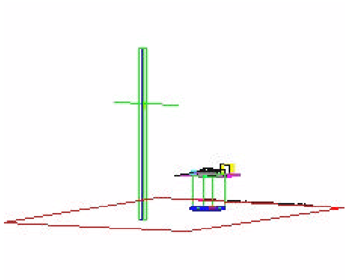


Figure 6. 3-Meter Test Site

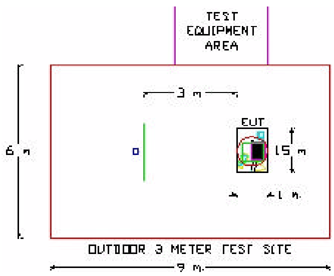


Figure 7. Dimensions of Outdoor Test Site

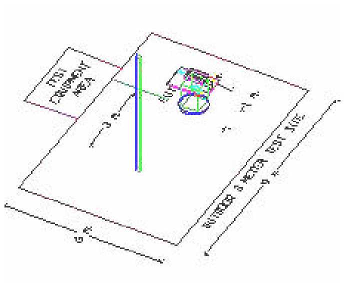


Figure 8. Turntable and System Setup

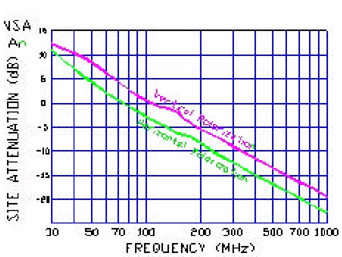


Figure 9. Normalized Site Attenuation Curves (H&V)

4.1 §15.203 Antenna Requirement

An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the applicant can be used with the device. The use of permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with this requirement.

CONCLUSION

The SPORTS SENSORS INC. wireless transmitter complies with the requirement of §15.203 with a microloop antenna integrated onto the circuit board of the transmitter.

5.1 §2.989(c) Occupied Bandwidth

Ball spreads from 20mph to 100mph were simulated and the peak frequency deviations were recorded and plotted from a spectrum analyzer placed on maximum hold.

6.1 Frequency Measurements (Fundamental & Harmonics)

Operating Frequency: 5.8 GHz
Distance of Measurements: 3 meters

FREQ. (GHz)	Level (dBµV)	AFCL (dB)	POL (H/V)	Height (m)	F/S (dBµV/m)	DET. (PEAK/AVG)	MARGIN (dB)
5.86	49.2	41.6	HH	1.4	90.8	Peak	- 3.2
11.72	3.5	47.0	HH	1.3	50.5	Peak	- 3.5
17.58	- 7.5	55.3	HH	1.2	47.8	Peak	- 6.2
23.44	- 11.8	57.9	HH	1.1	46.1	Peak	- 7.9

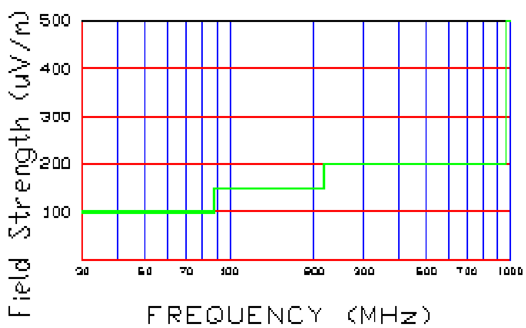


Figure 10. Spurious Radiated Limits at 3

NOTES:

1. The limit at fundamental frequency is 50,000 µV/m @ 3m. using QP detector. The harmonic limit is 500µV/m @ 3m.
2. The emissions radiated outside of the specified frequency band, except harmonics, are attenuated by at least 50dBc or to the limits in §15.209, whichever is lesser.
3. All harmonic emissions in the restricted bands specified in §15.205 are below the limit shown in Fig. 10.
4. The EUT is supplied with a new/fully recharged battery.
5. All modes of operation were investigated and the worst-case is reported.

7.1 Frequency Measurements (Fundamental & Spurious)

NOTES:

1. All modes of operation were investigated, and no significant emissions were found.

8.1 Plot(s) of Emissions

See Attachment D

9.1 Sample Calculations

$$\mathbf{dB\mu V = 20 \log_{10} (\mu V/m)}$$
$$\mathbf{dB\mu V = dBm + 107}$$

9.2 Example 1:

@ 20.3 MHz

Class B limit	= 250 µV = 47.96 dBµV
Reading	= - 67.8 dBm (calibrated level)
Convert to dbµV	= - 67.8 + 107 = 39.2 dBµV
$10^{(39.2/20)}$	= 91.2 µV
Margin	= 39.2 - 47.96 = - 8.76
	= **8.8 dB below limit**

9.3 Example 2:

@ 66.7 MHz

Class B limit	= 100 µV/m = 47.96 dBµV/m	
Reading	= - 76.0 dBm (calibrated level)	
Convert to dbµV/m	= - 76.0 + 107 = 31.0 dBµV/m	
Antenna Factor + Cable Loss		= 5.8 dB
	Total	= 36.8 dBµV/m
Margin	= 36.8 - 40.0 = - 3.2	
	= **3.2 dB below limit**	

10.1 Accuracy of Measurement

10.2 Measurement Uncertainty Calculations:

The measurement uncertainties stated were calculated in accordance with the requirements of NIST Technical Note 1297 and NIS 81 (1994).

Contribution (Line Conducted)	Probability Distribution	Uncertainty (± dB)	
		9kHz-150MHz	150-30MHz
Receiver specification	Rectangular	1.5	1.5
LISN coupling specification	Rectangular	1.5	1.5
Cable and input attenuator calibration	Normal (k=2)	0.3	0.5
Mismatch: Receiver VRC Γ_1 = 0.03 LISN VRC Γ_R = 0.8 (9kHz) 0.2 (30MHz) Uncertainty limits 20Log(1 ± Γ_1 Γ_R)	U-Shaped	0.2	0.35
System repeatability	Std. deviation	0.2	0.05
Repeatability of EUT		-	-
Combined standard uncertainty	Normal	1.26	1.30
Expanded uncertainty	Normal (k=2)	2.5	2.6

Calculations for 150kHz to 30MHz:

$$u_C(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)} = \pm\sqrt{\frac{1.5^2 + 1.5^2}{3} + (\frac{0.5}{2})^2 + 0.35} = \pm 1.298\text{dB}$$

$$U = 2U_C(y) = \pm 2.6\text{dB}$$

Contribution (Radiated Emissions)	Probability Distribution	Uncertainties (± dB)	
		3 m	10 m
Ambient Signals		-	-
Antenna factor calibration	Normal (k=2)	± 1.0	± 1.0
Cable loss calibration	Normal (k=2)	± 0.5	± 0.5
Receiver specification	Rectangular	± 1.5	±1.5
Antenna directivity	Rectangular	+ 0.5 / - 0	+ 0.5
Antenna factor variation with height	Rectangular	± 2.0	± 0.5
Antenna phase centre variation	Rectangular	0.0	± 0.2
Antenna factor frequency interpolation	Rectangular	±. 0.25	± 0.25
Measurement distance variation	Rectangular	± 0.6	± 0.4
Site imperfections	Rectangular	± 2.0	± 2.0
Mismatch: Receiver VRC Γ_1 = 0.2 Antenna VRC Γ_R = 0.67 (Bi) 0.3 (Lp) Uncertainty limits 20Log(1 ± Γ_1 Γ_R)	U-Shaped	+ 1.1 - 1.25	± 0.5
System repeatability	Std. Deviation	± 0.5	± 0.5
Repeatability of EUT		-	-
Combined standard uncertainty	Normal	+ 2.19 / - 2.21	+ 1.74 / - 1.72
Expanded uncertainty U	Normal (k=2)	+ 4.38 / - 4.42	+ 3.48 / - 3.44

Calculations for 3m biconical antenna. Coverage factor of k=2 will ensure that the level of confidence will be approximately 95%, therefore:

$$U = 2u_C(y) = 2 \times \pm 2.19 = \pm 4.38\text{dB}$$

11.1 Test Equipment

Type	Model	Cal. Due Date	S/N
Microwave Spectrum Analyzer	HP 8566B (100Hz-22GHz)	08/15/99	3638A08713
Microwave Spectrum Analyzer	HP 8566B (100Hz-22GHz)	04/17/99	2542A11898
Spectrum Analyzer/Tracking Gen.	HP 8591A (100Hz-1.8GHz)	08/10/99	3144A02458
Signal Generator*	HP 8640B (500Hz-1GHz)	08/09/99	2232A19558
Signal Generator*	HP 8640B (500Hz-1GHz)	08/09/99	1851A09816
Signal Generator*	Rohde & Schwarz (0.1-1000MHz)	09/11/99	894215/012
Ailtech/Eaton Receiver	NM 37/57A-SL (30-1000MHz)	04/12/99	0792-03271
Ailtech/Eaton Receiver	NM 37/57A (30-1000MHz)	03/11/99	0805-03334
Ailtech/Eaton Receiver	NM 17/27A (0.1-32MHz)	09/17/99	0608-03241
Quasi-Peak Adapter	HP 85650A	08/15/99	2043A00301
Ailtech/Eaton Adapter	CCA-7 CISPR/ANSI QP Adapter	03/11/99	0194-04082
RG58 Coax Test Cable	No. 167		n/a
Harmonic/Flicker Test System	HP 6841A (IEC 555-2/3)		3531A00115
Broadband Amplifier (2)	HP 8447D		1145A00470, 1937A03348
Broadband Amplifier	HP 8447F		2443A03784
Transient Limiter	HP 11947A (9kHz-200MHz)		2820A00300
Horn Antenna	EMCO Model 3115 (1-18GHz)		9704-5182
Horn Antenna	EMCO Model 3115 (1-18GHz)		9205-3874
Horn Antenna	EMCO Model 3116 (18-40GHz)		9203-2178
Biconical Antenna (4)	Eaton 94455/Eaton 94455-1/Singer 94455-1/Compliance Design		1295, 1332, 0355
Log-Spiral Antenna (3)	Ailtech/Eaton 93490-1		0608, 1103, 1104
Roberts Dipoles	Compliance Design (1 set)		
Ailtech Dipoles	DM-105A (1 set)		33448-111
EMCO LISN	3816/2		1079
EMCO LISN	3816/2		1077
EMCO LISN	3725/2		2009
Microwave Preamplifier 40dB Gain	HP 83017A (0.5-26.5GHz)		3123A00181
Microwave Cables	MicroCoax (1.0-26.5GHz)		
Ailtech/Eaton Receiver	NM37/57A-SL		0792-03271
Spectrum Analyzer	HP 8594A		3051A00187
Spectrum Analyzer (2)	HP 8591A		3034A01395, 3108A02053
Modulation Analyzer	HP 8901A		2432A03467
NTSC Pattern Generator	Leader 408		0377433
Noise Figure Meter	HP 8970B		3106A02189
Noise Figure Meter	Ailtech 7510		TE31700
Noise Generator	Ailtech 7010		1473
Microwave Survey Meter	Holaday Model 1501 (2.450GHz)		80931
Digital Thermometer	Extech Instruments 421305		426966
Attenuator	HP 8495A (0-70dB) DC-4GHz		
Bi-Directional Coax Coupler	Narda 3020A (50-1000MHz)		
Shielded Screen Room	RF Lindgren Model 26-2/2-0		6710 (PCT270)
Shielded Semi-Anechoic Chamber	Ray Proof Model S81		R2437 (PCT278)
Environmental Chamber	Associated Systems Model 1025 (Temperature/Humidity)		PCT285

* Calibration traceable to the National Institute of Standards and Technology (NIST).

12.1 Recommendation/Conclusion

The data collected shows that the **SPORTS SENSORS INC. (Model: *GLOVE RADAR™*) Mini Sports Radar Transceiver FCC ID: NVE360** complies with Part 15 Subpart C of the FCC Rules.