Engineering Test Report No. 2104523-04 Rev. A		
Report Date	June 13, 2022	
Manufacturer Name	Fastenal	
Manufacturer Address	2001 Theurer Blvd Winona, MN 55987	
Test Item Name Model No.	RFID Reader, Model No. 922194627	
Date Received	February 23, 2022	
Test Dates	February 24, 2022 through May 19, 2022; September 28, 2022; October 4, 2022	
Specifications	FCC "Code of Federal Regulations" Title 47 Part 15, Subpart C, Section 15.247 Innovation, Science, and Economic Development Canada, RSS-GEN Innovation, Science, and Economic Development Canada, RSS-247	
Test Facility	Elite Electronic Engineering, Inc. 1516 Centre Circle, Downers Grove, IL 60515	FCC Reg. Number: 269750 IC Reg. Number: 2987A CAB Identifier: US0107
Signature	MARK E. LONGINOTTI	
Tested by	Mark E. Longinotti	
Signature	Raymond J Klouda	
Approved by	Raymond J. Klouda, Registered Professional Engineer of Illinois – 44894	
PO Number	01N9964-011822-0743 and 01N9964-040622-0736	

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1. Report Revision History

Revision	Date	Description
–	13 JUN 2022	Initial Release of Engineering Test Report No. 2104523-014
A	19 OCT 2022 By Mark Longinotti	– Changed the Engineering Test Report No. from 2104523-04 to 2104523-04 Rev. A throughout the report. – Title page: changed test dates from February 24, 2022 through May 19, 2022 to February 24, 2022 through October 4, 2022 – Section 18: Removed the equipment used for EIRP and Case Spurious Radiated Emissions tests in February. Added the equipment used for EIRP and Case Spurious Radiated Emissions tests in September. – Section 27: Removed EIRP data taken in February and replaced it with data that was taken in September. The data taken in September represents the final configuration of the transmitter antennas in the EUT. – Section 28: Removed case spurious radiated emissions data taken in February and replaced it with data that was taken in October. The data taken in October represents the final configuration of the transmitter antennas in the EUT.

2. Introduction

2.1. Scope of Tests

This document presents the results of a series of RF emissions tests that were performed on the Fastenal RFID Reader (hereinafter referred to as the Equipment Under Test (EUT)). The EUT contained a ST Micro ST25RU3993 RFID module (no FCC ID or IC ID). The EUT was manufactured and submitted for testing by Fastenal located in Winona, MN.

2.2. Purpose

The test series was performed to determine if the EUT meets the RF emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, §15.247 for a Frequency Hopping Spread Spectrum intentional radiator operating within the 902 – 928MHz band.

The test series was also performed to determine if the EUT meets the RF emission requirements of the Innovation, Science, and Economic Development Canada Radio Standards Specification RSS-Gen and Innovation, Science, and Economic Development Canada Radio Standards Specification RSS-247 for a Frequency Hopping Spread Spectrum intentional radiator operating within the 902 – 928MHz band.

Testing was performed in accordance with ANSI C63.10-2013.

2.3. Identification of the EUT

The EUT was identified as follows:

EUT Identification	
Product Description	RFID Reader
Model/Part No.	922194627
Size of EUT	48" x 24" x 18"
Software/Firmware Version	"AS3993.X.production .unified.test.v0_09a.hex"
Device Type	Frequency Hopping Transmission Device
Band of Operation	902 – 928MHz
Antenna Type	PCB
Antenna Gain (dBi) [1]	5
Conducted Output Power	15.88dBm
Rated Output Power	14dBm
20dB Bandwidth	101.9kHz
Occupied Bandwidth (99% CBW)	376kHz

Note 1 – Antenna gain is supplied by the manufacturer and Elite is not responsible for the accuracy of the antenna gain.

The EUT listed above was used throughout the test series.

3. Power Input

The EUT obtained 5VDC power through a 2 wire, 1.6-meter power cable from the output of a CUI, Inc. power supply, Model No. SDI18-5-UD. The power supply was powered with 115V, 60Hz power via a 2 wire, 2.9-meter power cable.

4. Grounding

The EUT was not connected to ground.

5. Support Equipment

No support equipment was used during the tests.

6. Interconnect Leads

No interconnect leads were used during the tests.

7. Modifications Made to the EUT

No modifications were made to the EUT during the testing.

8. Modes of Operation

The EUT and all peripheral equipment were energized. The unit was programmed to transmit in one of the following modes:

- Transmit at 902.75MHz, power setting = 14dBm
- Transmit at 914.25MHz, power setting = 14dBm
- Transmit at 927.25MHz, power setting = 14dBm
- Hopping, power setting = 14dBm

9. Test Specifications

The tests were performed to selected portions of, and in accordance with, the test specifications.

- Federal Communications Commission "Code of Federal Regulations", Title 47, Chapter I, Subchapter A, Part 15, Subpart C

- ANSI C63.10-2013, “American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices”

- Federal Communications Commission Office of Engineering and Technology Laboratory Division, Guidance For Compliance Measurements On Digital Transmission Systems, Frequency Hopping Spread Spectrum System, and Hybrid System Devices Operating Under Section 15.247 April 2, 2019 KDB 558074 D01v05r02

- RSS-Gen Issue 5, February 2020, Amendment 2, Innovation, Science, and Economic Development Canada, “General Requirements for Compliance of Radio Apparatus”

- RSS-247 Issue 2, February 2017, “Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices”

10. Test Plan

No test plan was provided. Instructions were provided by personnel from Fastenal and used in conjunction with the FCC "Code of Federal Regulations" Title 47 Part 15, Subpart C, Section 15.247, Innovation, Science, and Economic Development Canada, RSS-247, and ANSI C63.10-2013 specifications.

11. Deviation, Additions to, or Exclusions from Test Specifications

There were no deviations, additions to, or exclusions from the test specifications during this test series.

12. Laboratory Conditions

The ambient parameters of the laboratory during testing were as follows:

Ambient Parameters	Value
Temperature	22°C
Relative Humidity	18%
Atmospheric Pressure	1014mb

13. Summary

The following EMC tests were performed, and the results are shown below:

Test Description	Requirements	Test Method	Results
Transmitter Conducted Emissions (AC Mains)	FCC 15.207 ISED RSS-GEN	ANSI C63.10:2013	Conforms
20dB Bandwidth	FCC 15.247 ISED RSS-247	ANSI C63.10:2013	Conforms
Occupied Bandwidth (99%)	FCC 15.247 ISED RSS-247	ANSI C63.10:2013	Conforms
Carrier Frequency Separation	FCC 15.247 ISED RSS-247	ANSI C63.10:2013	Conforms
Number of Carrier Channels	FCC 15.247 ISED RSS-247	ANSI C63.10:2013	Conforms
Average Time of Occupancy	FCC 15.247 ISED RSS-247	ANSI C63.10:2013	Conforms
Maximum Peak Conducted Output Power	FCC 15.247 ISED RSS-247	ANSI C63.10:2013	Conforms
Effective Isotropic Radiated Power (EIRP)	FCC 15.247 ISED RSS-247	ANSI C63.10:2013	Conforms
Case Spurious Radiated Emissions	FCC 15.247 ISED RSS-247	ANSI C63.10:2013	Conforms
Band-Edge Compliance	FCC 15.247 ISED RSS-247	ANSI C63.10:2013	Conforms

14. Sample Calculations

For Powerline Conducted Emissions:

The resultant voltage level (VL) is a summation in decibels (dB) of the receiver meter reading (MTR) and the cable loss factor (CF).

Formula 1: VL (dBµV) = MTR (dBµV) + CF (dB).

For Radiated Emissions:

The resultant field strength (FS) is a summation in decibels (dB) of the receiver meter reading (MTR), the antenna correction factor (AF), and the cable loss factor (CF). If an external preamplifier is used, the total is reduced by its gain (-PA). If a distance correction (DC) is required, it is added to the total.

Formula 1: FS (dBµV/m) = MTR (dBµV) + AF (dB/m) + CF (dB) + (- PA (dB)) + DC (dB)

To convert the Field Strength dBµV/m term to µV/m, the dBµV/m is first divided by 20. The Base 10 AntiLog is taken of this quotient. The result is the Field Strength value in µV/m terms.

Formula 2: FS (µV/m) = AntiLog [(FS (dBµV/m))/20]

15. Statement of Conformity

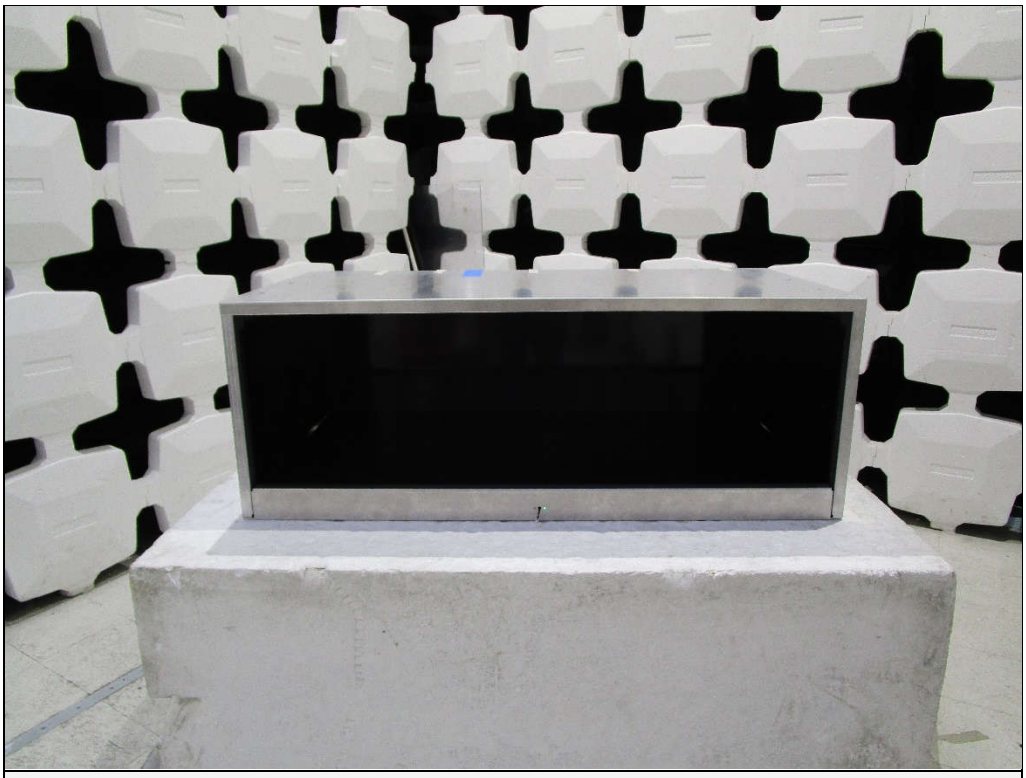
The Fastenal RFID Reader (Model No. 922194627) did fully conform to the selected requirements of FCC "Code of Federal Regulations" Title 47 Part 15, Subpart C, Section 15.247 and Innovation, Science, and Economic Development Canada, RSS-247.

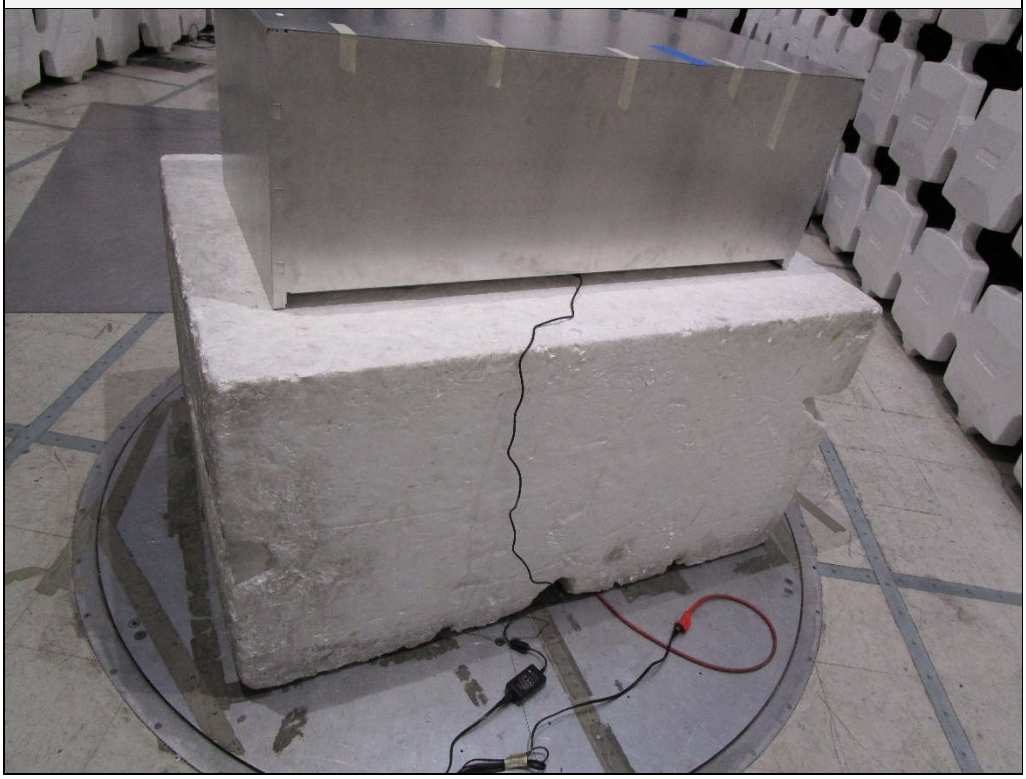
16. Certification

Elite Electronic Engineering Incorporated certifies that the information contained in this report was obtained

under conditions which meet or exceed those specified in the FCC "Code of Federal Regulations" Title 47 Part 15, Subpart C, Section 15.247 and Innovation, Science, and Economic Development Canada, RSS-247 test specifications. The data presented in this test report pertains to the EUT on the test date specified. Any electrical or mechanical modifications made to the EUT subsequent to the specified test date will serve to invalidate the data and void this certification.

17. Photographs of EUT





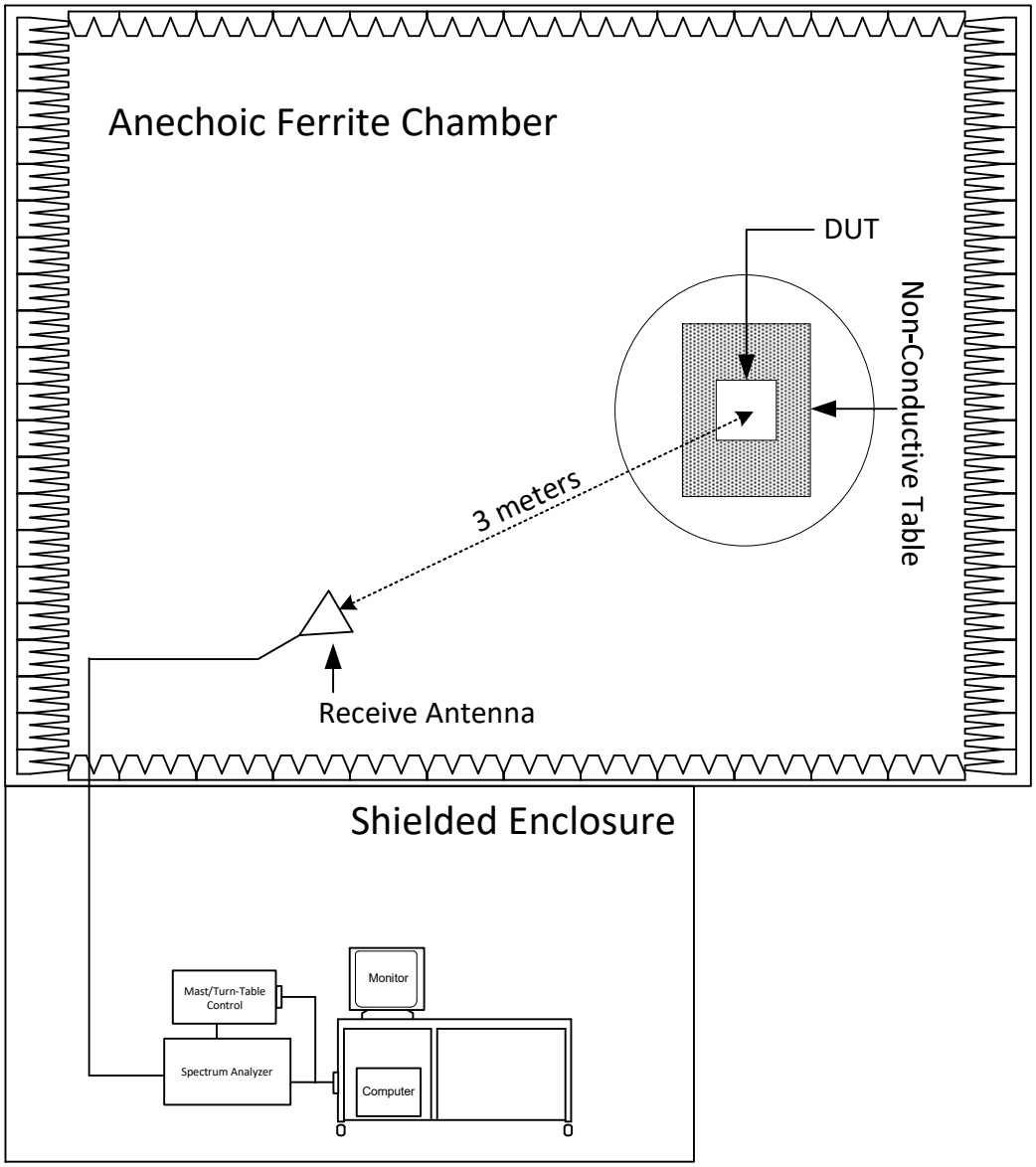
18. Equipment List

Eq ID	Equipment Description	Manufacturer	Model No.	Serial No.	Frequency Range	Cal Date	Due Date
APW14	PREAMPLIFIER	PLANAR	PE2-35-120-5R0-10-12-SFF	PL22671	1-20GHz	9/21/2022	9/21/2023
APW3	PREAMPLIFIER	PLANAR ELECTRONICS	PE2-35-120-5R0-10-12	PL2924	1GHZ-20GHZ	3/9/2022	3/9/2023
CDZ2	LAB WORKSTATION	ELITE	LWS-10		WINDOWS 10	CNR	
CDZ3	LAB WORKSTATION	ELITE	LWS-10		WINDOWS 10	CNR	
CDZ4	LAB WORKSTATION	ELITE	LWS-10		WINDOWS 10	CNR	
GRB0	1MHZ, LISN SIGNAL CHECKER	ELITE	LISNCHKR1M	1	1MHZ	6/17/2021	6/17/2023
GSE0	SIGNAL GENERATOR (40GHZ)	ROHDE & SCHWARZ	SMB100A	175137	100KHZ-40GHZ	9/22/2022	9/22/2023
NDQ0	TUNED DIPOLE ANTENNA	EMCO	3121C-DB4	311	400-1000MHZ	6/7/2022	6/7/2024
NTA4	BILOG ANTENNA	TESEQ	6112D	46660	20-2000GHZ	10/5/2020	11/5/2022
NWQ1	DOUBLE RIDGED WAVEGUIDE ANTENNA	ETS-LINDGREN	3117	66655	1GHZ-18GHZ	5/26/2022	5/26/2024
NWQ2	DOUBLE RIDGED WAVEGUIDE ANTENNA	ETS LINDGREN	3117	66659	1GHZ-18GHZ	4/27/2022	4/27/2024
PLF2	CISPR16 50UH LISN	ELITE	CISPR16/70A	002	.15-30MHz	4/5/2022	4/5/2023
PLF4	CISPR16 50UH LISN	ELITE	CISPR16/70A	003	.15-30MHz	4/5/2022	4/5/2023
RBG0	EMI ANALYZER	ROHDE & SCHWARZ	ESW44	101533	10HZ-44GHZ	11/15/2021	11/15/2022
RBG2	EMI ANALYZER	ROHDE & SCHWARZ	ESW44	101591	2HZ-44GHZ	3/31/2022	3/31/2023
RBG3	EMI ANALYZER	ROHDE & SCHWARZ	ESW44	101592	2HZ-44GHZ	4/7/2022	4/7/2023
SES0	24VDC POWER SUPPLY	P-TRANS	FS-32024-1M	001	18-27VDC	NOTE 1	
T1ED	10DB 25W ATTENUATOR	WEINSCHEL	46-10-34	BN2320	DC-18GHZ	1/6/2022	1/6/2024
T2DC	20DB, 25W ATTENUATOR	WEINSCHEL	46-20-34	BH5448	DC-18GHZ	1/14/2022	1/14/2024
T2S8	20DB 25W ATTENUATOR	WEINSCHEL	46-20-34	BV3541	DC-18GHZ	1/4/2022	1/4/2024
VBR8	CISPR EN FCC CE VOLTAGE.exe					N/A	
WKA1	SOFTWARE, UNIVERSAL RCV EMI	ELITE	UNIV_RCV_EMI	1	---	I/O	
XPQ7	HIGH PASS FILTER	K&L MICROWAVE	4IH30-1804/T10000-0	5	1.8-10GHZ	2/3/2021	2/3/2023
XPQ8	HIGH PASS FILTER	K&L MICROWAVE	4IH30-1804/T10000-0	6	1.8-10GHZ	2/3/2021	2/3/2023

N/A: Not Applicable I/O: Initial Only CNR: Calibration Not Required

NOTE 1: For the purpose of this test, the equipment was calibrated over the specified frequency range, pulse rate, or modulation prior to the test or monitored by a calibrated instrument.

19. Block Diagram of Test Setup



Radiated Measurements Test Setup

20. Transmitter Conducted Emissions (AC Mains)

Test Information	
Manufacturer	Fastenal
Product	RFID Reader
Model No.	922194627
Mode	Hopping

Test Setup Details	
Setup Format	Tabletop
Height of Support (For Floor Standing only)	N/A
Type of Test Site	Shielded Enclosure
Test Site Used	Room #23 side
Notes	

Measurement Uncertainty	
Measurement Type	Expanded Measurement Uncertainty
Conducted disturbance (mains port) (150 kHz – 30 MHz)	2.7

Requirements
All radio frequency voltages on the power lines for any frequency or frequencies of an intentional radiator shall not exceed the limits in the following table:

Transmitter Conducted Emissions Limits		
Frequency of Emission (MHz)	Conducted Limits (dBµV)	
	Quasi-peak	Average
0.15 – 0.5	66 to 56*	56-46*
0.5 – 5	56	46
5 – 30	60	50
* The lower limit shall apply at the transition frequencies.		

Procedure
The interference on each power lead of the EUT was measured by connecting the measuring equipment to the appropriate meter terminal of the Line Impedance Stabilization Network (LISN). The meter terminal of the LISN not under test was terminated with 50 ohms. 1) The EUT was operated in the Hopping mode. 2) Measurements were first made on the 115V, 60Hz high line of the CUI Inc AC Adapter, P/N: SDI18-5-UDC-P254-C1 which was used to provide 5VDC to the EUT. 3) The frequency range from 150kHz to 30MHz was broken up into smaller frequency sub-bands. 4) Conducted emissions measurements were taken on the first frequency sub-band using a peak detector. 5) The data thus obtained was then searched by the computer for the highest levels. Any emissions levels that were within 10dB of the average limit were then measured again using both a quasi-peak detector and an average detector. (If no peak readings were within 10dB of the average limit, quasi-peak and average readings were taken on the highest emissions levels measured during the peak detector scan.) 6) Steps (4) and (5) were repeated for the remainder of the frequency sub-bands until the entire frequency range from 150kHz to 30MHz was investigated. The peak trace was automatically plotted. The plot also shows quasi-peak and average readings that were taken on discrete frequencies. A table showing the quasi-peak and average readings was also generated. This tabular data compares the quasi-peak and average conducted emissions to the applicable conducted emissions limits. The resultant voltage level (VL) is a summation in decibels (dB) of the receiver meter reading (MTR) and the cable loss factor (CF). Formula 1: VL (dBμV) = MTR (dBμV) + CF (dB) 7) Steps (3) through (6) were repeated on the 115V, 60Hz return line of the CUI Inc AC Adapter, P/N: SDI18-5-UDC-P254-C1 which was used to provide 5VDC to the EUT.

Test Setup for RF Conducted Emissions (AC Mains)

Test Setup for RF Conducted Emissions (AC Mains)

Test Setup for RF Conducted Emissions (AC Mains)

Test Setup for RF Conducted Emissions (AC Mains)

FCC Part 15 Subpart C Conducted Emissions Test

Significant Emissions Data

VBR8 05/14/2020

Manufacturer	:	Fastenal
Model	:	AS3993
DUT Revision	:	NA
Serial Number	:	NA
DUT Mode	:	Tx - Hopping
Line Tested	:	High
Scan Step Time [ms]	:	30
Meas. Threshold [dB]	:	-10
Notes	:	None
Test Engineer	:	J. Cardenas
Limit	:	FCC Part 15 Subpart C
Test Date	:	May 06, 2022 09:06:56 AM
Data Filter	:	Up to 80 maximum levels detected with 6 dB level excursion threshold over 10 dB margin below limit

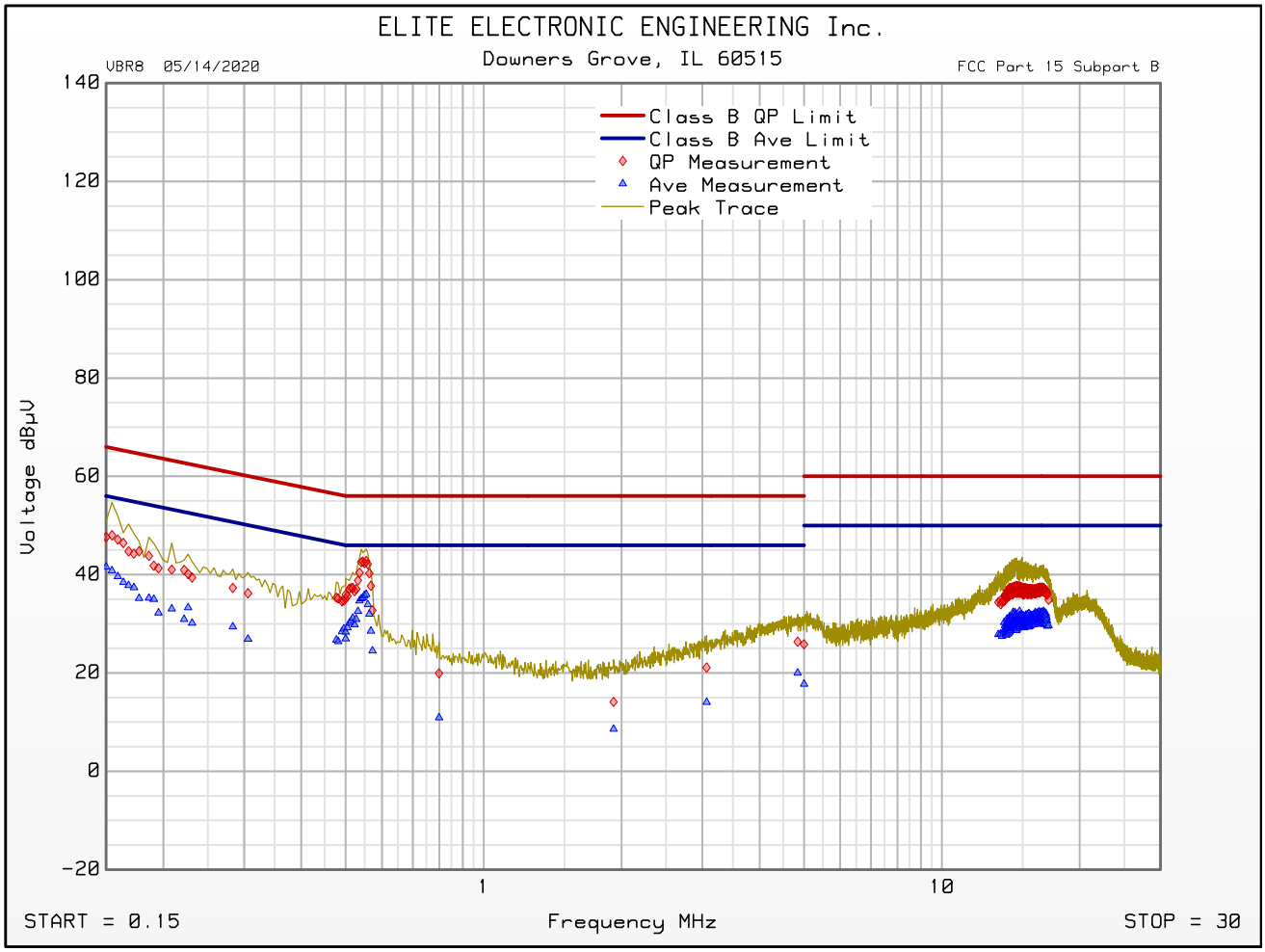
Freq MHz	Quasi-peak Level dBµV	Quasi-peak Limit dBµV	Excessive Quasi-peak Emissions	Average Level dBµV	Average Limit dBµV	Excessive Average Emissions
0.155	48.0	65.8		40.8	55.8	
0.500	35.9	56.0		27.0	46.0	
0.799	19.9	56.0		10.9	46.0	
1.921	14.1	56.0		8.6	46.0	
3.065	21.1	56.0		14.1	46.0	
4.841	26.4	56.0		20.0	46.0	
5.000	25.8	56.0		17.8	46.0	
14.549	37.7	60.0		31.9	50.0	
16.574	37.4	60.0		31.5	50.0	

FCC Part 15 Subpart C Conducted Emissions Test

Cumulative Data

VBR8 05/14/2020

Manufacturer	:	Fastenal
Model	:	AS3993
DUT Revision	:	NA
Serial Number	:	NA
DUT Mode	:	Tx - Hopping
Line Tested	:	High
Scan Step Time [ms]	:	30
Meas. Threshold [dB]	:	-10
Notes	:	None
Test Engineer	:	J. Cardenas
Limit	:	FCC Part 15 Subpart C
Test Date	:	May 06, 2022 09:06:56 AM



Emissions Meet QP Limit
Emissions Meet Ave Limit

FCC Part 15 Subpart C Conducted Emissions Test

Significant Emissions Data

VBR8 05/14/2020

Manufacturer	:	Fastenal
Model	:	AS3993
DUT Revision	:	NA
Serial Number	:	NA
DUT Mode	:	Tx - Hopping
Line Tested	:	Neutral
Scan Step Time [ms]	:	30
Meas. Threshold [dB]	:	-10
Notes	:	None
Test Engineer	:	J. Cardenas
Limit	:	FCC Part 15 Subpart C
Test Date	:	May 06, 2022 09:26:10 AM
Data Filter	:	Up to 80 maximum levels detected with 6 dB level excursion threshold over 10 dB margin below limit

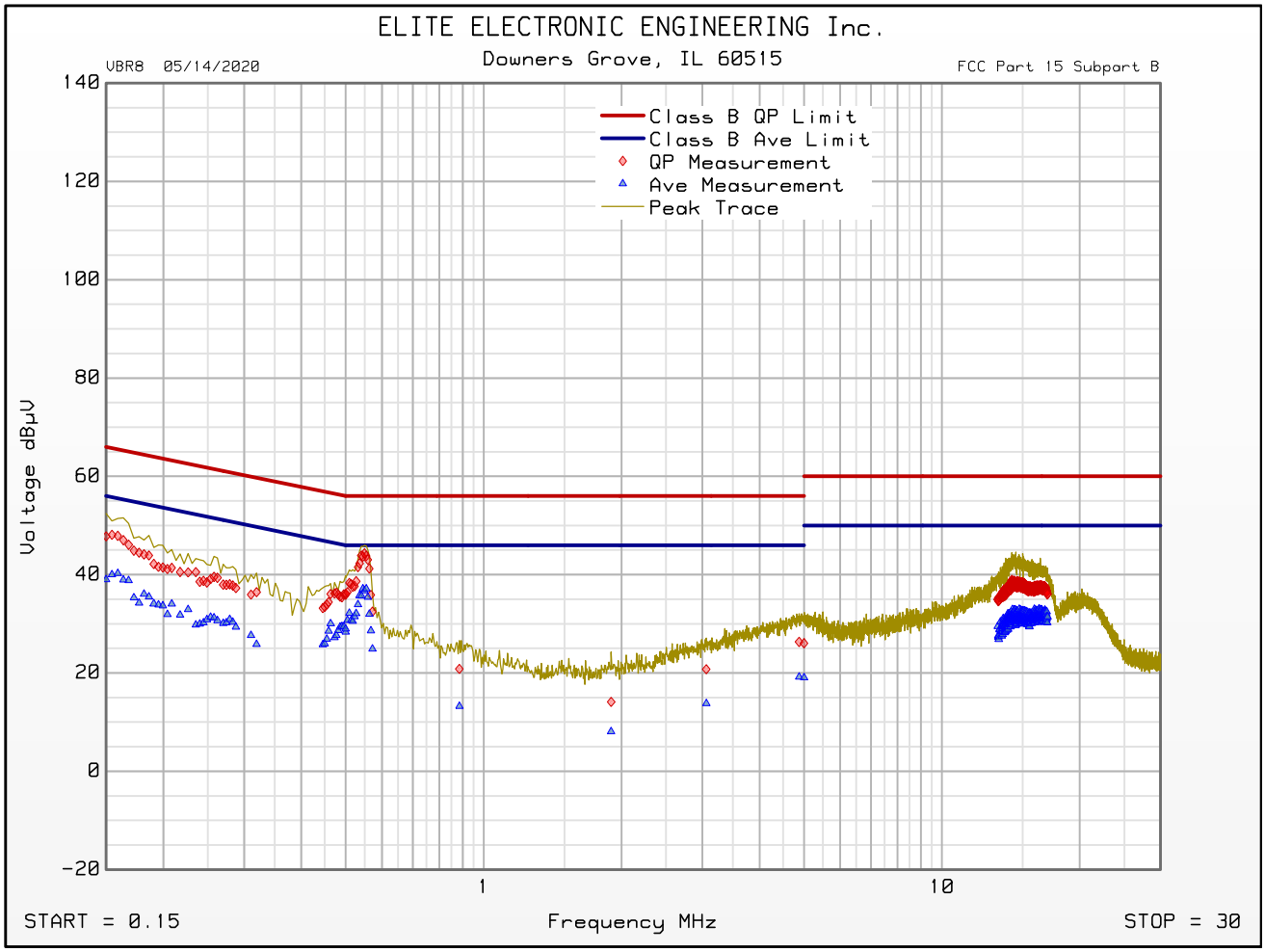
Freq MHz	Quasi-peak Level dBµV	Quasi-peak Limit dBµV	Excessive Quasi-peak Emissions	Average Level dBµV	Average Limit dBµV	Excessive Average Emissions
0.159	47.9	65.5		40.3	55.5	
0.500	36.1	56.0		29.0	46.0	
0.545	43.7	56.0		37.2	46.0	
0.554	43.8	56.0		37.1	46.0	
0.885	20.8	56.0		13.2	46.0	
1.898	14.1	56.0		8.1	46.0	
3.060	20.7	56.0		13.8	46.0	
4.877	26.3	56.0		19.2	46.0	
5.000	26.1	56.0		19.1	46.0	
14.216	38.9	60.0		31.9	50.0	
16.529	37.7	60.0		30.9	50.0	

FCC Part 15 Subpart C Conducted Emissions Test

Cumulative Data

VBR8 05/14/2020

Manufacturer	:	Fastenal
Model	:	AS3993
DUT Revision	:	NA
Serial Number	:	NA
DUT Mode	:	Tx - Hopping
Line Tested	:	Neutral
Scan Step Time [ms]	:	30
Meas. Threshold [dB]	:	-10
Notes	:	None
Test Engineer	:	J. Cardenas
Limit	:	FCC Part 15 Subpart C
Test Date	:	May 06, 2022 09:26:10 AM



Emissions Meet QP Limit
Emissions Meet Ave Limit

21. 20dB Bandwidth

EUT Information	
Manufacturer	Fastenal
Product	RFID Reader
Model No.	922194627
Mode	Transmit at 902.75MHz Transmit at 914.25MHz Transmit at 927.25MHz

Test Setup Details	
Setup Format	Tabletop
Height of Support (For Floor Standing only)	N/A
Measurement Method	Antenna Conducted
Type of Test Site	Tabletop
Test Site Used	N/A
Notes	

Measurement Uncertainty	
Measurement Type	Expanded Measurement Uncertainty
Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1000 MHz)	4.3
Radiated disturbance (electric field strength on an open area test site or alternative test site) (1 GHz – 6 GHz)	3.1

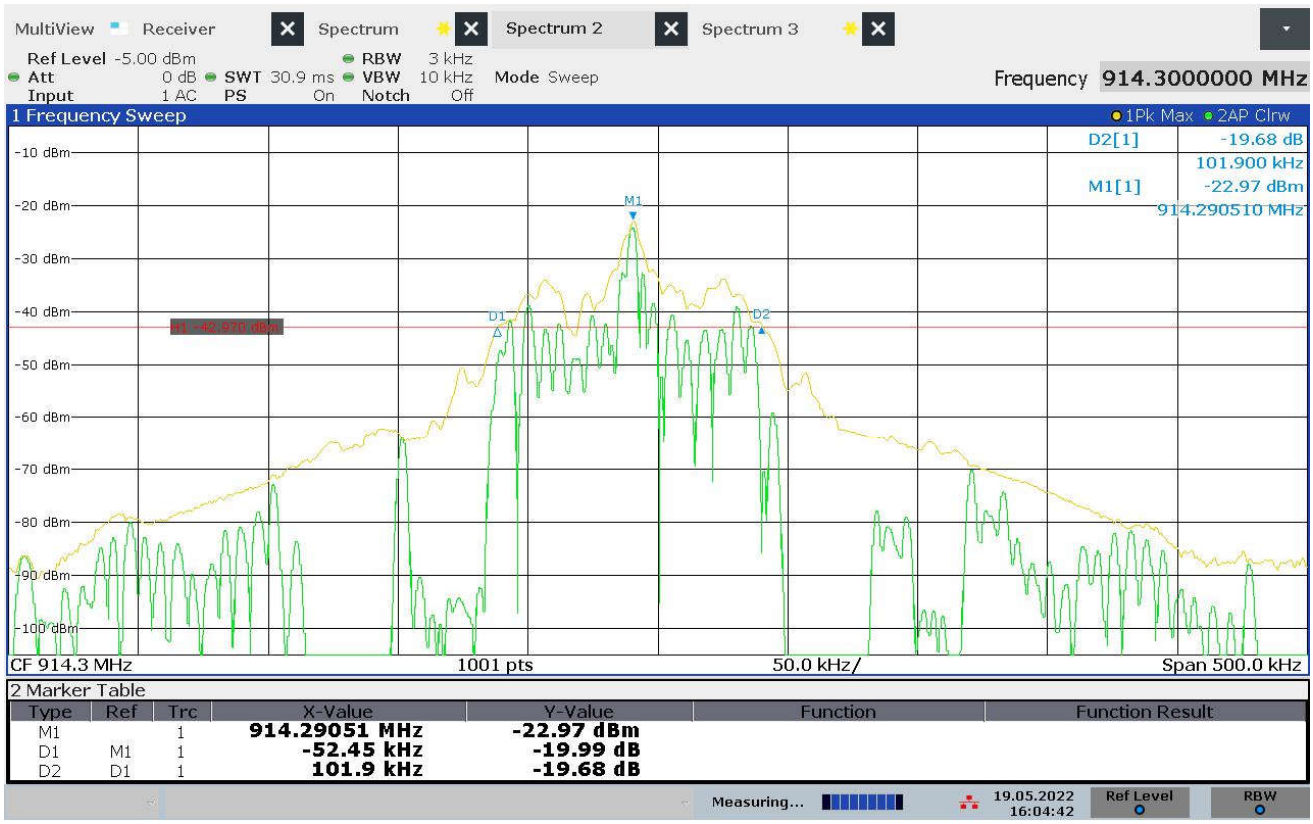
Requirements
Systems using frequency hopping techniques operating in the 902 – 928MHz band are allowed a maximum 20dB bandwidth of 500kHz.

Procedure
The antenna port of the EUT was connected to the spectrum analyzer through 30dB of attenuation. With the hopping function disabled, the EUT was allowed to transmit continuously. The frequency hopping channel was set separately to low, middle, and high hopping channels. The resolution bandwidth (RBW) was set to ≥ 1% of the 20dB BW. The span was set to approximately 2 to 3 times the 20dB bandwidth. The 'Max-Hold' function was engaged. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined. The analyzer's display was then screenshot and saved.

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 902.75MHz
Date Tested	May 19, 2022
Result	20dB BW = 101.65kHz
Notes	

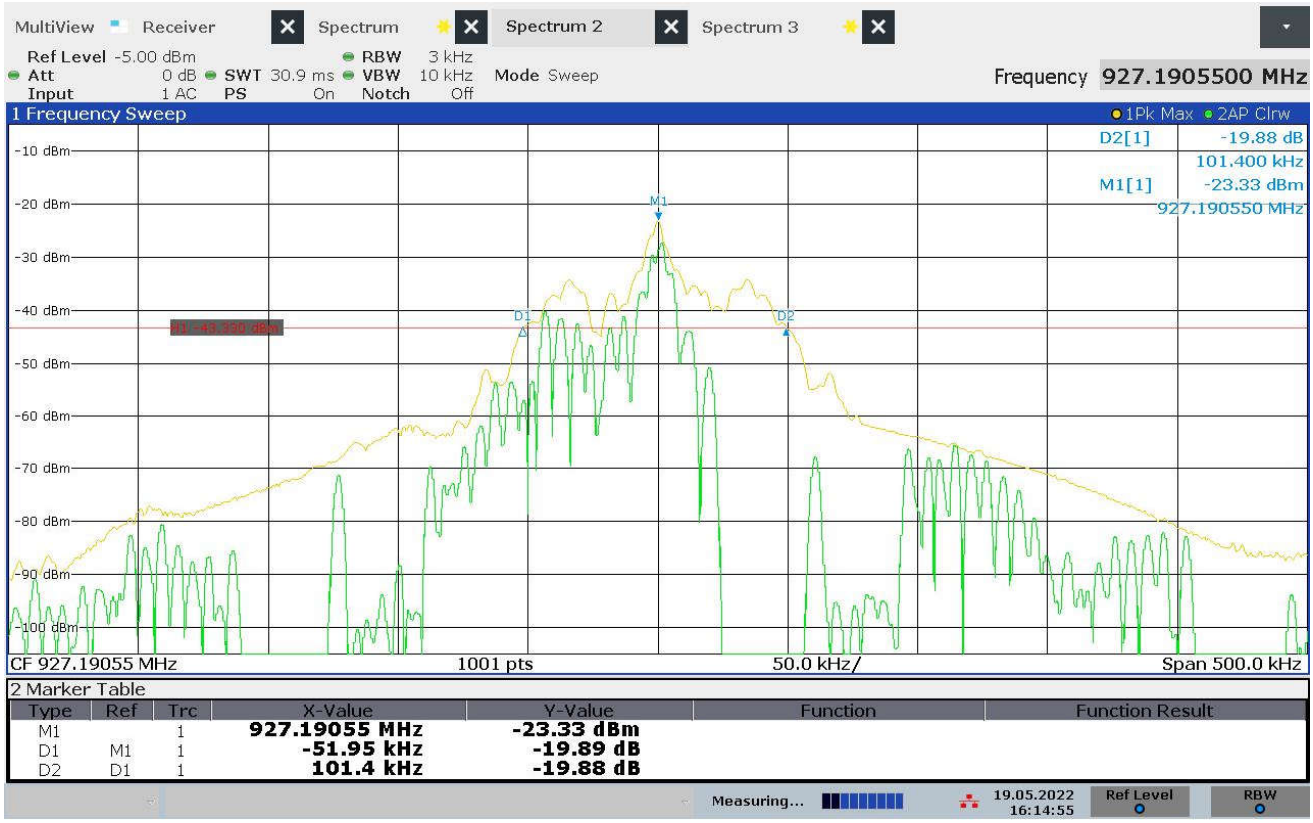
16:19:28 19.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 914.25MHz
Date Tested	May 19, 2022
Result	20dB BW = 101.9kHz
Notes	



16:04:43 19.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 927.25MHz
Date Tested	May 19, 2022
Result	20dB BW = 101.4kHz
Notes	



16:14:56 19.05.2022

22. Occupied Bandwidth (99%)

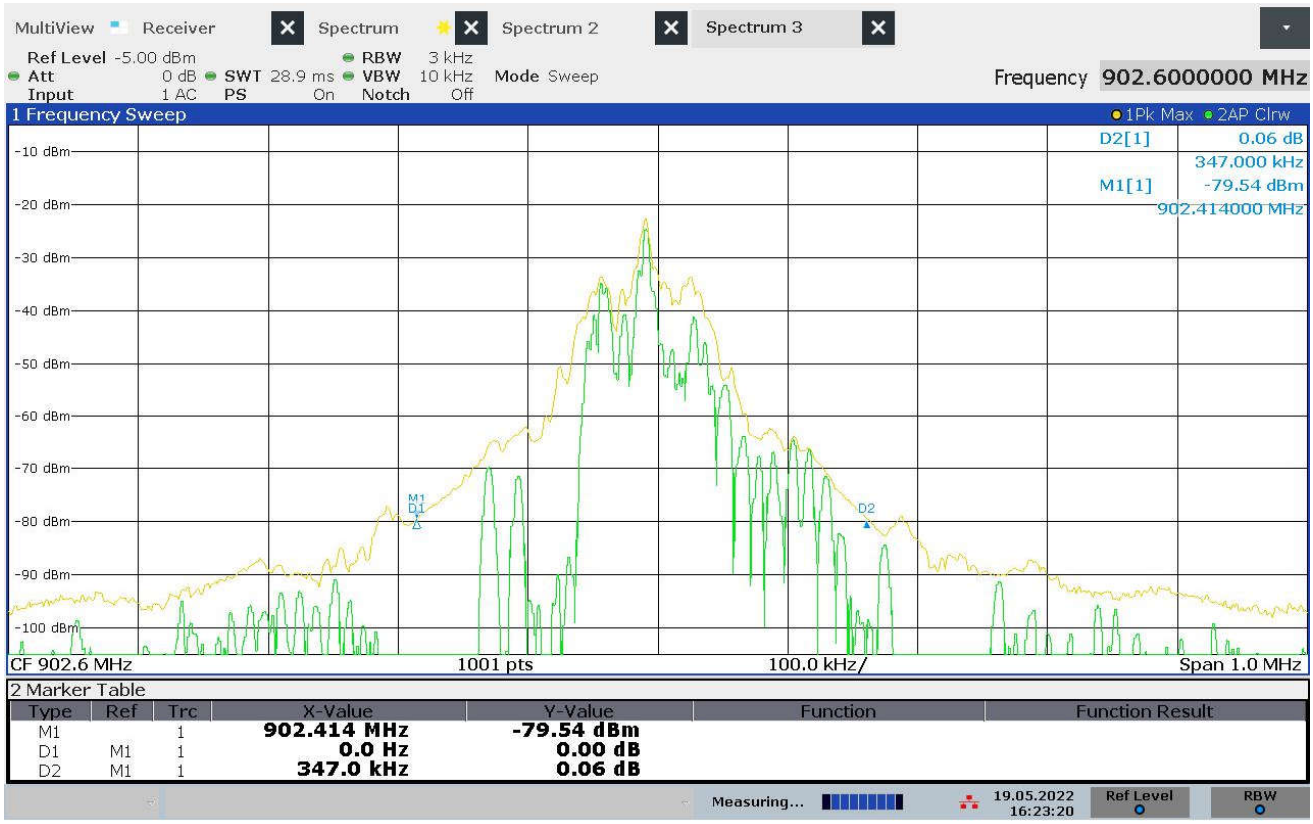
EUT Information	
Manufacturer	Fastenal
Product	RFID Reader
Model No.	922194627
Mode	Transmit at 902.75MHz Transmit at 914.25MHz Transmit at 927.25MHz

Test Setup Details	
Setup Format	Tabletop
Height of Support (For Floor Standing only)	N/A
Measurement Method	Antenna Conducted
Type of Test Site	Tabletop
Test Site Used	N/A
Notes	

Measurement Uncertainty	
Measurement Type	Expanded Measurement Uncertainty
Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1000 MHz)	4.3
Radiated disturbance (electric field strength on an open area test site or alternative test site) (1 GHz – 6 GHz)	3.1

Procedure
The antenna port of the EUT was connected to the spectrum analyzer through 30dB of attenuation. The EUT was allowed to transmit continuously. The transmit channel was set separately to low, middle, and high channels. The resolution bandwidth (RBW) was set to 1% to 5% of the actual occupied / x dB bandwidth, the video bandwidth (VBW) was set 3 times greater than the RBW, and the span was set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency. The 99% bandwidth function on the spectrum analyzer was utilized. The 'Max-Hold' function was engaged. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined. The analyzer's display was plotted using a 'screen dump' utility.

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 902.75MHz
Date Tested	May 19, 2022
Result	OBW = 347kHz
Notes	

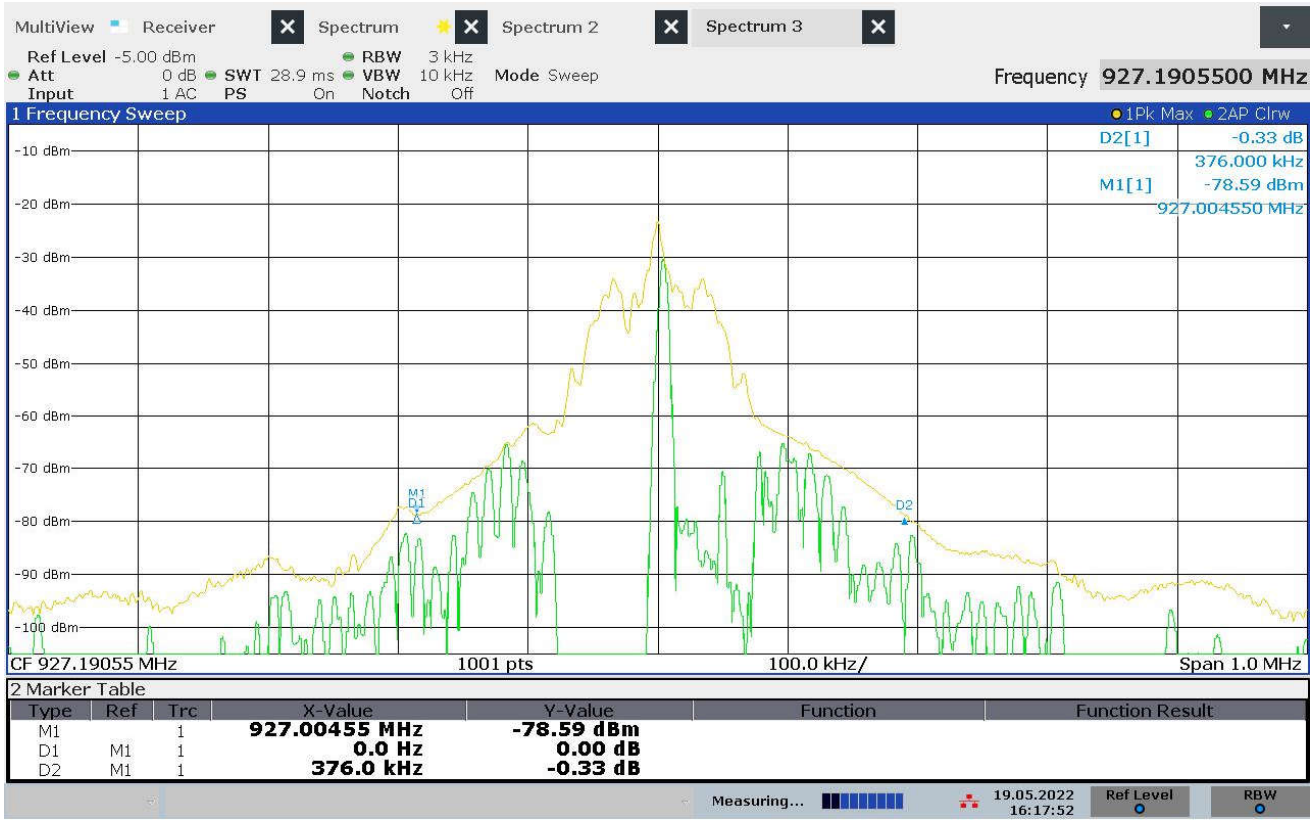


16:23:21 19.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 914.25MHz
Date Tested	May 19, 2022
Result	OBW = 357kHz
Notes	

16:08:59 19.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 927.25MHz
Date Tested	May 19, 2022
Result	OBW = 376kHz
Notes	



16:17:52 19.05.2022

23. Carrier Frequency Separation

EUT Information	
Manufacturer	Fastenal
Product	RFID Reader
Model No.	922194627
Mode	Hopping

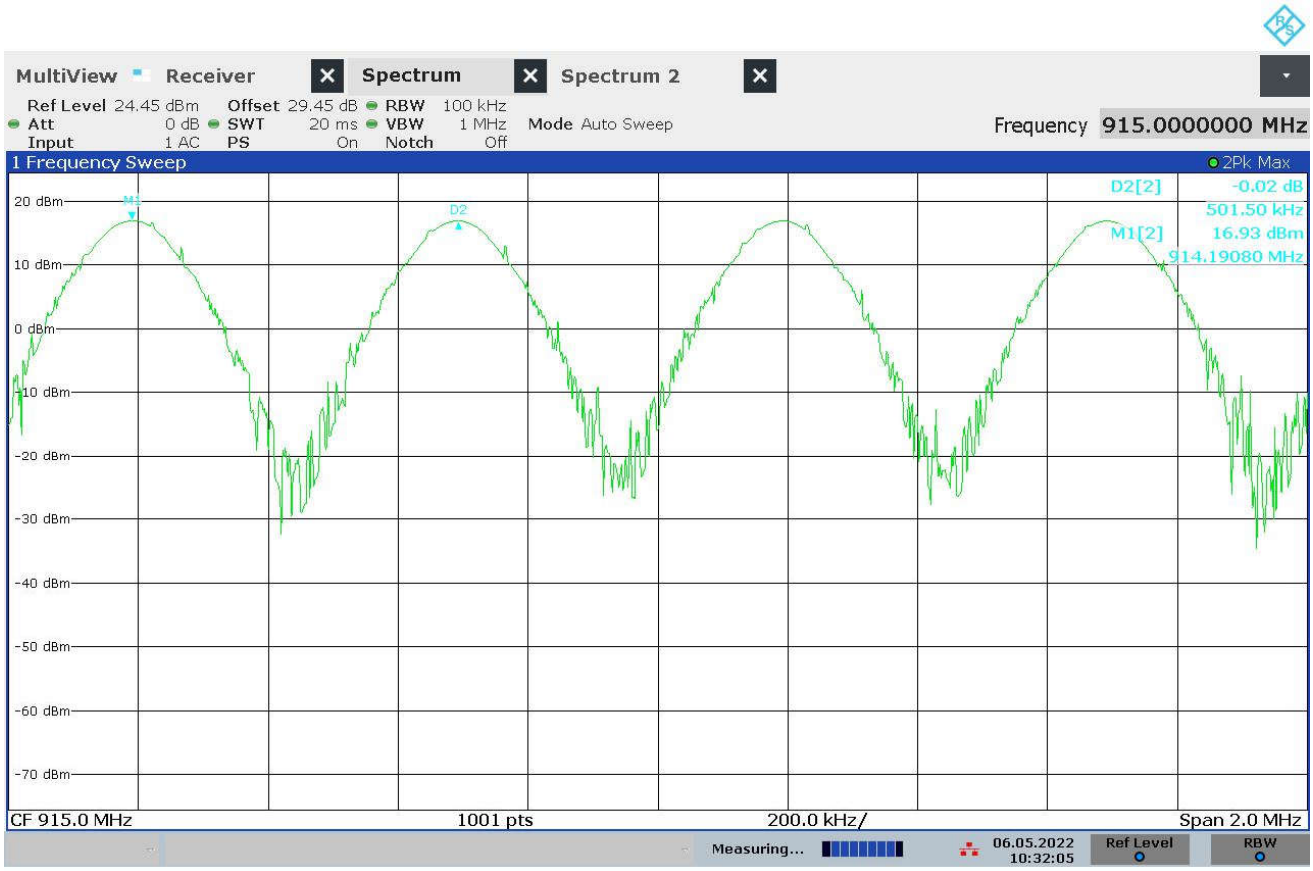
Test Setup Details	
Setup Format	Tabletop
Height of Support (For Floor Standing only)	N/A
Measurement Method	Antenna Conducted
Type of Test Site	Tabletop
Test Site Used	N/A
Notes	

Measurement Uncertainty	
Measurement Type	Expanded Measurement Uncertainty
Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1000 MHz)	4.3
Radiated disturbance (electric field strength on an open area test site or alternative test site) (1 GHz – 6 GHz)	3.1

Requirement
Channel carrier frequencies shall be separated by a minimum of 25kHz or the 20dB bandwidth, whichever is greater.

Procedure
The antenna port of the EUT was connected to the spectrum analyzer through 30dB of attenuation. With the hopping function enabled, the EUT was allowed to transmit continuously. Span was set wide enough to capture the peaks of two adjacent channels. The resolution bandwidth was set to approximately 30% of the channel spacing. The peak detector and 'Max-Hold' function were engaged. The span was set wide enough to capture the peaks of at least two adjacent channels. When the trace had stabilized after multiple scans, the marker-delta function was used to determine the separation between the peaks of the adjacent channels. The analyzer's display was plotted using a 'screen dump' utility.

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Hopping
Date Tested	May 6, 2022
Result	Carrier Frequency Separation = 501.5kHz
Notes	



10:32:05 06.05.2022

24. Number of Carrier Channels

EUT Information	
Manufacturer	Fastenal
Product	RFID Reader
Model No.	922194627
Mode	Hopping

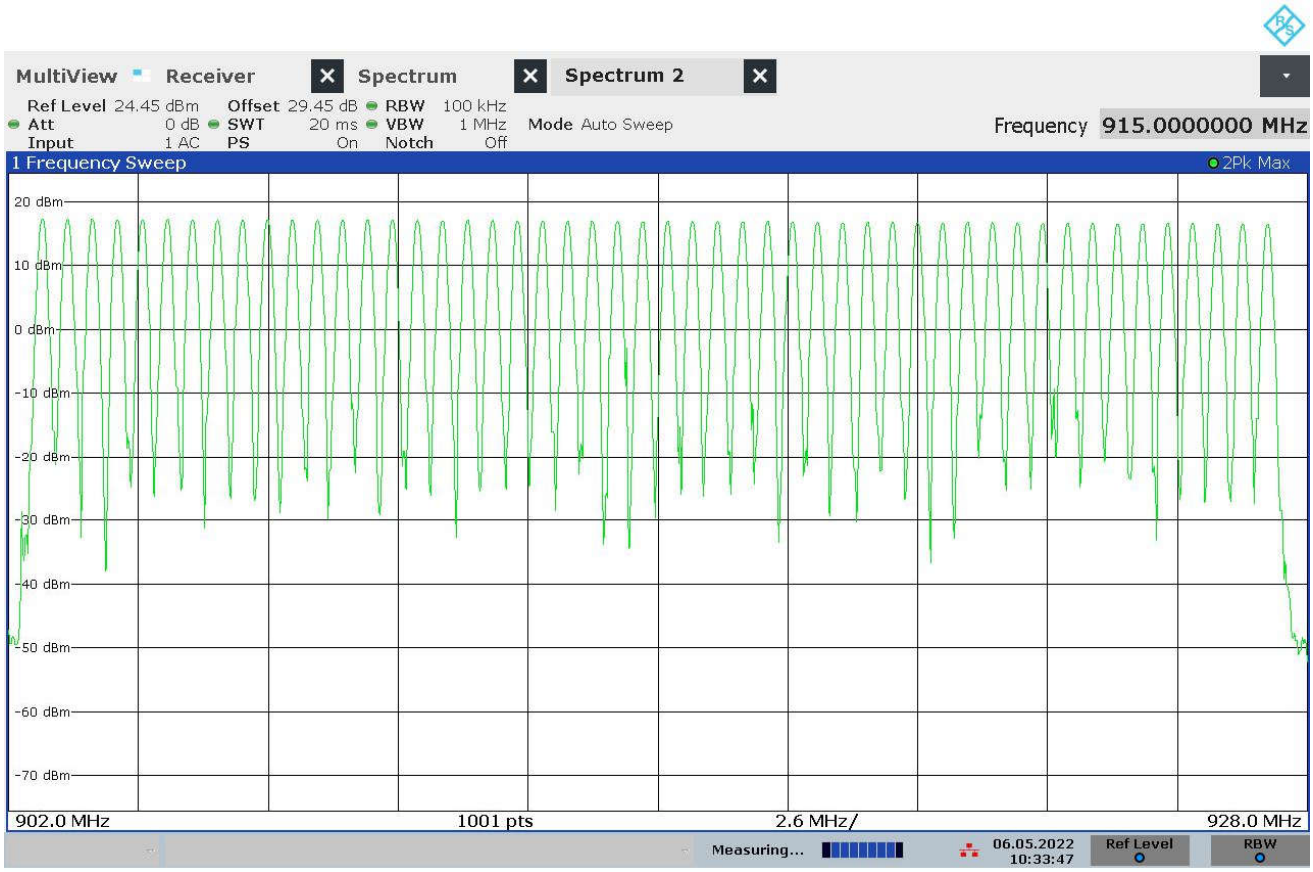
Test Setup Details	
Setup Format	Tabletop
Height of Support (For Floor Standing only)	N/A
Measurement Method	Antenna Conducted
Type of Test Site	Tabletop
Test Site Used	N/A
Notes	

Measurement Uncertainty	
Measurement Type	Expanded Measurement Uncertainty
Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1000 MHz)	4.3
Radiated disturbance (electric field strength on an open area test site or alternative test site) (1 GHz – 6 GHz)	3.1

Requirements
For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies

Procedure
The antenna port of the EUT was connected to the spectrum analyzer through 30dB of attenuation. With the hopping function enabled, the EUT was allowed to transmit continuously. The resolution bandwidth (RBW) was set to less than 30% of the channel spacing or the 20dB bandwidth, whichever is smaller. The peak detector and 'Max-Hold' function were engaged. The span was set wide enough to capture the entire frequency band of operation. The EUT's signal was allowed to stabilize after multiple scans. The number of hopping frequencies was counted. The analyzer's display was plotted using a 'screen dump' utility.

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Hopping
Date Tested	May 6, 2022
Result	Number of Hopping Frequencies = 50
Notes	



10:33:48 06.05.2022

25. Average Time of Occupancy

EUT Information	
Manufacturer	Fastenal
Product	RFID Reader
Model No.	922194627
Mode	Hopping

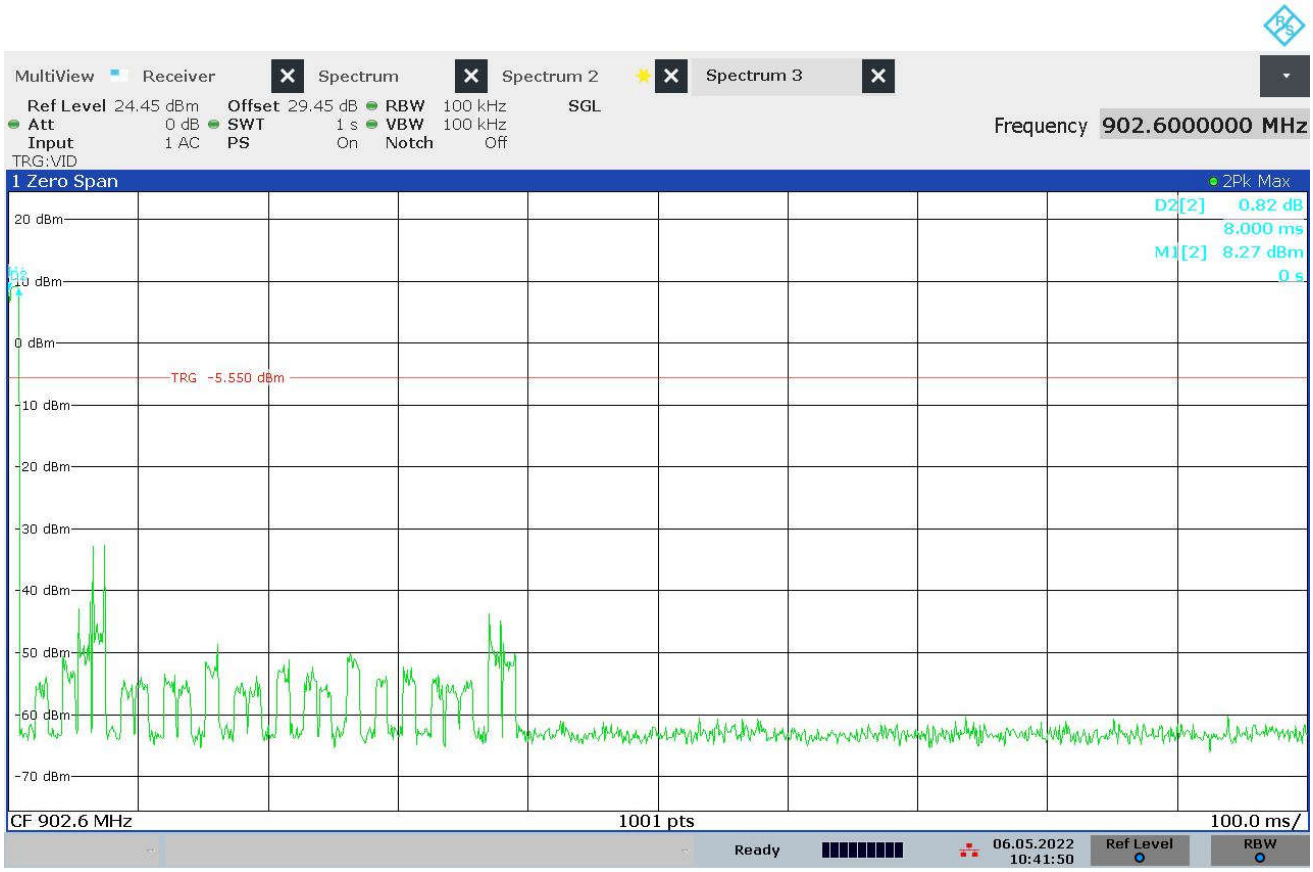
Test Setup Details	
Setup Format	Tabletop
Height of Support (For Floor Standing only)	N/A
Measurement Method	Antenna Conducted
Type of Test Site	Tabletop
Test Site Used	N/A
Notes	

Measurement Uncertainty	
Measurement Type	Expanded Measurement Uncertainty
Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1000 MHz)	4.3
Radiated disturbance (electric field strength on an open area test site or alternative test site) (1 GHz – 6 GHz)	3.1

Requirements
For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period.

Procedure
The antenna port of the EUT was connected to the spectrum analyzer through 30dB of attenuation. With the hopping function enabled, the EUT was allowed to transmit continuously. The spectrum analyzer was set to zero span centered on a hopping channel. The resolution bandwidth (RBW) was set ≥ to the channel spacing. The sweep time was set to 1 sec to capture the duration of each pulse transmission. The analyzer's display was plotted using a 'screen dump' utility. Next the sweep time was increased to 20 sec and the number of times the EUT transmitted on that channel in a 20 second period was counted. The analyzer's display was plotted using a 'screen dump' utility. The average time of occupancy was calculated by multiplying the duration of each pulse by the number of times the EUT transmits on the channel in a 20 second period.

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Hopping
Date Tested	May 6, 2022
Result	Pulse width = 8msec
Notes	



10:41:50 06.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Hopping
Date Tested	May 6, 2022
Result	Number of times the EUT transmit on channel in a 20 second period = 4
Notes	Average time of occupancy = (pulse width) x (# times the EUT transmits on channel) Average time of occupancy = 8 msec x 4 = 32msec

10:42:56 06.05.2022

26. Maximum Peak Conducted Output Power

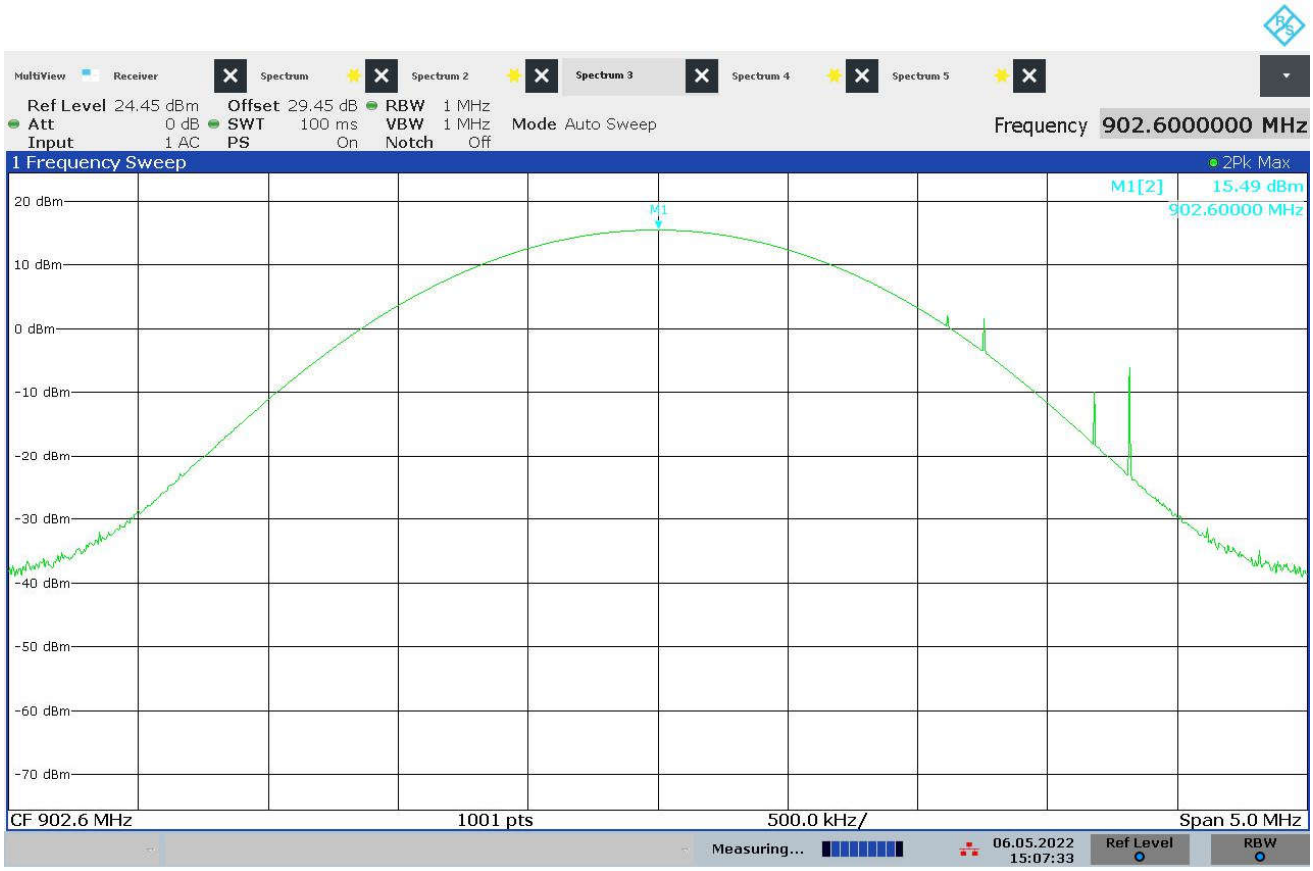
EUT Information	
Manufacturer	Fastenal
Product	RFID Reader
Model No.	922194627
Mode	Transmit at 902.75MHz Transmit at 914.25MHz Transmit at 927.25MHz

Test Setup Details	
Setup Format	Tabletop
Height of Support (For Floor Standing only)	N/A
Measurement Method	Antenna Conducted
Type of Test Site	Tabletop
Test Site Used	N/A
Notes	

Requirements
The maximum peak conducted output power for frequency hopping systems operating in the 902-928 MHz band and employing at least 50 hopping channels shall not exceed 1 watt.

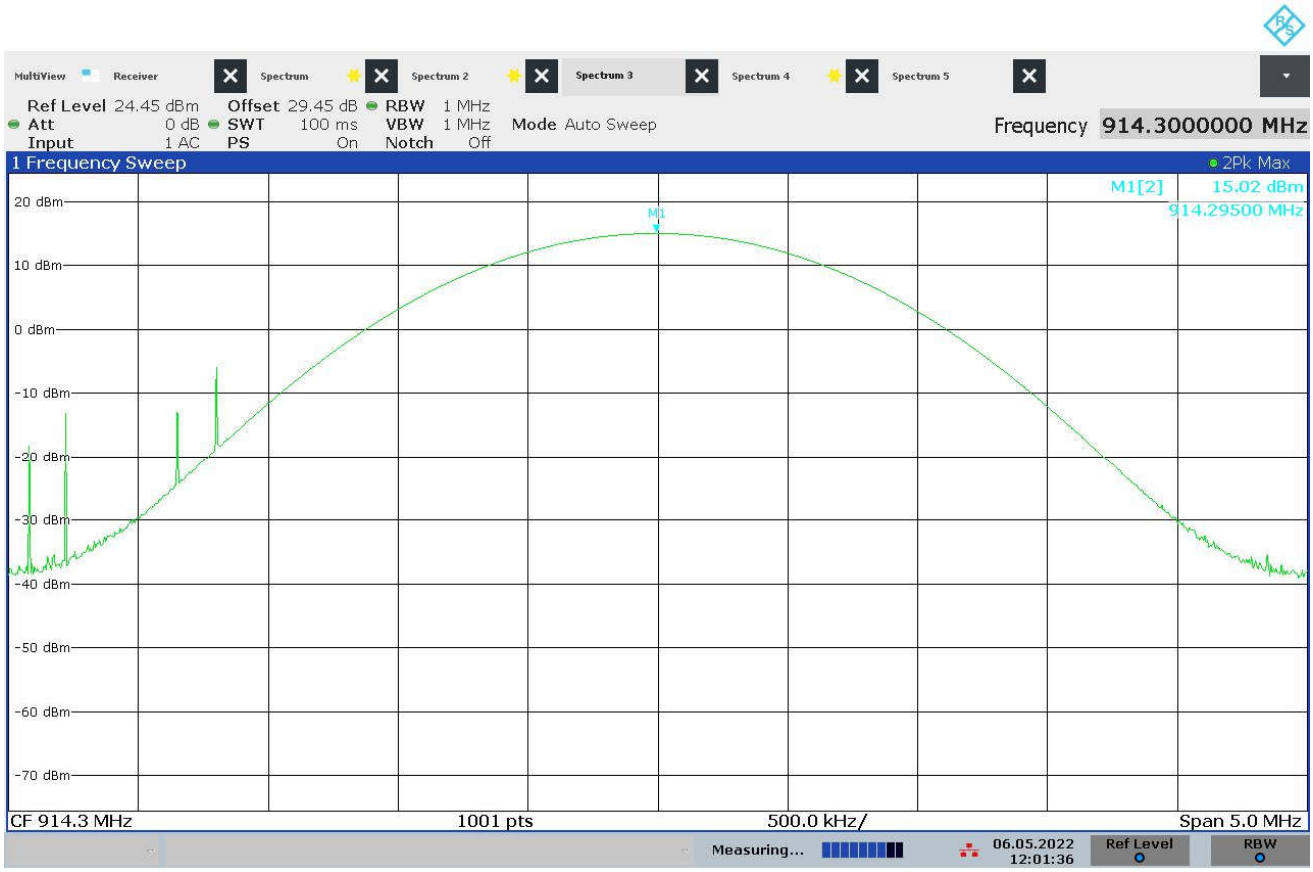
Procedure
The antenna port of the EUT was connected to the spectrum analyzer through 30dB of attenuation. With the hopping function disabled, the EUT was allowed to transmit continuously. The frequency hopping channel was set separately to low, middle, and high hopping channels. The resolution bandwidth (RBW) was set to greater than the 20dB bandwidth. The span was set to approximately 5 times the 20dB bandwidth. The 'Max-Hold' function was engaged. The maximum meter reading was recorded. The peak power output was calculated for the low, middle, and high hopping frequencies.

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 902.75MHz
Date Tested	May 6, 2022
Result	Output Power = 0.035W (15.49dBm)
Notes	Antenna 1



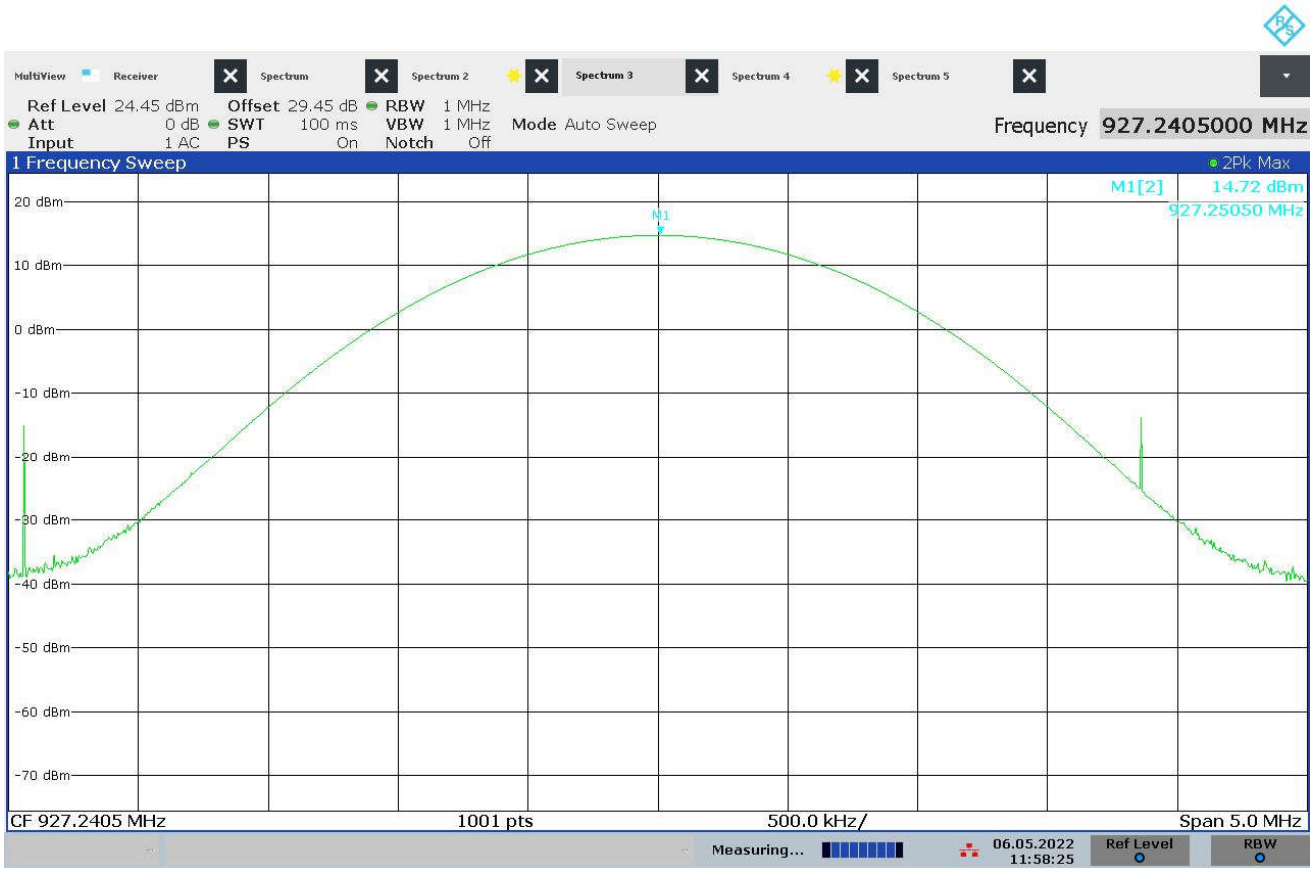
15:07:33 06.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 914.25MHz
Date Tested	May 6, 2022
Result	Output Power = 0.0318W (15.02dBm)
Notes	Antenna 1



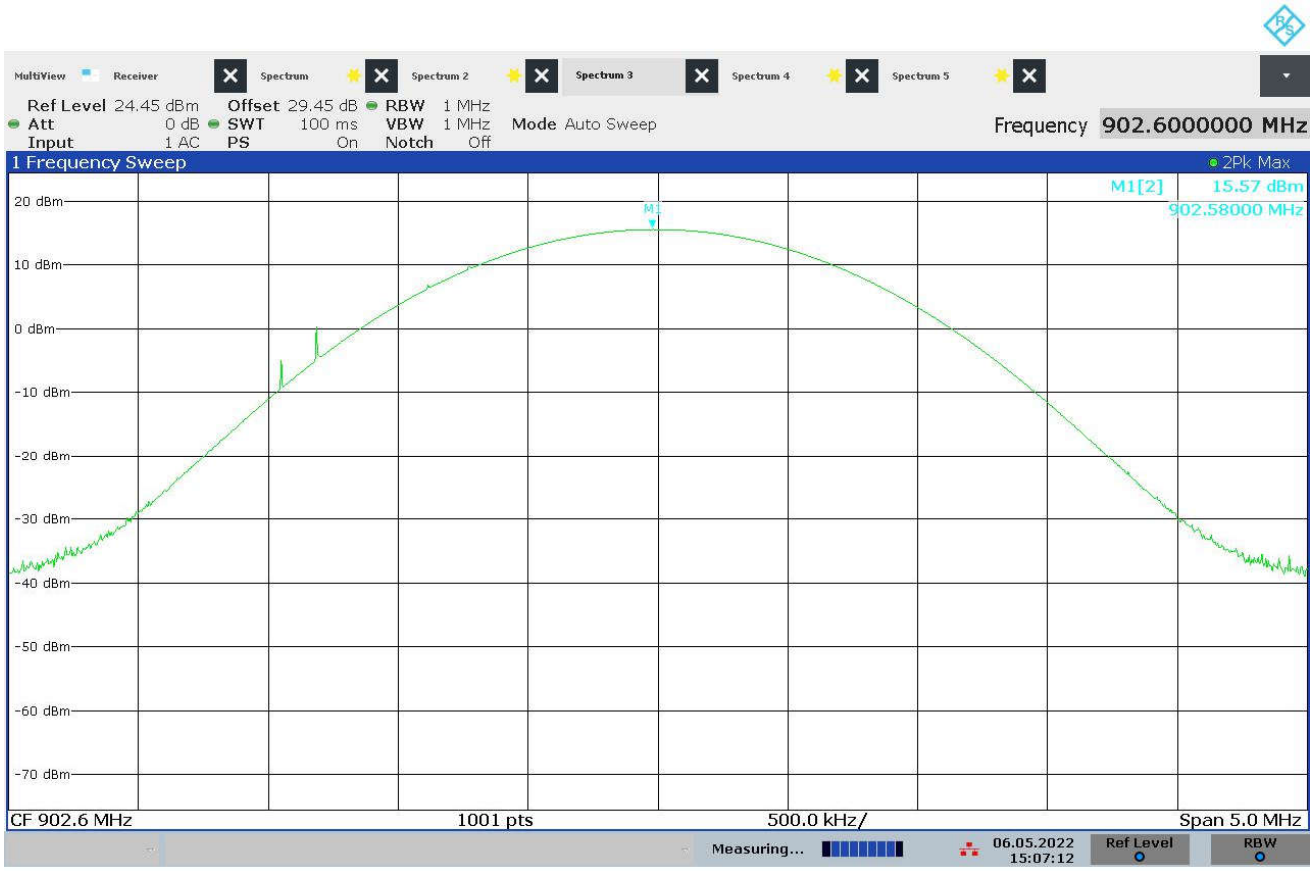
12:01:37 06.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 927.25MHz
Date Tested	May 6, 2022
Result	Output Power = 0.0296W (14.72dBm)
Notes	Antenna 1



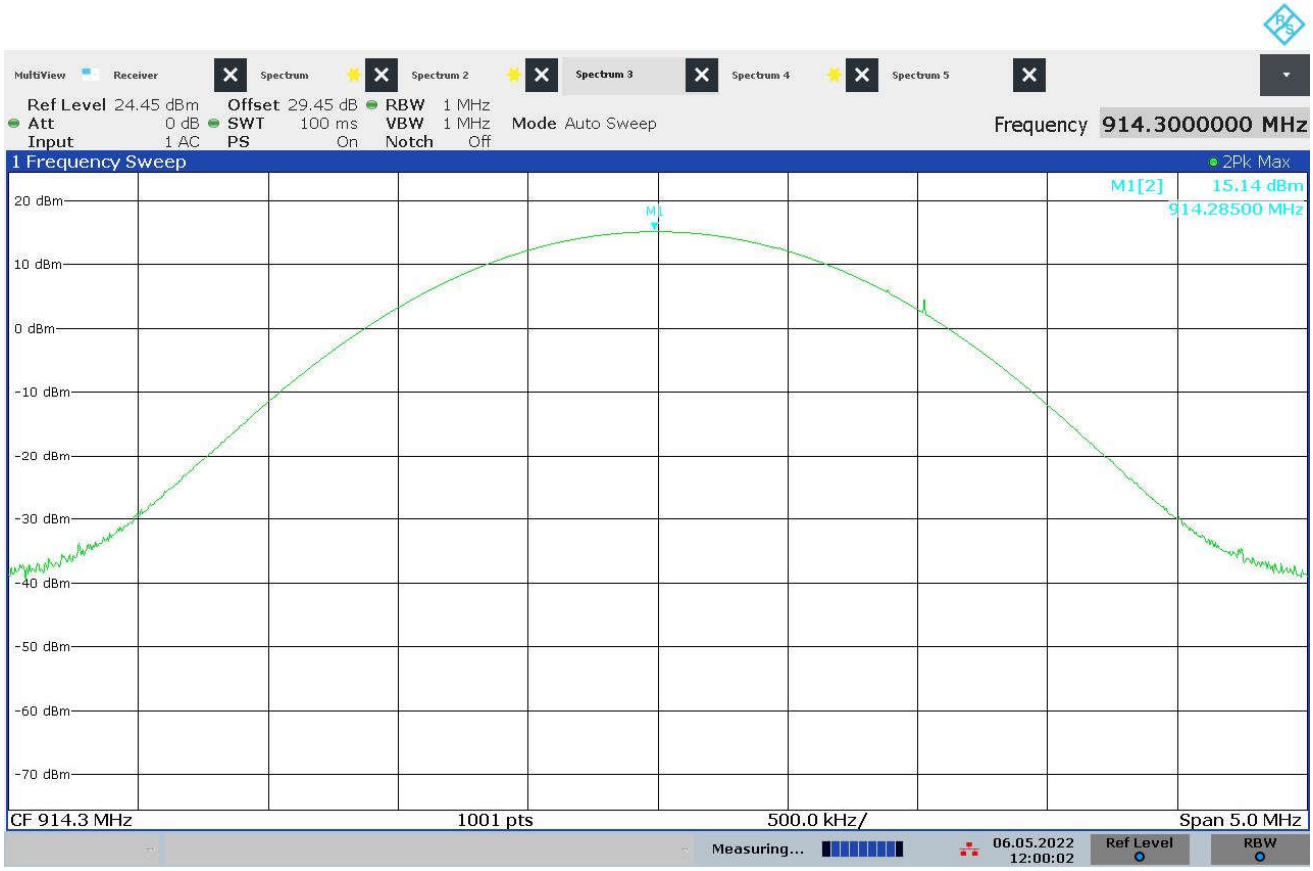
11:58:26 06.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 902.75MHz
Date Tested	May 6, 2022
Result	Output Power = 0.036W (15.57dBm)
Notes	Antenna 2



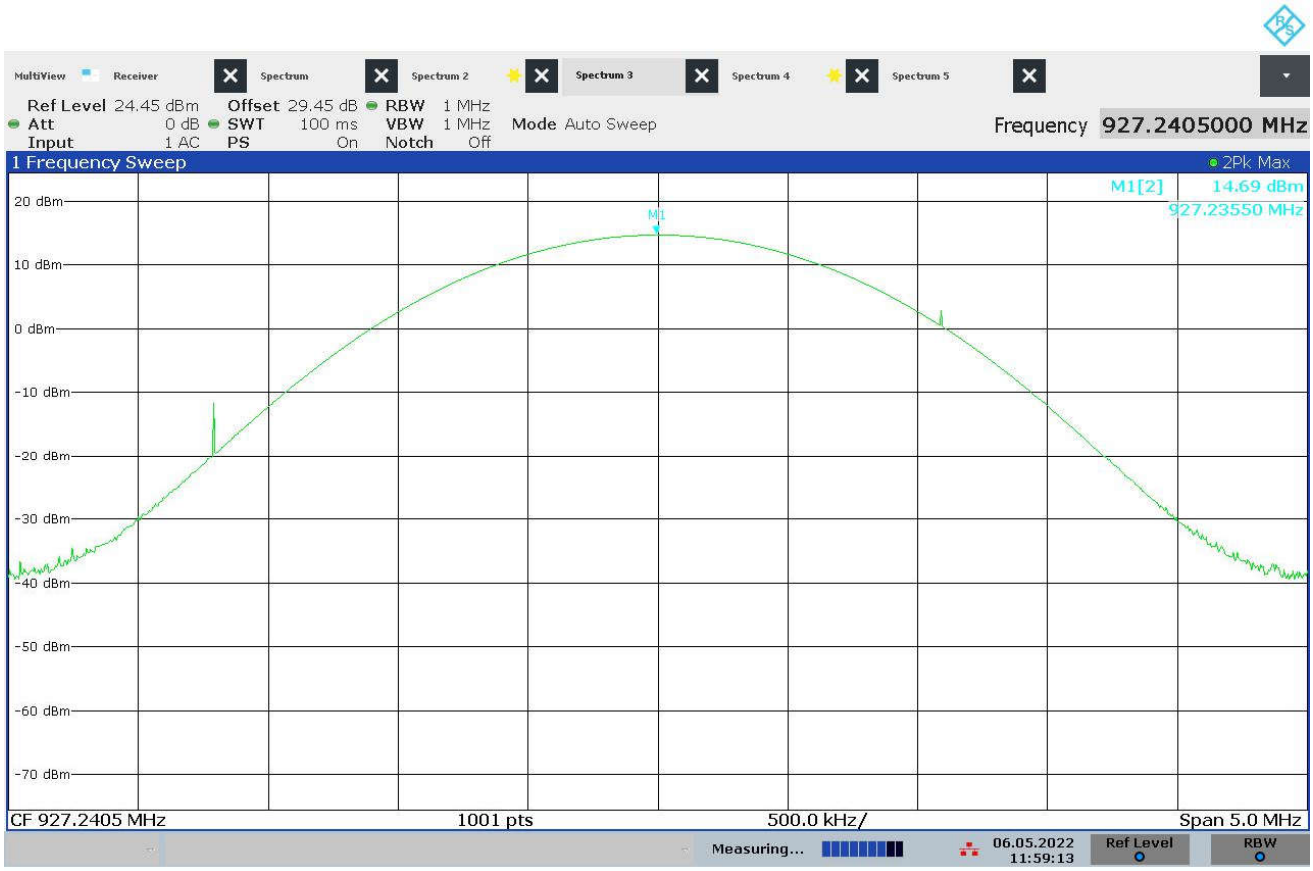
15:07:12 06.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 914.25MHz
Date Tested	May 6, 2022
Result	Output Power = 0.033W (15.14dBm)
Notes	Antenna 2



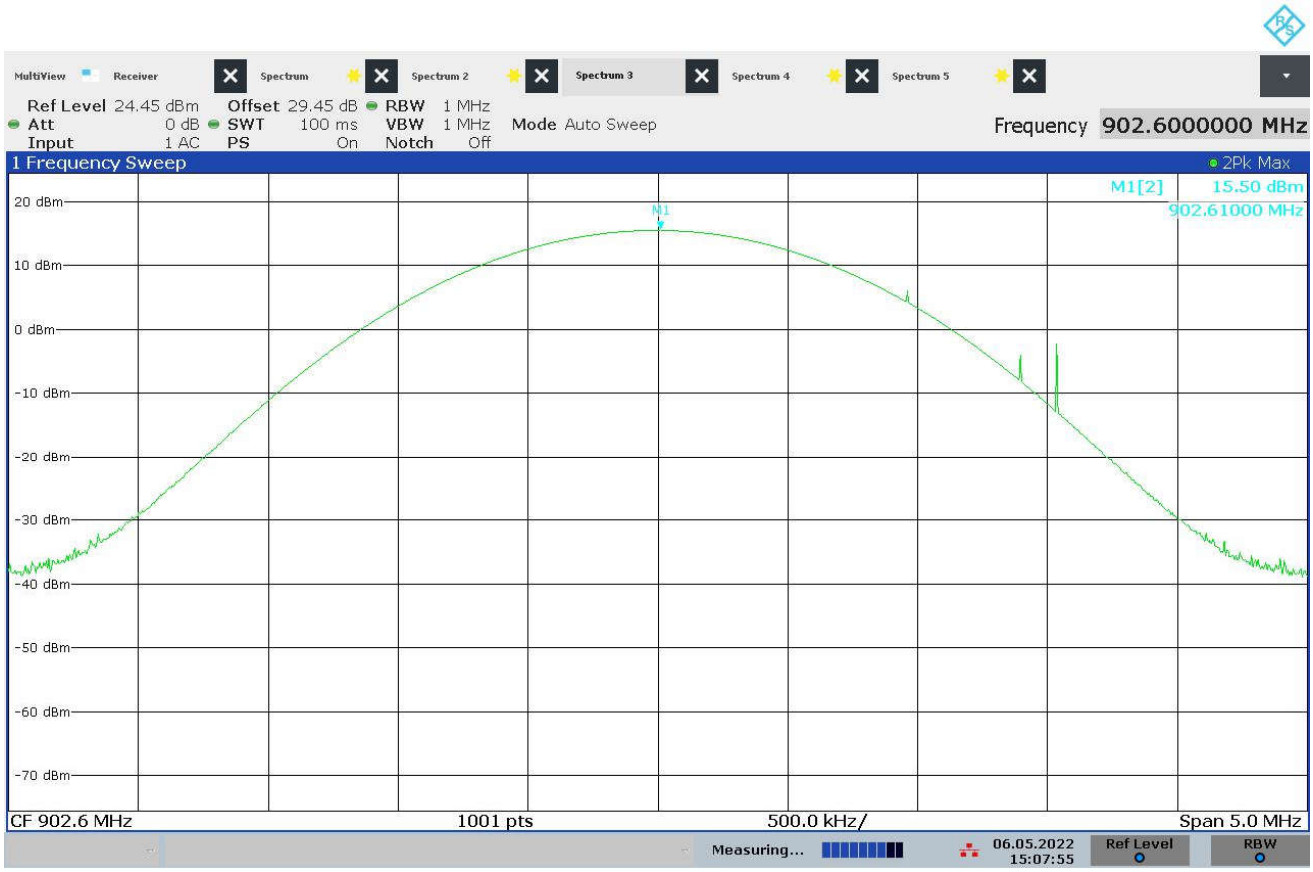
12:00:03 06.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 927.25MHz
Date Tested	May 6, 2022
Result	Output Power = 0.029W (14.69dBm)
Notes	Antenna 2



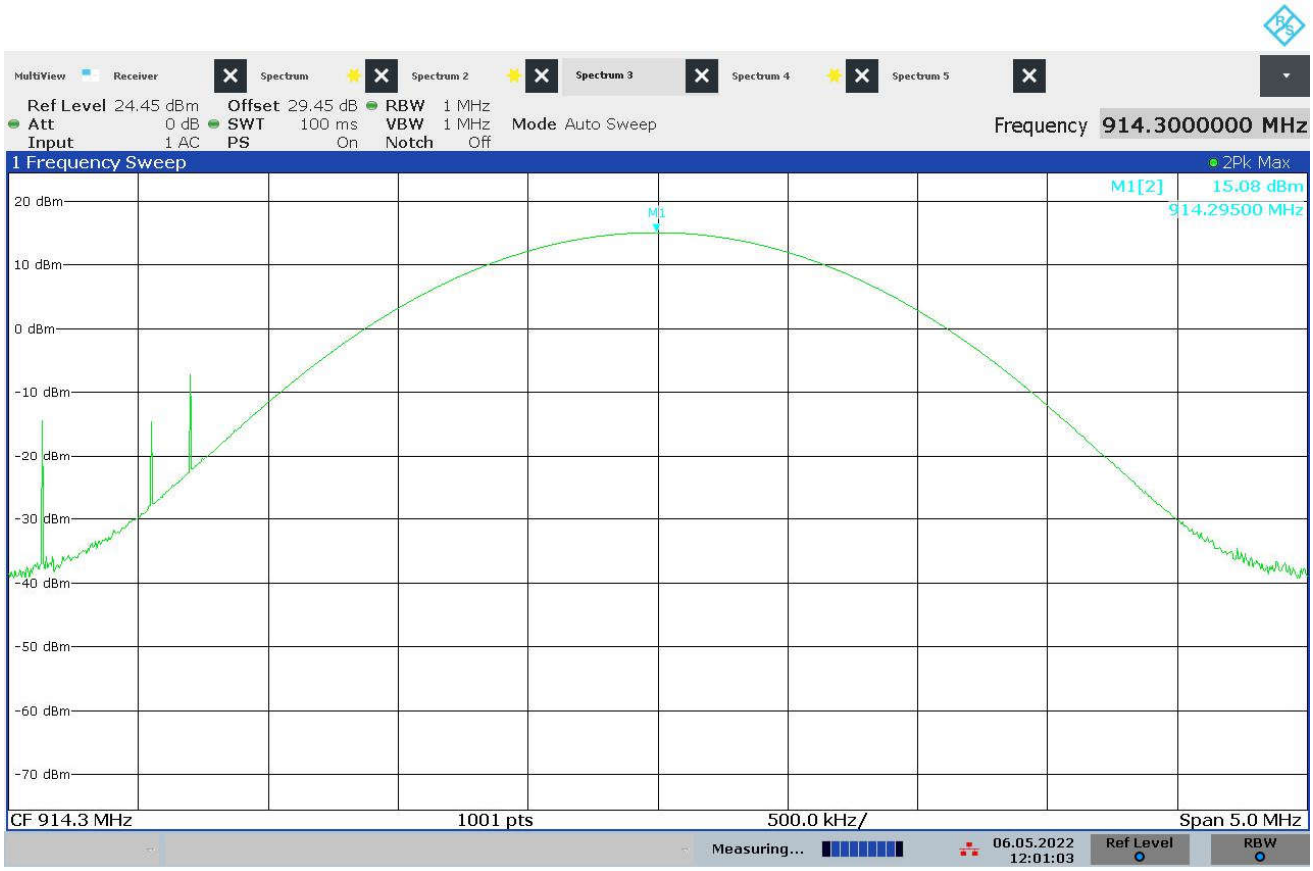
11:59:13 06.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 902.75MHz
Date Tested	May 6, 2022
Result	Output Power = 0.035W (15.5dBm)
Notes	Antenna 3



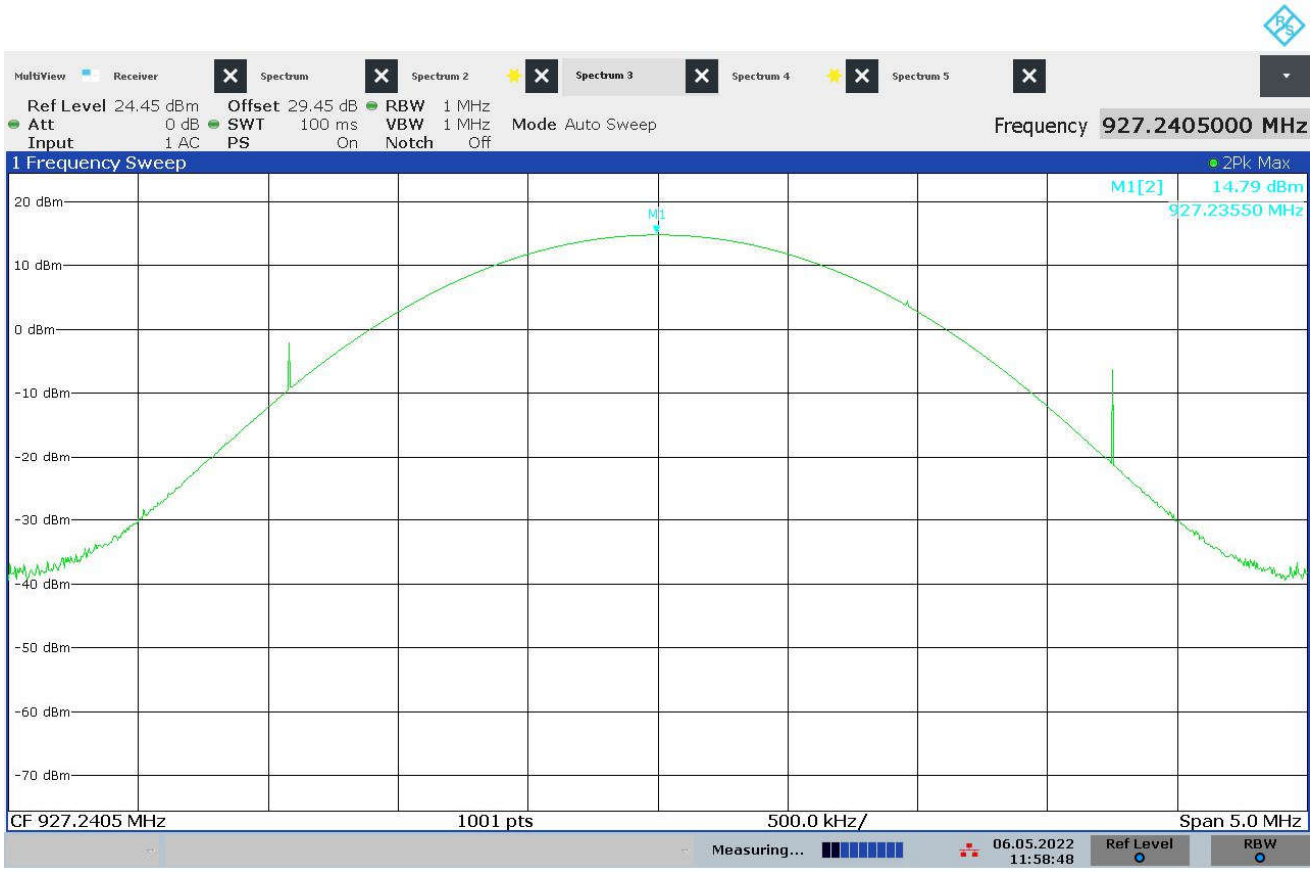
15:07:56 06.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 914.25MHz
Date Tested	May 6, 2022
Result	Output Power = 0.032W (15.08dBm)
Notes	Antenna 3



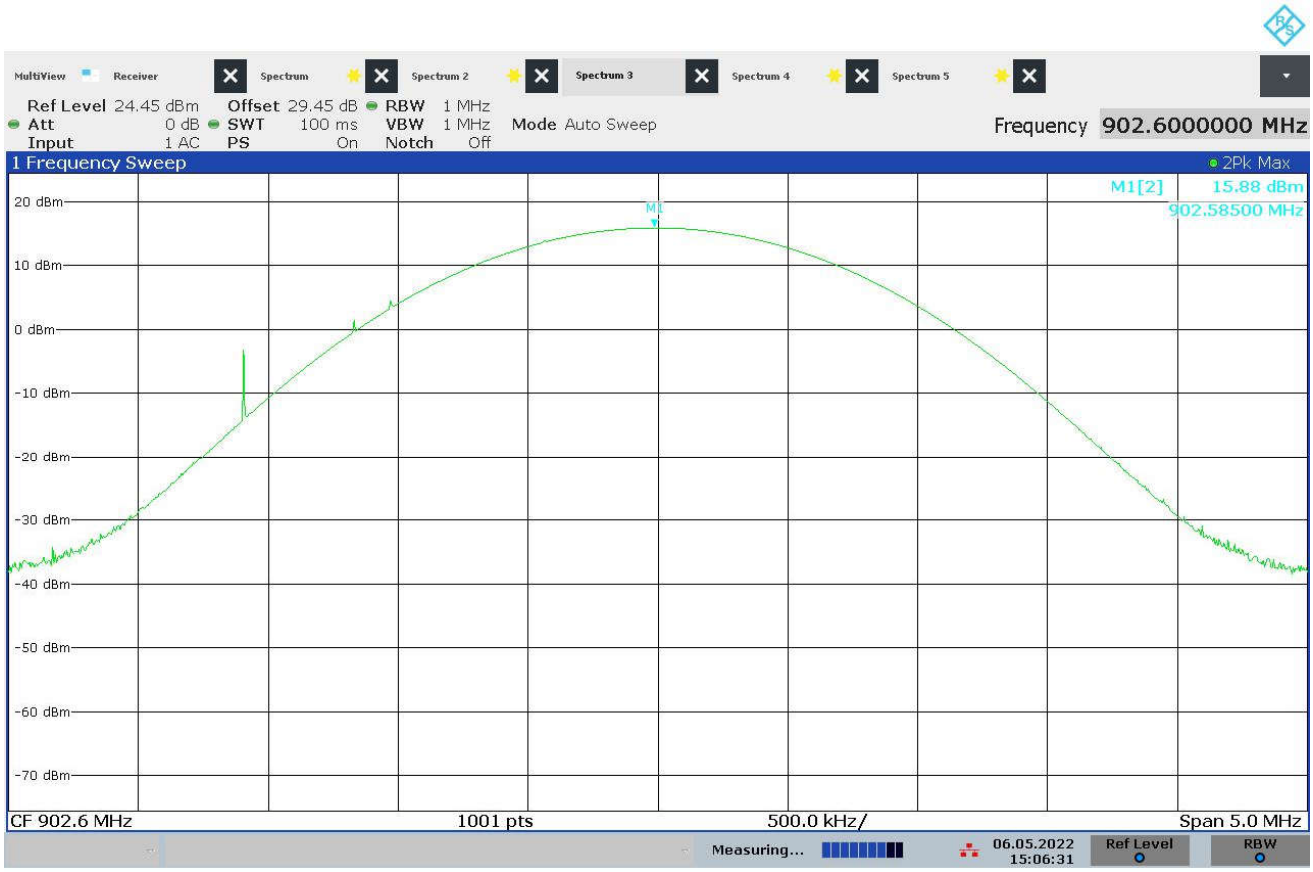
12:01:04 06.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 927.25MHz
Date Tested	May 6, 2022
Result	Output Power = 0.030W (14.79dBm)
Notes	Antenna 3



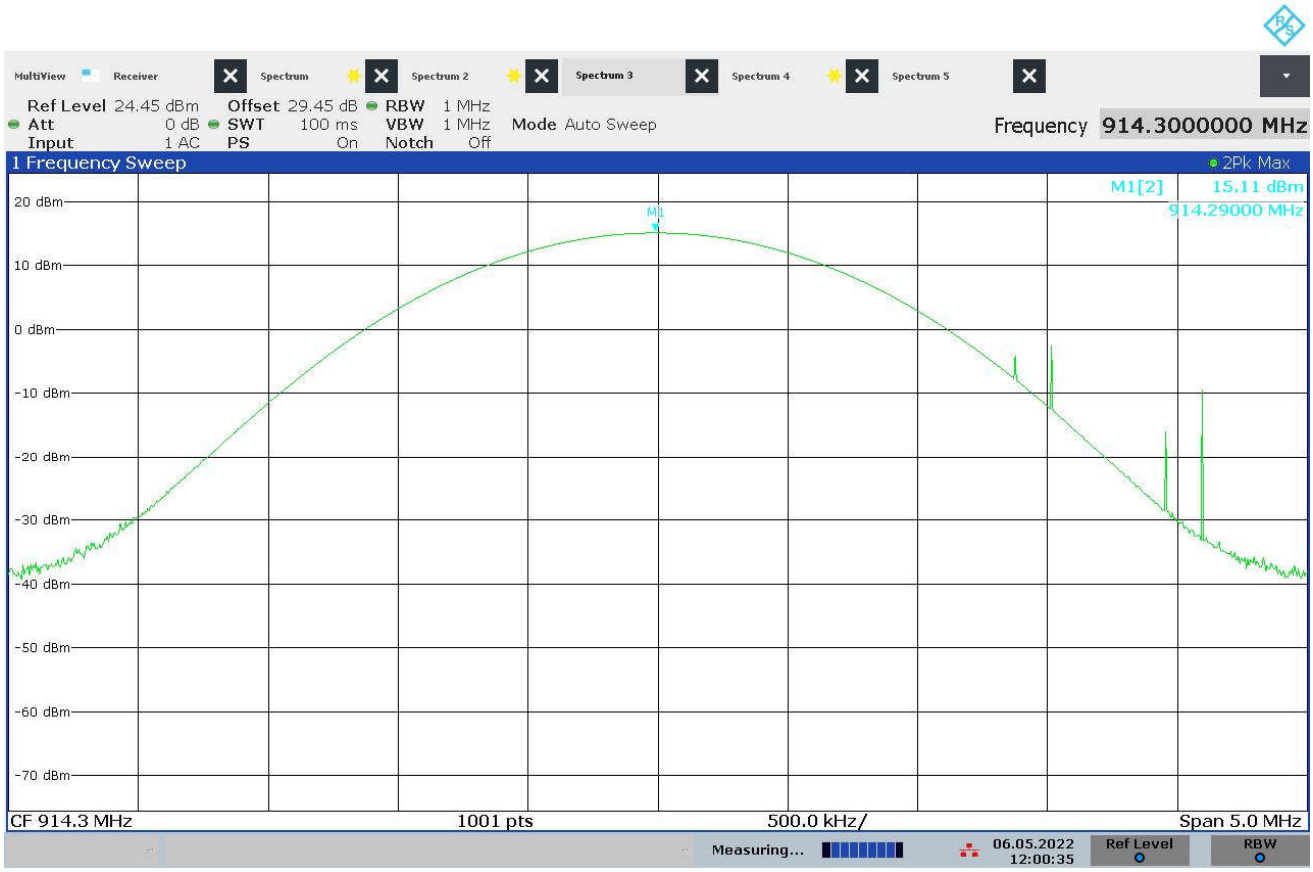
11:58:49 06.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 902.75MHz
Date Tested	May 6, 2022
Result	Output Power = 0.0387W (15.88dBm)
Notes	Antenna 4



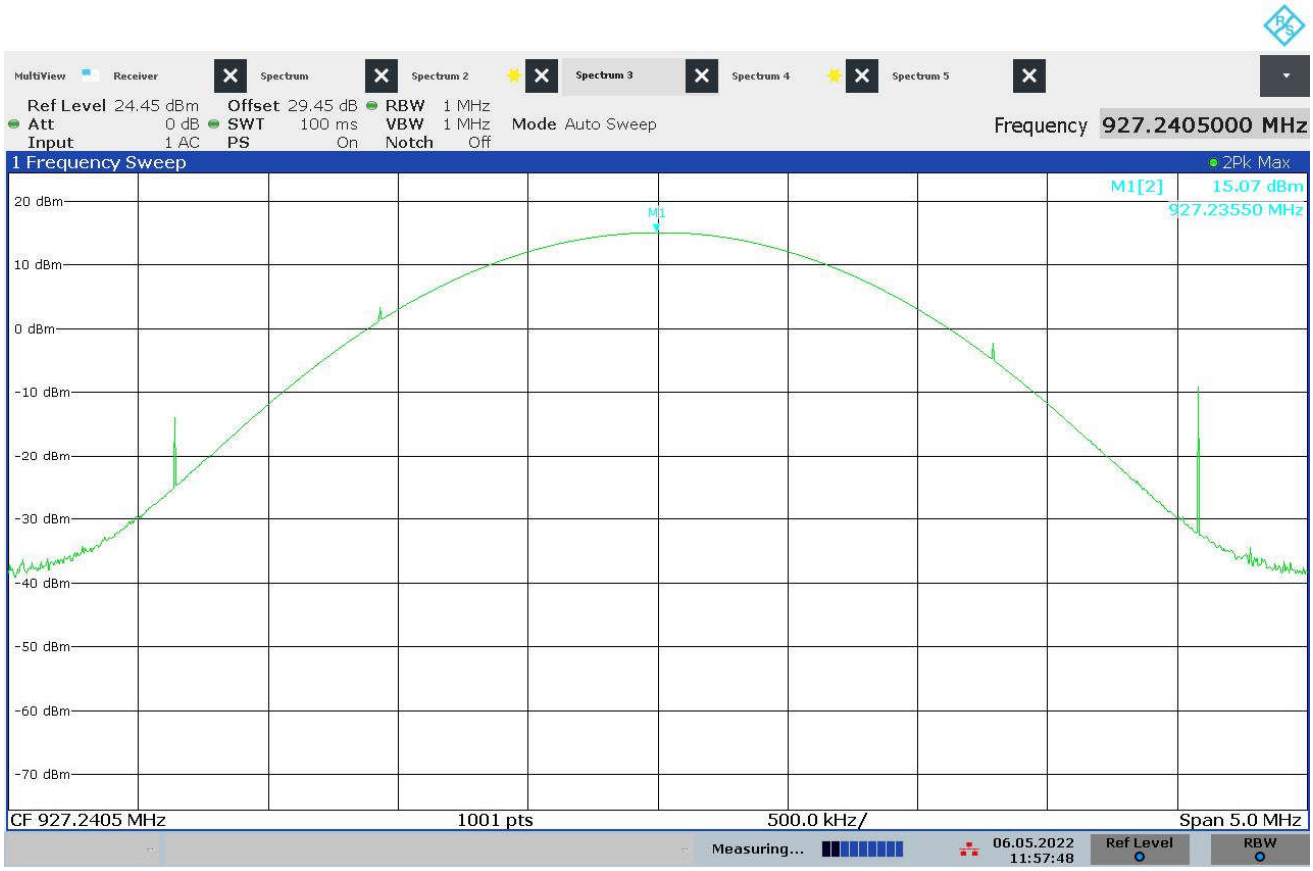
15:06:32 06.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 914.25MHz
Date Tested	May 6, 2022
Result	Output Power = 0.0324W (15.11dBm)
Notes	Antenna 4



12:00:35 06.05.2022

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 927.25MHz
Date Tested	May 6, 2022
Result	Output Power = 0.0321W (15.07dBm)
Notes	Antenna 4



11:57:48 06.05.2022

27. Effective Isotropic Radiated Power (EIRP)

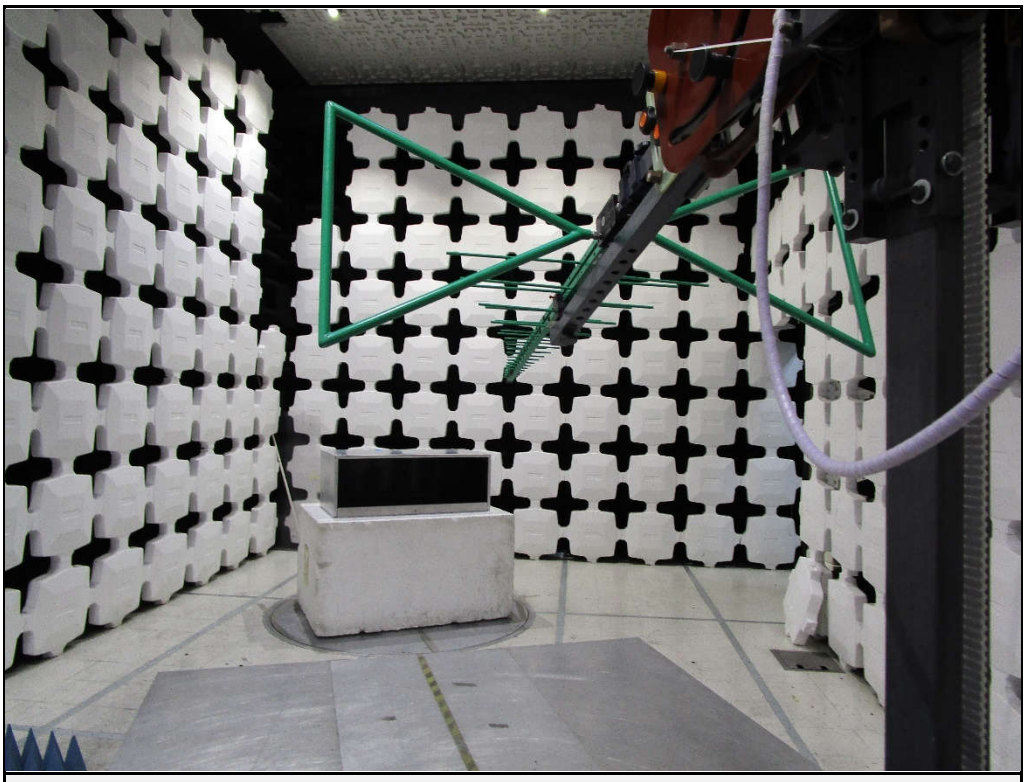
EUT Information	
Manufacturer	Fastenal
Product	RFID Reader
Model No.	922194627
Mode	Transmit at 902.75MHz Transmit at 914.25MHz Transmit at 927.25MHz

Test Setup Details	
Setup Format	Tabletop
Height of Support (For Floor Standing only)	N/A
Measurement Method	Radiated
Type of Test Site	Semi-Anechoic Chamber
Test Site Used	Room 29
Type of Antennas Used	Below 1GHz: Bilog (or equivalent) Above 1GHz: Double-ridged waveguide (or equivalent)
Notes	new (final) transmit antenna orientation

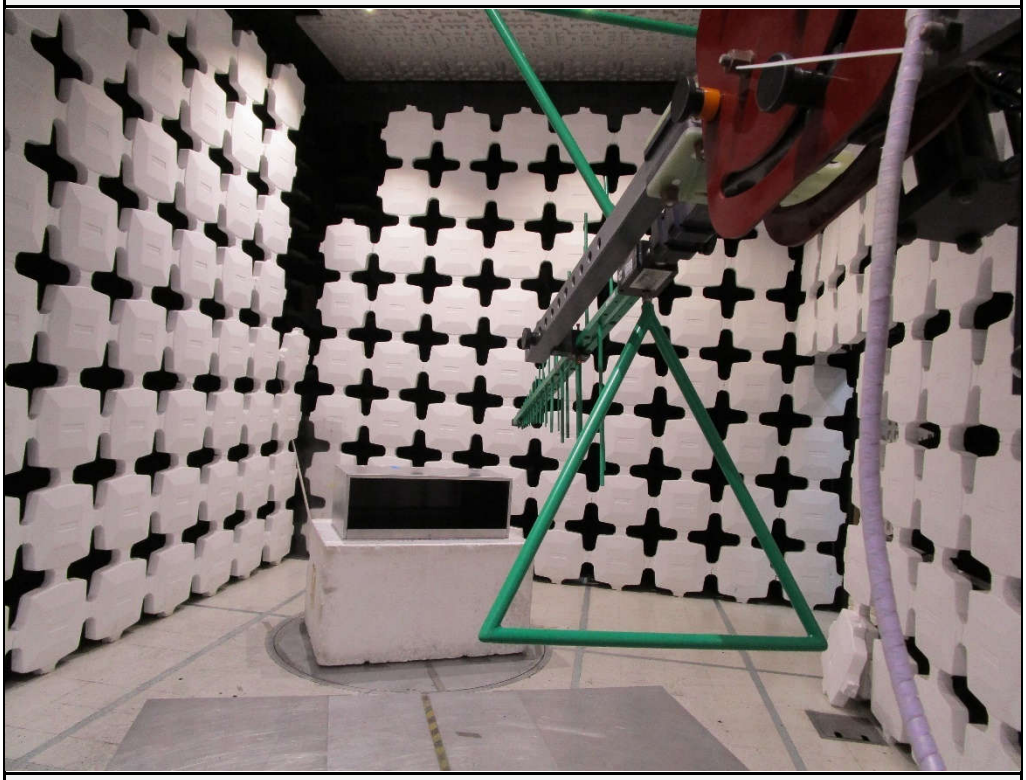
Measurement Uncertainty	
Measurement Type	Expanded Measurement Uncertainty
Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1000 MHz)	4.3
Radiated disturbance (electric field strength on an open area test site or alternative test site) (1 GHz – 6 GHz)	3.1

Requirements
The maximum peak conducted output power for frequency hopping systems operating in the 902-928 MHz band and employing at least 50 hopping channels shall not exceed 1 watt. The conducted output power limit is based on the use of antennas with directional gains that do not exceed 6dBi. Therefore, the maximum EIRP shall not exceed 4W (36dBm).

Procedure
The EUT was placed on an 80cm high non-conductive stand and set to transmit with hopping disabled. A bilog antenna was placed at a test distance of 3 meters from the EUT. The resolution bandwidth (RBW) of the spectrum analyzer was set to greater than the 20dB bandwidth. The span was set to approximately 5 times the 20 dB bandwidth. The EUT was maximized for worst case emissions (or maximum output power) at the measuring antenna. The maximum meter reading was recorded. The peak power output was measured for the low, middle, and high hopping frequencies. The equivalent power was determined from the field intensity levels measured at 3 meters using the substitution method. To determine the emission power, a dipole antenna was then set in place of the EUT and connected to a calibrated signal generator. The output of the signal generator was adjusted to match the received level at the spectrum analyzer. The signal level was recorded. The reading was then corrected to compensate for cable loss, as required. The peak power output was calculated for low, middle, and high hopping frequencies.



Test Setup for EIRP Tests – Antenna Polarization Horizontal



Test Setup for EIRP Tests – Antenna Polarization Vertical

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Mode	Transmit at 902.75MHz
Date Tested	September 28, 2022
Result	Max EIRP = 0.112W (20.5dBm)
Notes	EUT was sequentially transmitting on all four antennas during testing
Notes	Transmit antennas on the EUT were oriented in the final configuration.

Freq (MHz)	Ant Pol	Wide BW Meter Reading (dBµV)	Matched Sig Gen Reading (dBm)	Equivalent Antenna Gain (dB)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)	Margin (dB)
902.75	H	89.0	20.0	2.2	1.6	20.5	36.0	-15.5
	V	81.2	14.7	2.2	1.6	15.2	36.0	-20.8

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Date Tested	September 28, 2022
Mode	Transmit at 914.25MHz
Result	Max EIRP = 0.0977W (19.9dBm)
Notes	EUT was sequentially transmitting on all four antennas during testing
Notes	Transmit antennas on the EUT were oriented in the final configuration.

Freq (MHz)	Ant Pol	Wide BW Meter Reading (dBµV)	Matched Sig Gen Reading (dBm)	Equivalent Antenna Gain (dB)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)	Margin (dB)
914.25	H	87.7	19.4	2.2	1.6	19.9	36.0	-16.1
	V	78.2	13.1	2.2	1.6	13.6	36.0	-22.4

Test Details	
Manufacturer	Fastenal
EUT	RFID Reader
Model No.	922194627
Date Tested	September 28, 2022
Mode	Transmit at 927.25MHz
Result	Max EIRP = 0.0398W (16.0dBm)
Notes	EUT was sequentially transmitting on all four antennas during testing
Notes	Transmit antennas on the EUT were oriented in the final configuration.

Freq (MHz)	Ant Pol	Wide BW Meter Reading (dBµV)	Matched Sig Gen Reading (dBm)	Equivalent Antenna Gain (dB)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)	Margin (dB)
927.25	H	78.9	11.0	2.2	1.7	11.5	36.0	-24.5
	V	79.9	15.5	2.2	1.7	16.0	36.0	-20.0

28. Case Spurious Radiated Emissions

EUT Information	
Manufacturer	Fastenal
Product	RFID Reader
Model No.	922194627
Mode	Transmit at 902.75MHz Transmit at 914.25MHz Transmit at 927.25MHz

Test Setup Details	
Setup Format	Tabletop
Height of Support (For Floor Standing only)	N/A
Type of Test Site	Semi-Anechoic Chamber
Test Site Used	Room 29
Type of Antennas Used	Below 1GHz: Bilog (or equivalent) Above 1GHz: Double-Ridged Waveguide
Notes	new (final) transmit antenna orientation

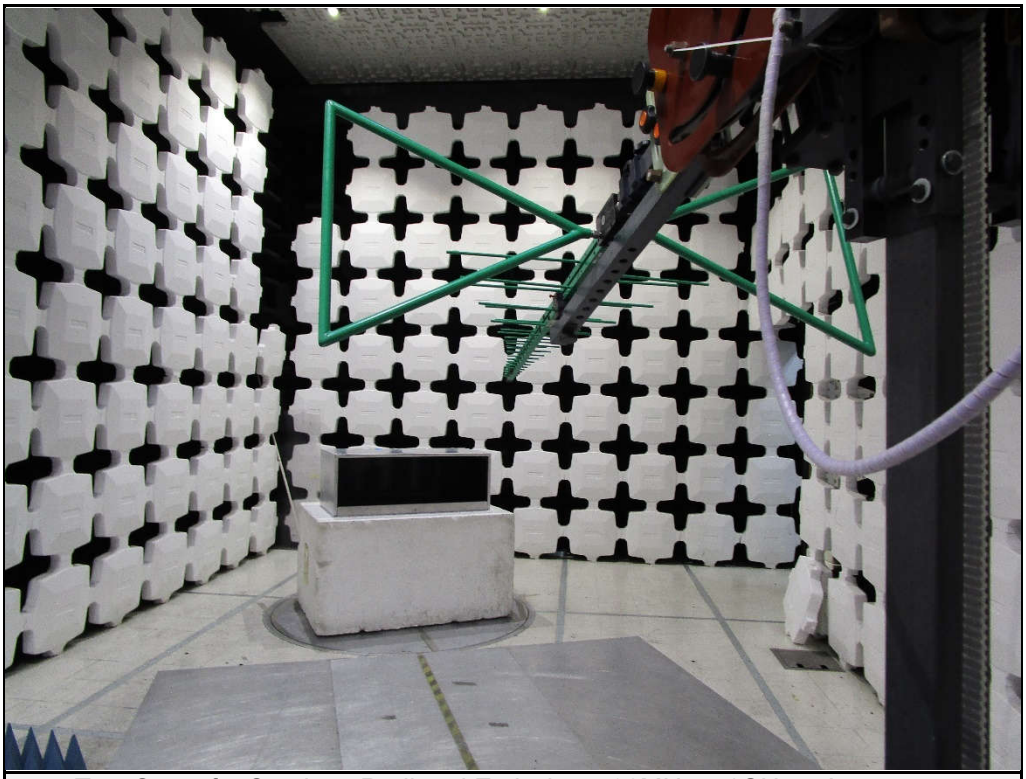
Measurement Uncertainty	
Measurement Type	Expanded Measurement Uncertainty
Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1000 MHz)	4.3
Radiated disturbance (electric field strength on an open area test site or alternative test site) (1 GHz – 6 GHz)	3.1
Radiated disturbance (electric field strength on an open area test site or alternative test site) (6 GHz – 18 GHz)	3.2
Radiated disturbance (electric field strength on an open area test site or alternative test site) (18 GHz – 26.5 GHz)	3.3
Radiated disturbance (electric field strength on an open area test site or alternative test site) (26.5 GHz – 40 GHz)	3.4

Procedure
Radiated measurements were performed in a 32ft. x 20ft. x 14ft. high shielded enclosure. The shielded enclosure prevents emissions from other sources, such as radio and TV stations from interfering with the measurements. All powerlines and signal lines entering the enclosure pass through filters on the enclosure wall. The powerline filters prevent extraneous signals from entering the enclosure on these leads. Preliminary radiated emissions tests were performed to determine the emission characteristics of the EUT. For the preliminary test, a broadband measuring antenna was positioned at a 3-meter distance from the EUT. The entire frequency range from 30MHz to 10.0GHz was investigated using a peak detector function. The final radiated emission tests were then manually performed over the frequency range of 30MHz to 10.0GHz. 1) For all harmonics not in the restricted bands, the following procedure was used: a) The field strength of the fundamental was measured using a bilog antenna. The bilog antenna was positioned at a 3-meter distance from the EUT. The EUT was placed on an 80cm high non-conductive stand. A peak detector with a resolution bandwidth of 100 kHz was used on the spectrum analyzer. b) The field strengths of all of the harmonics not in the restricted band were then measured using a double-ridged waveguide antenna. The waveguide antenna was positioned at a 3-meter distance from the EUT. The EUT was placed on a 1.5-meter-high non-conductive stand. A peak detector with a resolution bandwidth of 100kHz was used on the spectrum analyzer. c) To ensure that maximum or worst-case emission levels at the fundamental and harmonics were measured, the following steps were taken when measuring the fundamental emissions and the spurious emissions: i) The EUT was rotated so that all of its sides were exposed to the receiving antenna. ii) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured. iii) The measuring antenna was raised and lowered for each antenna polarization to maximize the readings. d) All harmonics not in the restricted bands must be at least 20dB below levels measured at the fundamental. However, attenuation below the general limits specified in §15.209(a) is not required. 2) For all emissions in the restricted bands, the following procedure was used: a) The field strengths of all emissions below 1GHz were measured using a bi-log antenna. The bi-log antenna was positioned at a 3-meter distance from the EUT. The EUT was placed on an 80cm high non-conductive stand. A peak detector with a resolution bandwidth of 100 kHz was used on the spectrum analyzer. b) The field strengths of all emissions above 1GHz were measured using a double-ridged waveguide antenna. The waveguide antenna was positioned at a 3-meter distance from the EUT. The EUT was placed on a 1.5-meter-high non-conductive stand. A peak detector with a resolution bandwidth of 1MHz was used on the spectrum analyzer. c) To ensure that maximum or worst-case emission levels were measured, the following steps were taken when taking all measurements: i) The EUT was rotated so that all of its sides were exposed to the receiving antenna. ii) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured. iii) The measuring antenna was raised and lowered for each antenna polarization to maximize the readings. d) For all radiated emissions measurements below 1GHz, if the peak reading is below the limits listed

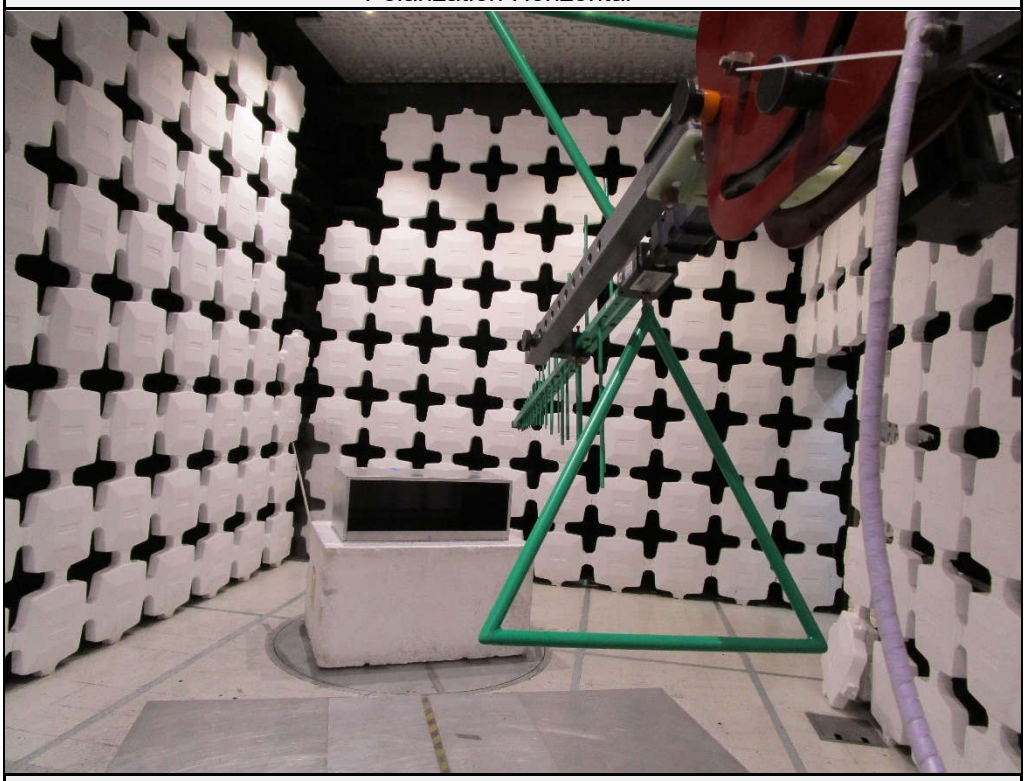
in §15.209(a), no further measurements are required. If, however, the peak readings exceed the limits listed in §15.209(a), then the emissions are remeasured using a quasi-peak detector.

e) For all radiated emissions measurements above 1GHz, the peak readings must comply with the §15.35(b) limits. §15.35(b) states that when average radiated emissions measurements are specified, there also is a limit on the peak level of the radiated emissions. The limit on the peak radio frequency emissions is 20dB above the maximum permitted average emission limit applicable to the equipment under test. Therefore, all peak readings above 1GHz must be no greater than 20dB above the limits specified in §15.209(a).

f) Next, for all radiated emissions measurements above 1GHz, the resolution bandwidth was set to 1MHz. The analyzer was set to linear mode with a 10Hz video bandwidth in order to simulate an average detector. An average reading was taken.



Test Setup for Spurious Radiated Emissions, 30MHz – 1GHz – Antenna Polarization Horizontal



Test Setup for Spurious Radiated Emissions, 30MHz – 1GHz – Antenna Polarization Vertical