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EMC Test Report

Application for FCC Grant of Equipment Authorization
Canada Certification

FCC Part 15 Subpart C

Model: PIE1X01

IC CERTIFICATION #:	11508A-PIE1X01
FCC ID:	2AAZF-PIE1X01
APPLICANT:	Intuitive Surgical Inc. 1266 Kifer Road Building 101 Sunnyvale, CA 94086
TEST SITE(S):	National Technical Systems 41039 Boyce Road. Fremont, CA. 94538-2435
IC SITE REGISTRATION #:	2845B-3
PROJECT NUMBER:	PR136055
REPORT DATE:	July 27, 2021
REISSUE DATE:	October 11, 2021
FINAL TEST DATES:	May 18, 24 and 25, 2021
TOTAL NUMBER OF PAGES:	35

A2LA ACCREDITED
Testing Cert #0214.26

VALIDATING SIGNATORIES

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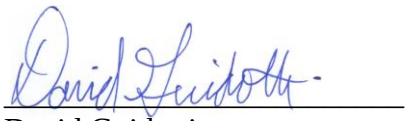

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REVISION HISTORY

Rev#	Date	Comments	Modified By
-	July 27, 2021	First release	
1	October 11, 2021	Corrected FCC Rules references from §15.255 to §15.225	dwb

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SCOPE

An electromagnetic emissions test has been performed on the Intuitive Surgical Inc. model PIE1X01, pursuant to the following rules:

RSS-GEN Issue 5 " General Requirements for Compliance of Radio Apparatus"
RSS 210 Issue 8 "Low-power Licence-exempt Radiocommunication Devices (All Frequency Bands): Category I Equipment"
FCC Part 15 Subpart C

Conducted and radiated emissions data has been collected, reduced, and analyzed within this report in accordance with measurement guidelines set forth in the following reference standards and as outlined in National Technical Systems test procedures:

ANSI C63.10-2013

The intentional radiator above has been tested in a simulated typical installation to demonstrate compliance with the relevant Industry Canada performance and procedural standards.

Final system data was gathered in a mode that tended to maximize emissions by varying orientation of EUT, orientation of power and I/O cabling, antenna search height, and antenna polarization.

Every practical effort was made to perform an impartial test using appropriate test equipment of known calibration. All pertinent factors have been applied to reach the determination of compliance.

National Technical Systems is accredited by the A2LA, certificate number 0214.26, to perform the test(s) listed in this report, except where noted otherwise.

OBJECTIVE

The primary objective of the manufacturer is compliance with the regulations outlined in the previous section.

Prior to marketing in the USA, all unlicensed transmitters and transceivers require certification. Receive-only devices operating between 30 MHz and 960 MHz are subject to either certification or a manufacturer's declaration of conformity, with all other receive-only devices exempt from the technical requirements.

Prior to marketing in Canada, Class I transmitters, receivers and transceivers require certification. Class II devices are required to meet the appropriate technical requirements but are exempt from certification requirements.

Certification is a procedure where the manufacturer submits test data and technical information to a certification body and receives a certificate or grant of equipment authorization upon successful completion of the certification body's review of the submitted documents. Once the equipment authorization has been obtained, the label indicating compliance must be attached to all identical units, which are subsequently manufactured.

Maintenance of compliance is the responsibility of the manufacturer. Any modification of the product which may result in increased emissions should be checked to ensure compliance has been maintained (i.e., printed circuit board layout changes, different line filter, different power supply, harnessing or I/O cable changes, etc.).

STATEMENT OF COMPLIANCE

The tested sample of Intuitive Surgical Inc. model PIE1X01 complied with the requirements of the following regulations:

RSS-GEN Issue 5 " General Requirements for Compliance of Radio Apparatus"
RSS 210 Issue 8 "Low-power Licence-exempt Radiocommunication Devices (All Frequency Bands): Category I Equipment"
FCC Part 15 Subpart C

Maintenance of compliance is the responsibility of the manufacturer. Any modifications to the product should be assessed to determine their potential impact on the compliance status of the device with respect to the standards detailed in this test report.

The test results recorded herein are based on a single type test of Intuitive Surgical Inc. model PIE1X01 and therefore apply only to the tested sample. The sample was selected and prepared by Tony Permsombut of Intuitive Surgical Inc..

DEVIATIONS FROM THE STANDARDS

No deviations were made from the published requirements listed in the scope of this report.

TEST RESULTS SUMMARY

FCC Rule Part	RSS Rule Part	Description	Measured Value / Comments	Limit / Requirement	Result
15.225	RSS 210 B.6	Transmitter Fundamental Signal Emissions, 13.56 MHz	14.7 dBµV/m @ 13.559 MHz (margin: -69.3 dB)	Refer to table in limits section	Complies
15.209	RSS-GEN Table 5 and 6	Transmitter Radiated Spurious Emissions, 10 - 150 MHz	39.0 dBµV/m @ 120.00 MHz (margin: -4.5 dB)	Refer to table in limits section	Complies
15.225	RSS 210 B.6	Frequency Stability	3.6 ppm	Less than 100 ppm	Complies

GENERAL REQUIREMENTS APPLICABLE TO ALL BANDS

FCC Rule Part	RSS Rule part	Description	Measured Value / Comments	Limit / Requirement	Result (margin)
15.203	-	RF Connector	Integral Antenna	Unique or integral antenna required	Complies
15.407 (b) (6)	RSS-Gen Table 4	AC Conducted Emissions	50.1 dBµV @ 0.233 MHz (Margin: -12.2 dB)	Refer to page 17	Complies
15.247 (i) 15.407 (f)	RSS 102	RF Exposure Requirements	Refer to RSS 102 declaration	Refer to OET 65, FCC Part 1 and RSS 102	Complies
-	RSS-Gen 8.4	User Manual		Statement for all products	Complies
-	RSP-100 RSS-Gen 6.7	Occupied Bandwidth	2Hz	Information only	N/A
Note 1 Pass/Fail criteria defined by standards listed above.					

MEASUREMENT UNCERTAINTIES

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level and were calculated in accordance with UKAS document LAB 34.

Measurement Type	Measurement Unit	Frequency Range	Expanded Uncertainty
Radiated emission (field strength)	dBµV/m	10 to 1000 MHz	± 3.6 dB
		1000 to 40000 MHz	± 6.0 dB
Conducted Emissions (AC Power)	dBµV	0.15 to 30 MHz	± 2.4 dB

EQUIPMENT UNDER TEST (EUT) DETAILS

GENERAL

The Intuitive Surgical Inc. model PIE1X01 is an RFID 13.56MHz transceiver module for use in the Endoscopic Instrument Control System, model IS5000, intended to assist in the accurate control of endoscopic instruments. Since the EUT would be installed in an Endoscopic system cart during operation, the EUT was treated as tabletop equipment during testing to simulate the end-user environment. The electrical rating of the EUT is 3.3 Volts.

The EUT would be installed in and powered from the Vision Side Cart (VSC) of IS5000 system. The electrical rating for the VSC is 100-230 V, 50/60 Hz, 12 A

The sample was received on May 17, 2021 and tested on May 18, 24 and 25, 2021. The EUT consisted of the following component(s):

Company	Model	Description	Serial Number	FCC ID
Intuitive Surgical Inc.	PIE1X01	RF Module	FNW20090168	2AAZF-PIE1X01

ANTENNA SYSTEM

The antenna system consists of an integral loop.

ENCLOSURE

The module does not have an enclosure. It is intended to be mounted in the VSC of the IS5000 system.

MODIFICATIONS

No modifications were made to the EUT during the time the product was at NTS Silicon Valley.

SUPPORT EQUIPMENT

The following equipment was used as local support equipment during testing:

Conducted Emissions

Manufacturer	Model	Description	Serial Number	FCC ID
Dell	Precision5530	Laptop	CGR5Y2	-
Dell	DA130PM130	AC adapter of laptop	96D-1S3F-A01	-

Radiated Emissions

Manufacturer	Model	Description	Serial Number	FCC ID
BK Precision	1550	Power Supply	238B21160	-

EUT INTERFACE PORTS

The I/O cabling configuration during testing was as follows:

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length(m)
Power	Power Supply or Laptop depending on the test	2 wire	Unshielded	1.0

EUT OPERATION

The EUT was configured to continuously transmit in a read/write cycle at 13.56MHz.

TEST SITE

GENERAL INFORMATION

Final test measurements were taken at the test sites listed below. Pursuant to section 2.948 of the FCC's Rules and section 6.2 of RSS-GEN, NTS has been recognized as an accredited test laboratory by the Commission and Innovation, Science and Economic Development Canada. A description of the facilities employed for testing is maintained by NTS.

Site	Company / Registration Numbers		Location
	FCC	Canada	
Chamber 3	US1031	2845B (Wireless Test Lab #US0027)	41039 Boyce Road Fremont, CA 94538-2435

ANSI C63.4 recommends that ambient noise at the test site be at least 6 dB below the allowable limits. Ambient levels are below this requirement. The test site(s) contain separate areas for radiated and conducted emissions testing. Results from testing performed in this chamber have been correlated with results from an open area test site. Considerable engineering effort has been expended to ensure that the facilities conform to all pertinent requirements of ANSI C63.4.

CONDUCTED EMISSIONS CONSIDERATIONS

Conducted emissions testing is performed in conformance with ANSI C63.10. Measurements are made with the EUT connected to the public power network through a nominal, standardized RF impedance, which is provided by a line impedance stabilization network, known as a LISN. A LISN is inserted in series with each current-carrying conductor in the EUT power cord.

RADIATED EMISSIONS CONSIDERATIONS

The FCC has determined that radiation measurements made in a shielded enclosure are not suitable for determining levels of radiated emissions. Radiated measurements are performed in an open field environment or in a semi-anechoic chamber. The test sites are maintained free of conductive objects within the CISPR defined elliptical area incorporated in ANSI C63.4 guidelines and meet the Normalized Site Attenuation (NSA) requirements of ANSI C63.4.

MEASUREMENT INSTRUMENTATION

RECEIVER SYSTEM

An EMI receiver as specified in CISPR 16-1-1 is used for emissions measurements. The receivers used can measure over the frequency range of 9 kHz up to 2000 MHz. These receivers allow both ease of measurement and high accuracy to be achieved. The receivers have Peak, Average, and CISPR (Quasi-peak) detectors built into their design so no external adapters are necessary. The receiver automatically sets the required bandwidth for the CISPR detector used during measurements. If the repetition frequency of the signal being measured is below 20Hz, peak measurements are made in lieu of Quasi-Peak measurements.

For measurements above the frequency range of the receivers, a spectrum analyzer is utilized because it provides visibility of the entire spectrum along with the precision and versatility required to support engineering analysis. Average measurements above 1000MHz are performed on the spectrum analyzer using the linear-average method with a resolution bandwidth of 1 MHz and a video bandwidth of 10 Hz, unless the signal is pulsed in which case the average (or video) bandwidth of the measuring instrument is reduced to onset of pulse desensitization and then increased.

INSTRUMENT CONTROL COMPUTER

Software is used to view and convert receiver measurements to the field strength at an antenna or voltage developed at the LISN measurement port, which is then compared directly with the appropriate specification limit. This provides faster, more accurate readings by performing the conversions described under Sample Calculations within the Test Procedures section of this report. Results are printed in a graphic and/or tabular format, as appropriate. A personal computer is used to record all measurements made with the receivers. The software used for radiated and conducted emissions measurements is NTS EMI Test Software (rev 2.10)

LINE IMPEDANCE STABILIZATION NETWORK (LISN)

Line conducted measurements utilize a fifty microhenry Line Impedance Stabilization Network as the monitoring point. The LISN used also contains a 250 uH CISPR adapter. This network provides for calibrated radio frequency noise measurements by the design of the internal low pass and high pass filters on the EUT and measurement ports, respectively.

FILTERS/ATTENUATORS

External filters and precision attenuators are often connected between the receiving antenna or LISN and the receiver. This eliminates saturation effects and non-linear operation due to high amplitude transient events.

ANTENNAS

A loop antenna is used below 30 MHz. For the measurement range 30 MHz to 1000 MHz either a combination of a biconical antenna and a log periodic or a bi-log antenna is used. Above 1000 MHz, horn antennas are used. The antenna calibration factors to convert the received voltage to an electric field strength are included with appropriate cable loss and amplifier gain factors to determine an overall site factor, which is then programmed into the test receivers or incorporated into the test software.

ANTENNA MAST AND EQUIPMENT TURNTABLE

The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor-drive to vary the antenna height. Measurements below 30 MHz are made with the loop antenna at a fixed height of 1m above the ground plane.

ANSI C63.10 specifies that the test height above ground for table mounted devices shall be 80 centimeters for testing below 1 GHz and 1.5m for testing above 1 GHz. Floor mounted equipment shall be placed on the ground plane if the device is normally used on a conductive floor or separated from the ground plane by insulating material from 3 to 12 mm if the device is normally used on a non-conductive floor as specified in ANSI C63.4. During radiated measurements, the EUT is positioned on a motorized turntable in conformance with this requirement.

INSTRUMENT CALIBRATION

All test equipment is regularly checked to ensure that performance is maintained in accordance with the manufacturer's specifications. All antennas are calibrated at regular intervals with respect to tuned half-wave dipoles. An exhibit of this report contains the list of test equipment used and calibration information.

TEST PROCEDURES

EUT AND CABLE PLACEMENT

The regulations require that interconnecting cables be connected to the available ports of the unit and that the placement of the unit and the attached cables simulate the worst case orientation that can be expected from a typical installation, so far as practicable. To this end, the position of the unit and associated cabling is varied within the guidelines of ANSI C63.10, and the worst-case orientation is used for final measurements.

CONDUCTED EMISSIONS

Conducted emissions are measured at the plug end of the power cord supplied with the EUT. Excess power cord length is wrapped in a bundle between 30 and 40 centimeters in length near the center of the cord. Preliminary measurements are made to determine the highest amplitude emission relative to the specification limit for all the modes of operation. Placement of system components and varying of cable positions are performed in each mode. A final peak mode scan is then performed in the position and mode for which the highest emission was noted on all current carrying conductors of the power cord.

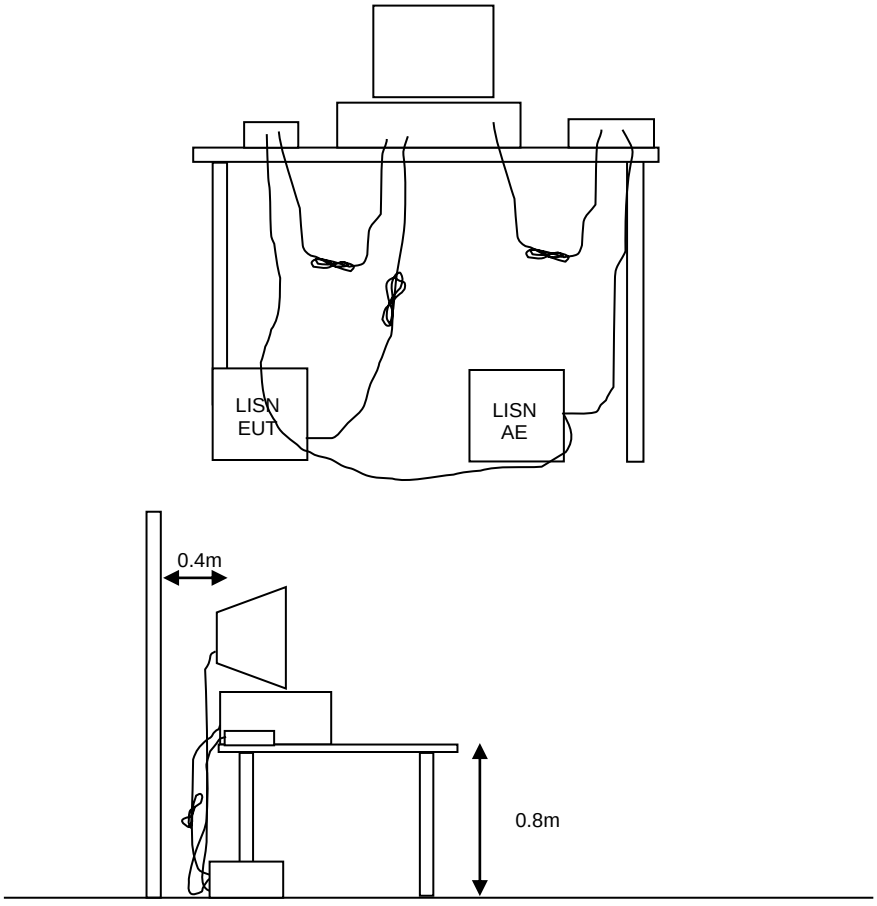


Figure 1 Typical Conducted Emissions Test Configuration

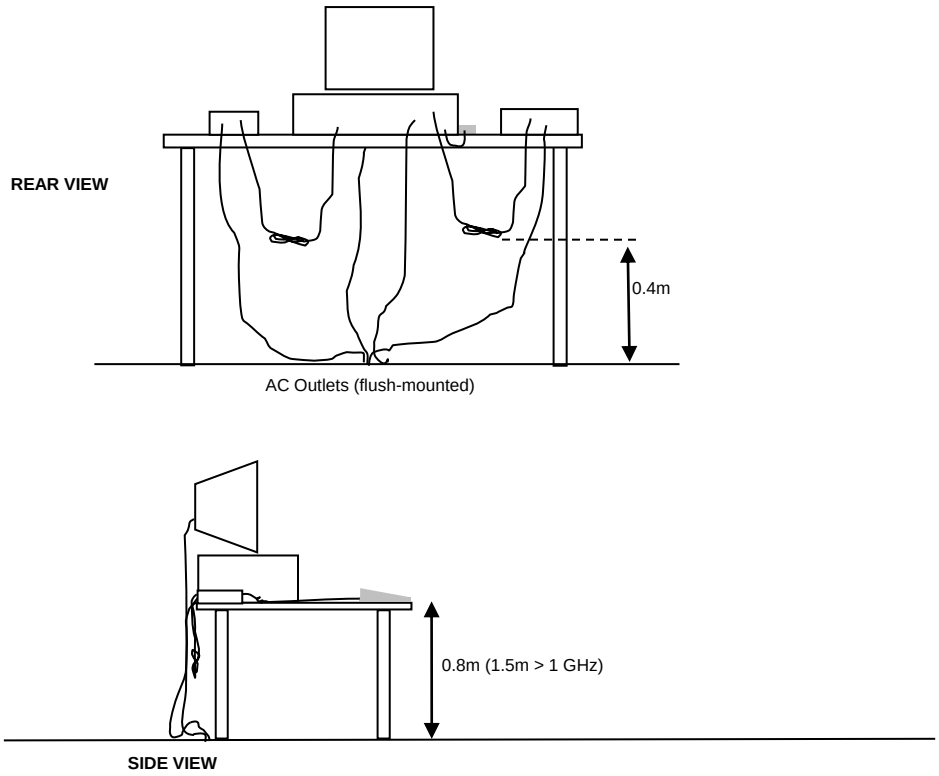
RADIATED EMISSIONS

A preliminary scan of the radiated emissions is performed in which all significant EUT frequencies are identified with the system in a nominal configuration. At least two scans are performed, one scan for each antenna polarization (horizontal and vertical; loop parallel and perpendicular to the EUT). During the preliminary scans, the EUT is rotated through 360˚, the antenna height is varied (for measurements above 30 MHz) and cable positions are varied to determine the highest emission relative to the limit. Preliminary scans may be performed in a fully anechoic chamber for the purposes of identifying the frequencies of the highest emissions from the EUT.

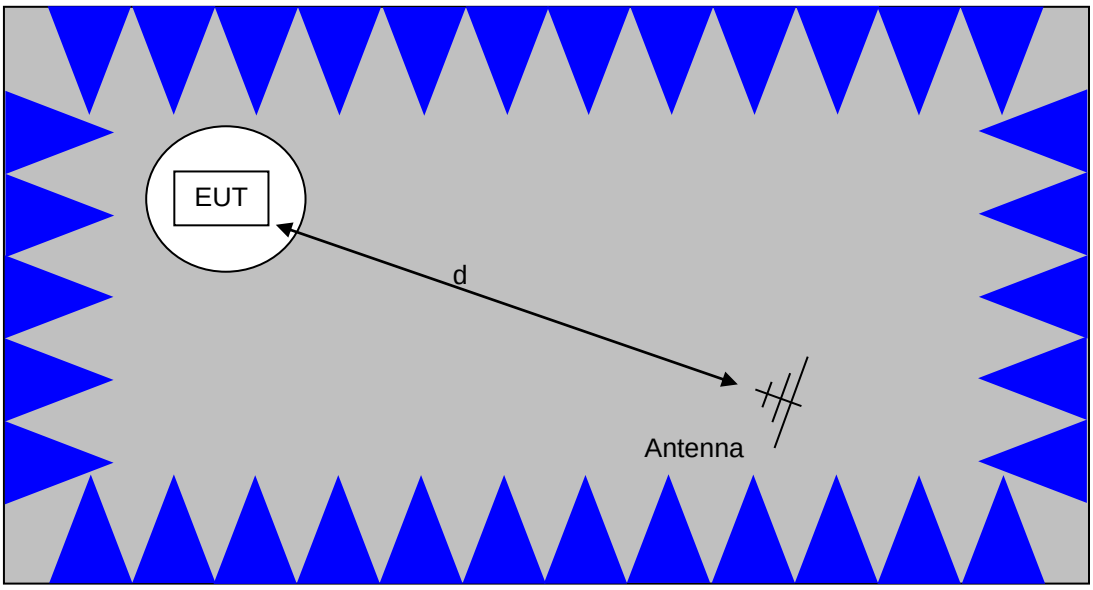
A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

Final maximization is a phase in which the highest amplitude emissions identified in the spectral search are viewed while the EUT azimuth angle is varied from 0 to 360 degrees relative to the receiving antenna. The azimuth, which results in the highest emission is then maintained while varying the antenna height from one to four meters (for measurements above 30 MHz, measurements below 30 MHz are made with the loop antenna at a fixed height of 1m). The result is the identification of the highest amplitude for each of the highest peaks. Each recorded level is corrected in the receiver using appropriate factors for cables, connectors, antennas, and preamplifier gain.

When testing above 18 GHz, the receive antenna is located at 1meter from the EUT and the antenna height is restricted to a maximum of 2.5 meters.

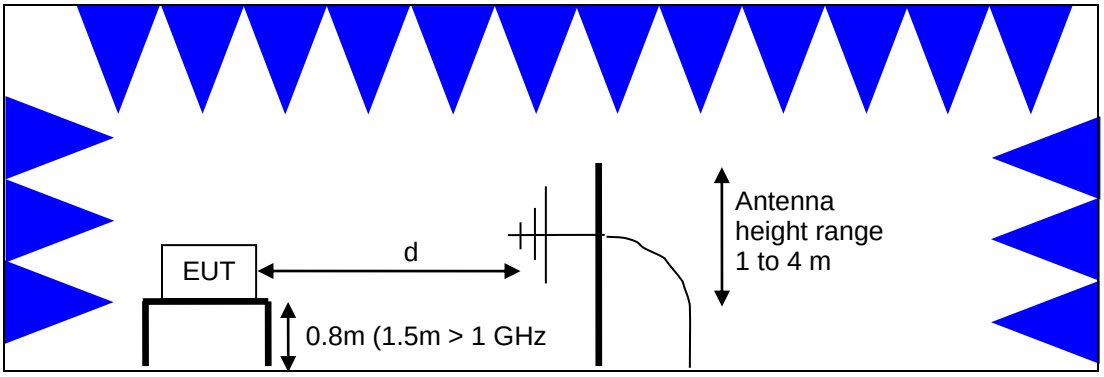


Typical Test Configuration for Radiated Field Strength Measurements



The anechoic materials on the walls and ceiling ensure compliance with the normalized site attenuation requirements of CISPR 16 / CISPR 22 / ANSI C63.4 for an alternate test site at the measurement distances used.

Floor-standing equipment is placed on the floor with insulating supports between the unit and the ground plane.



Test Configuration for Radiated Field Strength Measurements
Semi-Anechoic Chamber, Plan and Side Views

BANDWIDTH MEASUREMENTS

The 6dB, 20dB, 26dB and/or 99% signal bandwidth are measured using the bandwidths recommended by ANSI C63.10 and RSS GEN.

SPECIFICATION LIMITS AND SAMPLE CALCULATIONS

The limits for conducted emissions are given in units of microvolts, and the limits for radiated emissions are given in units of microvolts per meter at a specified test distance. Data is measured in the logarithmic form of decibels relative to one microvolt, or dB microvolts (dBuV). For radiated emissions, the measured data is converted to the field strength at the antenna in dB microvolts per meter (dBuV/m). The results are then converted to the linear forms of uV and uV/m for comparison to published specifications.

For reference, converting the specification limits from linear to decibel form is accomplished by taking the base ten logarithm, then multiplying by 20. These limits in both linear and logarithmic form are as follows:

CONDUCTED EMISSIONS SPECIFICATION LIMITS: FCC 15.207; RSS GEN

The table below shows the limits for the emissions on the AC power line from an intentional radiator and a receiver.

Frequency (MHz)	Average Limit (dBuV)	Quasi Peak Limit (dBuV)
0.150 to 0.500	Linear decrease on logarithmic frequency axis between 56.0 and 46.0	Linear decrease on logarithmic frequency axis between 66.0 and 56.0
0.500 to 5.000	46.0	56.0
5.000 to 30.000	50.0	60.0

GENERAL TRANSMITTER RADIATED EMISSIONS SPECIFICATION LIMITS

The table below shows the limits for the spurious emissions from transmitters that fall in restricted bands[1].

Frequency Range (MHz)	Limit (uV/m)	Limit (dBuV/m @ 3m)
0.009-0.490	$2400/F_{KHz}$ @ 300m	$67.6-20*\log_{10}(F_{KHz})$ @ 300m
0.490-1.705	$24000/F_{KHz}$ @ 30m	$87.6-20*\log_{10}(F_{KHz})$ @ 30m
1.705 to 30	30 @ 30m	29.5 @ 30m
30 to 88	100 @ 3m	40 @ 3m
88 to 216	150 @ 3m	43.5 @ 3m
216 to 960	200 @ 3m	46.0 @ 3m
Above 960	500 @ 3m	54.0 @ 3m

[1] The restricted bands are detailed in FCC 15.205 and RSS-Gen Table 7

SAMPLE CALCULATIONS - CONDUCTED EMISSIONS

Receiver readings are compared directly to the conducted emissions specification limit (decibel form) as follows:

$$R_r - S = M$$

where:
R_r = Receiver Reading in dBuV
S = Specification Limit in dBuV
M = Margin to Specification in +/- dB

SAMPLE CALCULATIONS - RADIATED EMISSIONS

Receiver readings are compared directly to the specification limit (decibel form). The receiver internally corrects for cable loss, preamplifier gain, and antenna factor. The calculations are in the reverse direction of the actual signal flow, thus cable loss is added and the amplifier gain is subtracted. The Antenna Factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

A distance factor, when used for electric field measurements above 30MHz, is calculated by using the following formula:

$$F_d = 20*LOG_{10} (D_m/D_s)$$

where:
F_d = Distance Factor in dB
D_m = Measurement Distance in meters
D_s = Specification Distance in meters

For electric field measurements below 30MHz the extrapolation factor is either determined by making measurements at multiple distances or a theoretical value is calculated using the formula:

$$F_d = 40*LOG_{10} (D_m/D_s)$$

Measurement Distance is the distance at which the measurements were taken and Specification Distance is the distance at which the specification limits are based. The antenna factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

The margin of a given emission peak relative to the limit is calculated as follows:

$$R_c = R_r + F_d$$

and

$$M = R_c - L_s$$

where:
R_r = Receiver Reading in dBuV/m
F_d = Distance Factor in dB
R_c = Corrected Reading in dBuV/m
L_s = Specification Limit in dBuV/m
M = Margin in dB Relative to Spec

Appendix A Test Equipment Calibration Data

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
Bandwidth and Stability, 18-May-21					
Agilent Technologies	PSA Spectrum Analyzer	E4446A	WC055650	8/20/2020	8/20/2021
Watlow	F4 Watlow Controller	F4	WC064561	6/23/2020	6/23/2021
Radiated Emissions, 10 - 30 MHz, 24-May-21					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	WC022452	N/A	
Rhode & Schwarz	Loop Antenna	HFH2-Z2	WC062457	1/23/2020	1/23/2022
Rohde & Schwarz	EMI test receiver, 20Hz-40GHz	ESI	WC068000	6/17/2020	6/17/2021
Radiated Emissions, 30 - 150 MHz, 24-May-21					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	WC022452	N/A	
ETS-Lindgren	EMC Chamber #3	FACT-10	WC055565	8/4/2019	8/4/2022
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	WC064582	7/8/2020	7/8/2022
Rohde & Schwarz	EMI test receiver, 20Hz-40GHz	ESI	WC068000	6/17/2020	6/17/2021
Com-Power	RF Preamplifier	PAM-103	WC072429	11/14/2020	11/14/2021
Conducted Emissions - AC Power Ports, 25-May-21					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	WC022452	N/A	
ETS-Lindgren	EMC Chamber #3	FACT-10	WC055565	8/4/2019	8/4/2022
EMCO	LISN, 10 kHz-100 MHz	3825/2	WC064399	8/2/2020	8/2/2021
Rohde & Schwarz	Pulse Limiter	ESH3 Z2	WC064445	7/6/2020	7/6/2021
Rohde & Schwarz	EMI test receiver, 20Hz-40GHz	ESI	WC068000	6/17/2020	6/17/2021

Appendix B Test Data

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Client:	Intuitive Surgical, Inc.	PR Number:	PR136055
Product	PIE1X01	T-Log Number:	TL136055-RA-PIE1X01
System Configuration:	Tested as module	Project Manager:	Deepa Shetty
Contact:	Tony Permsombut	Project Engineer:	David Bare
Emissions Standard(s):	FCC Part 15.225, RSS-210, EN 300 330, KS X 3123, Japan ELP	Class:	-
Immunity Standard(s):		Environment:	Radio

EMC Test Data

For The

Intuitive Surgical, Inc.

Product

PIE1X01

Date of Last Test: 5/26/2021

Client:	Intuitive Surgical, Inc.	PR Number:	PR136055
Model:	PIE1X01	T-Log Number:	TL136055-RA-PIE1X01
		Project Manager:	Deepa Shetty
Contact:	Tony Permsombut	Project Engineer:	David Bare
Standard:	FCC Part 15.225, RSS-210, EN 300 330, KS X 3123, Japan ELP	Class:	-

Conducted Emissions

(NTS Silicon Valley, Fremont Facility, Semi-Anechoic Chamber)

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Date of Test: 5/25/2021
Test Engineer: M. Birgani
Test Location: Fremont Chamber #3

Config. Used: 1
Config Change: None
EUT Voltage: 120V/60Hz

General Test Configuration

For tabletop equipment, the EUT was located on a table inside the semi-anechoic chamber, 40 cm from a vertical coupling plane and 80cm from the LISN.

Ambient Conditions:

Temperature: 21-22 °C
Rel. Humidity: 38-40 %

Summary of Results

Run #	Test Performed	Limit	Result	Margin
1	CE, AC Power,120V/60Hz	FCC §15.207	Pass	50.1 dBµV @ 0.233 MHz (Margin: -12.2 dB)

Modifications Made During Testing

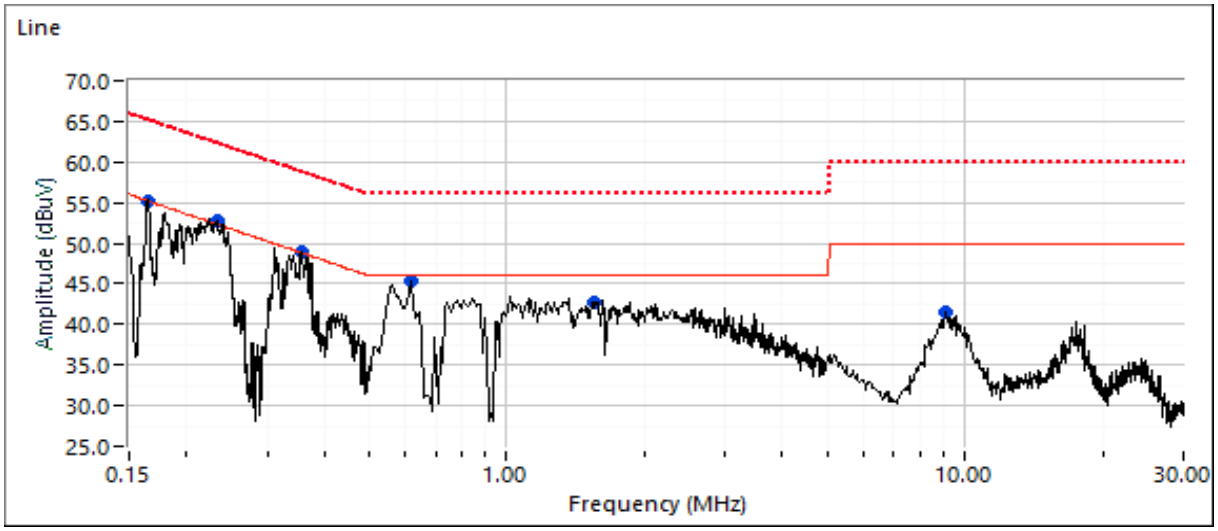
No modifications were made to the EUT during testing

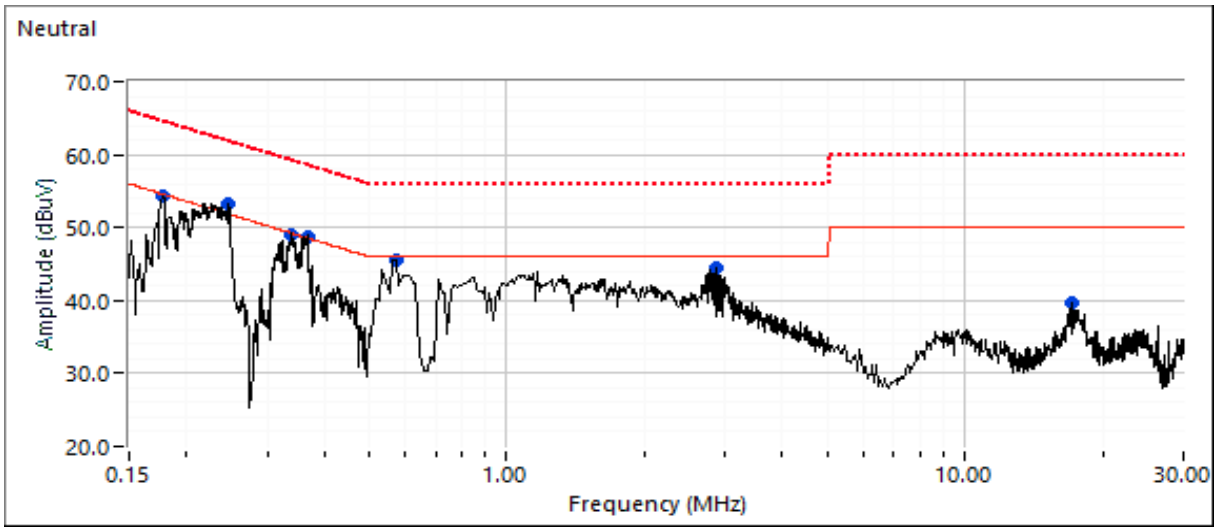
Deviations From The Standard

No deviations were made from the requirements of the standard.

Client:	Intuitive Surgical, Inc.	PR Number:	PR136055
Model:	PIE1X01	T-Log Number:	TL136055-RA-PIE1X01
		Project Manager:	Deepa Shetty
Contact:	Tony Permsombut	Project Engineer:	David Bare
Standard:	FCC Part 15.225, RSS-210, EN 300 330, KS X 3123, Japan ELP	Class:	-

Run #1: AC Power Port Conducted Emissions, 0.15 - 30MHz, 120V/60Hz





Client:	Intuitive Surgical, Inc.	PR Number:	PR136055
Model:	PIE1X01	T-Log Number:	TL136055-RA-PIE1X01
		Project Manager:	Deepa Shetty
Contact:	Tony Permsombut	Project Engineer:	David Bare
Standard:	FCC Part 15.225, RSS-210, EN 300 330, KS X 3123, Japan ELP	Class:	-

Run #1: AC Power Port Conducted Emissions, 0.15 - 30MHz, 120V/60Hz
Preliminary peak readings captured during pre-scan (peak readings vs. average limit)

Frequency	Level	AC	FCC §15.207		Detector	Comments
MHz	dBµV	Line	Limit	Margin	QP/Ave	
0.166	55.2	Line	55.2	0.0	Peak	
0.176	54.2	Neutral	54.6	-0.4	Peak	
0.233	52.8	Line	52.3	0.5	Peak	
0.246	53.3	Neutral	51.8	1.5	Peak	
0.339	49.0	Neutral	49.2	-0.2	Peak	
0.356	49.0	Line	48.8	0.2	Peak	
0.369	48.8	Neutral	48.5	0.3	Peak	
0.558	45.6	Neutral	46.0	-0.4	Peak	
0.609	45.3	Line	46.0	-0.7	Peak	
1.563	42.7	Line	46.0	-3.3	Peak	
2.837	44.4	Neutral	46.0	-1.6	Peak	
9.032	41.5	Line	50.0	-8.5	Peak	
17.308	39.6	Neutral	50.0	-10.4	Peak	

Client:	Intuitive Surgical, Inc.	PR Number:	PR136055
Model:	PIE1X01	T-Log Number:	TL136055-RA-PIE1X01
		Project Manager:	Deepa Shetty
Contact:	Tony Permsombut	Project Engineer:	David Bare
Standard:	FCC Part 15.225, RSS-210, EN 300 330, KS X 3123, Japan ELP	Class:	-

Final quasi-peak and average readings

Frequency	Level	AC	FCC §15.207		Detector	Comments
MHz	dBµV	Line	Limit	Margin	QP/Ave	
0.233	50.1	Line	62.3	-12.2	QP	QP (1.00s)
0.339	45.4	Neutral	59.2	-13.8	QP	QP (1.00s)
0.246	47.7	Neutral	61.9	-14.2	QP	QP (1.00s)
0.356	44.4	Line	58.8	-14.4	QP	QP (1.00s)
0.233	37.5	Line	52.3	-14.8	AVG	AVG (0.10s)
0.609	40.9	Line	56.0	-15.1	QP	QP (1.00s)
0.176	49.5	Neutral	64.7	-15.2	QP	QP (1.00s)
0.558	40.2	Neutral	56.0	-15.8	QP	QP (1.00s)
0.339	33.0	Neutral	49.2	-16.2	AVG	AVG (0.10s)
1.563	39.7	Line	56.0	-16.3	QP	QP (1.00s)
0.356	32.4	Line	48.8	-16.4	AVG	AVG (0.10s)
0.369	41.9	Neutral	58.5	-16.6	QP	QP (1.00s)
0.609	27.1	Line	46.0	-18.9	AVG	AVG (0.10s)
0.558	26.8	Neutral	46.0	-19.2	AVG	AVG (0.10s)
2.837	36.8	Neutral	56.0	-19.2	QP	QP (1.00s)
0.166	45.8	Line	65.2	-19.4	QP	QP (1.00s)
0.369	27.4	Neutral	48.5	-21.1	AVG	AVG (0.10s)
0.246	30.6	Neutral	51.9	-21.3	AVG	AVG (0.10s)
1.563	23.2	Line	46.0	-22.8	AVG	AVG (0.10s)
2.837	22.4	Neutral	46.0	-23.6	AVG	AVG (0.10s)
17.308	25.5	Neutral	50.0	-24.5	AVG	AVG (0.10s)
9.032	35.2	Line	60.0	-24.8	QP	QP (1.00s)
9.032	24.5	Line	50.0	-25.5	AVG	AVG (0.10s)
0.176	27.6	Neutral	54.7	-27.1	AVG	AVG (0.10s)
17.308	32.9	Neutral	60.0	-27.1	QP	QP (1.00s)
0.166	24.0	Line	55.2	-31.2	AVG	AVG (0.10s)

Client:	Intuitive Surgical, Inc.	PR Number:	PR136055
Model:	PIE1X01	T-Log Number:	TL136055-RA-PIE1X01
		Project Manager:	Deepa Shetty
Contact:	Tony Permsombut	Project Engineer:	David Bare
Standard:	FCC Part 15.225, RSS-210, EN 300 330, KS X 3123, Japan ELP	Class:	-

Radiated Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

General Test Configuration

The EUT and any local support equipment were located on the turntable for radiated emissions testing. Remote support equipment was located outside the chamber.

The test distance and extrapolation factor (if used) are detailed under each run description.

Note, preliminary testing indicates that the emissions were maximized by orientation of the EUT and elevation of the measurement antenna. Maximized testing indicated that the emissions were maximized by orientation of the EUT, elevation of the measurement antenna, and manipulation of the EUT's interface cables.

Ambient Conditions:

Temperature: 22 °C

Rel. Humidity: 36 %

Summary of Results

Run #	Test Performed	Limit	Result	Margin
1	Fundamental Signal Field Strength / Spectral Mask	FCC 15.225 & RSS 210 B.6	Pass	14.7 dBµV/m @ 13.559 MHz (margin: -69.3 dB)
2	5 - 30 MHz	FCC 15.209/RSS-GEN	Pass	7.40 dBµV/m @ 20.231 MHz (margin: -22.1 dB)
3	Transmitter Radiated Spurious Emissions, 30 - 150 MHz	FCC 15.209/RSS GEN	Pass	39.0 dBµV/m @ 120.00 MHz (margin: -4.5 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Client:	Intuitive Surgical, Inc.	PR Number:	PR136055
Model:	PIE1X01	T-Log Number:	TL136055-RA-PIE1X01
		Project Manager:	Deepa Shetty
Contact:	Tony Permsombut	Project Engineer:	David Bare
Standard:	FCC Part 15.225, RSS-210, EN 300 330, KS X 3123, Japan ELP	Class:	-

Run #1: Fundamental Signal Field Strength / Spectral Mask

Date of Test: 5/24/2021 Config. Used: 1
Test Engineer: David Bare Config Change: None
Test Location: Fremont Chamber #3 Host Unit Voltage 120V/60Hz

Frequency Range	Test Distance	Limit Distance	Extrapolation Factor
13.06 - 14.06 MHz	10	30	-19.1

Note - the extrapolation factor is based on 40*log(test distance/limit distance) as permitted by FCC 15.31

Fundamental Field Strength

Frequency	Level	Pol	FCC 15.225/RSS-210		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
13.559	14.7	C	84.0	-69.3	Peak	48	1.0	EUT upright
13.559	13.8	O	84.0	-70.2	Peak	325	1.0	EUT upright
13.559	14.5	C	84.0	-69.5	Peak	55	1.0	EUT flat
13.559	13.7	O	84.0	-70.3	Peak	300	1.0	EUT flat
13.559	14.6	C	84.0	-69.4	Peak	61	1.0	EUT side
13.559	13.7	O	84.0	-70.3	Peak	312	1.0	EUT side

Note 1:	As all emisisons from the radio were less than the noise floor, the EUT met the mask limits.

Limits for Fundamental

Freq (MHz)		RBW (kHz)	Limit (dBuV/m) @ 30m
< 13.110		9	29.5
13.110	13.410	9	40.5
13.410	13.553	9	50.5
13.553	13.567	9	84.0
13.567	13.710	9	50.5
13.710	14.010	9	40.5
> 14.010		9	29.5

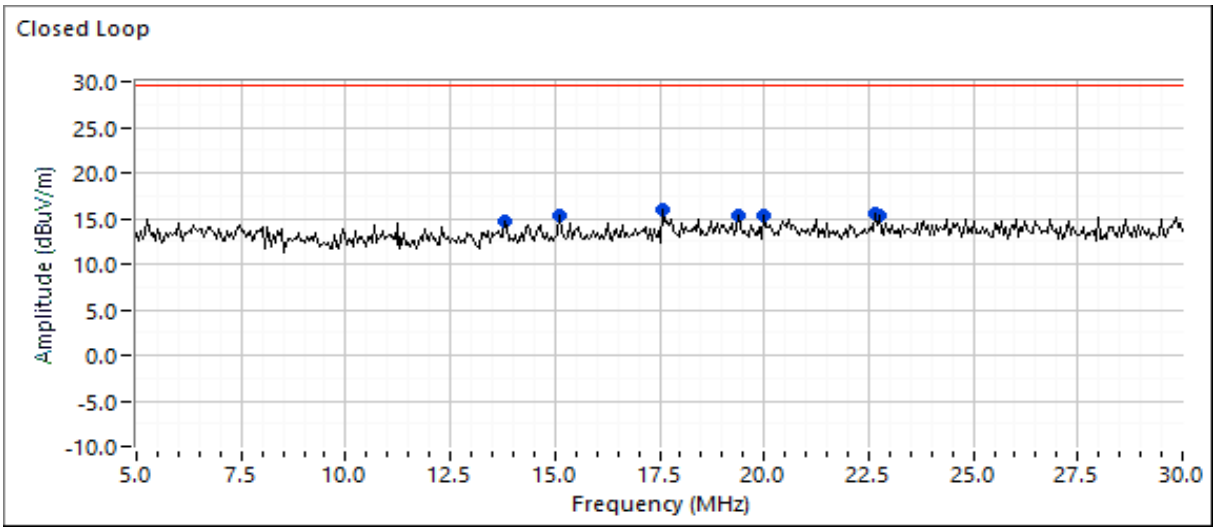
Client:	Intuitive Surgical, Inc.	PR Number:	PR136055
Model:	PIE1X01	T-Log Number:	TL136055-RA-PIE1X01
		Project Manager:	Deepa Shetty
Contact:	Tony Permsombut	Project Engineer:	David Bare
Standard:	FCC Part 15.225, RSS-210, EN 300 330, KS X 3123, Japan ELP	Class:	-

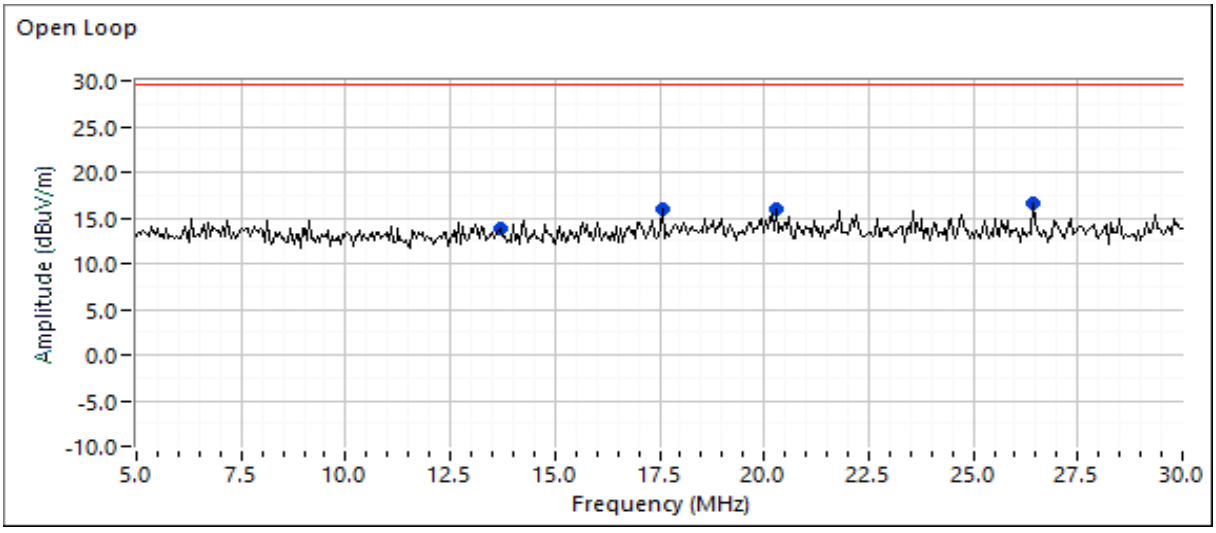
Run #2: Radiated Spurious Emissions, 10 - 30 MHz

Date of Test: 5/24/2021 Config. Used: 1
Test Engineer: David Bare Config Change: None
Test Location: Fremont Chamber #3 Host Unit Voltage 120V/60Hz

Frequency Range	Test Distance	Limit Distance	Extrapolation Factor
5 - 30.0 MHz	10	30	-19.1

Note - the extrapolation factor is based on 40*log(test distance/limit distance) as permitted by FCC 15.31





Client:	Intuitive Surgical, Inc.	PR Number:	PR136055
Model:	PIE1X01	T-Log Number:	TL136055-RA-PIE1X01
		Project Manager:	Deepa Shetty
Contact:	Tony Permsombut	Project Engineer:	David Bare
Standard:	FCC Part 15.225, RSS-210, EN 300 330, KS X 3123, Japan ELP	Class:	-

Preliminary readings

Frequency	Level	Pol	FCC 15.209/RSS-GEN		Detector	Azimuth	Height	Comments
MHz	dBµV/m	O/C	Limit	Margin	Pk/QP/Avg	degrees	meters	
26.431	16.5	O	29.5	-13.0	Peak	325	1.5	
20.231	16.0	O	29.5	-13.5	Peak	69	1.5	
17.620	15.9	O	29.5	-13.6	Peak	304	1.5	
17.567	15.9	C	29.5	-13.6	Peak	124	1.5	
22.633	15.6	C	29.5	-13.9	Peak	334	1.5	
22.719	15.4	C	29.5	-14.1	Peak	96	1.5	
20.005	15.4	C	29.5	-14.1	Peak	37	1.5	
15.108	15.3	C	29.5	-14.2	Peak	304	1.5	
19.408	15.3	C	29.5	-14.2	Peak	295	1.5	
13.559	14.7	C	29.5	-14.8	Peak	48	1.5	
13.559	13.8	O	29.5	-15.7	Peak	325	1.5	

Note 1:	The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector, with a peak limit 20dB above the average limit.

Maximized readings (includes manipulation of EUT interface cables)

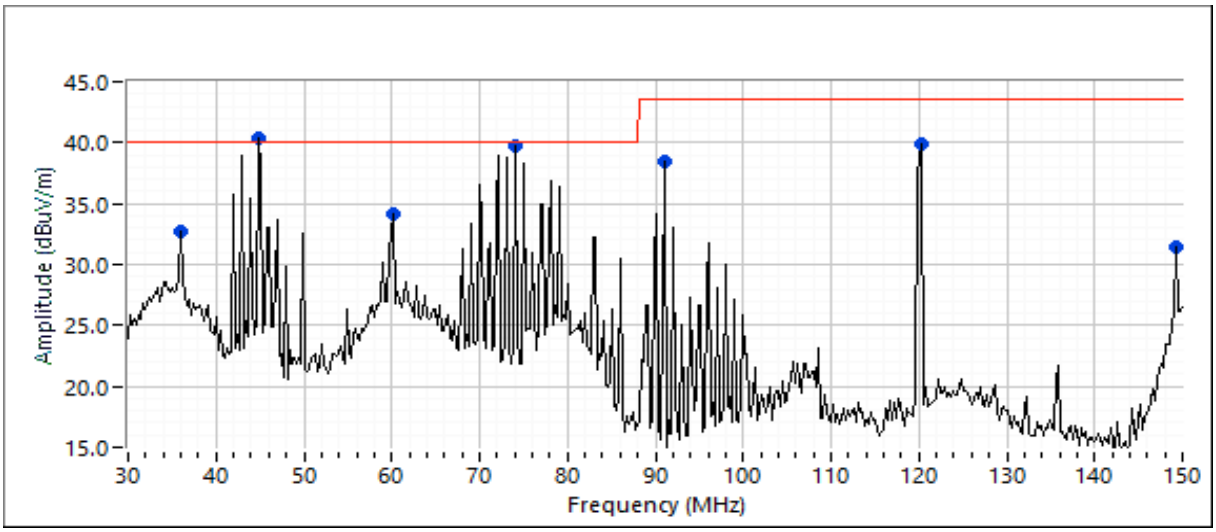
Frequency	Level	Pol	FCC 15.209/RSS-GEN		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
20.231	7.4	O	29.5	-22.1	QP	67	1.0	QP (1.00s)
17.567	7.2	C	29.5	-22.3	QP	125	1.0	QP (1.00s)
22.633	7.0	C	29.5	-22.5	QP	335	1.0	QP (1.00s)
22.719	7.0	C	29.5	-22.5	QP	94	1.0	QP (1.00s)
17.620	6.9	O	29.5	-22.6	QP	304	1.0	QP (1.00s)
26.431	6.8	O	29.5	-22.7	QP	327	1.0	QP (1.00s)

Note 1:	The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector, with a peak limit 20dB above the average limit.

Client:	Intuitive Surgical, Inc.	PR Number:	PR136055
Model:	PIE1X01	T-Log Number:	TL136055-RA-PIE1X01
		Project Manager:	Deepa Shetty
Contact:	Tony Permsombut	Project Engineer:	David Bare
Standard:	FCC Part 15.225, RSS-210, EN 300 330, KS X 3123, Japan ELP	Class:	-

Run #3: Radiated Spurious Emissions, 30 - 150 MHz

Frequency Range	Test Distance	Limit Distance	Extrapolation Factor
30 - 150 MHz	3	3	0.0



Preliminary Readings

Frequency	Level	Pol	FCC 15.209/RSS-GEN		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
35.993	32.7	V	40.0	-7.3	Peak	346	1.0	
45.618	40.3	V	40.0	0.3	Peak	315	3.0	
60.007	34.2	V	40.0	-5.8	Peak	277	1.0	
73.764	39.8	V	40.0	-0.2	Peak	240	3.5	
91.083	38.5	V	43.5	-5.0	Peak	186	4.0	
120.003	39.9	V	43.5	-3.6	Peak	264	1.0	
149.153	31.5	V	43.5	-12.0	Peak	264	1.0	

Note 1:	None of the emisisons observed are harmonics of the radio.

Client:	Intuitive Surgical, Inc.	PR Number:	PR136055
Model:	PIE1X01	T-Log Number:	TL136055-RA-PIE1X01
		Project Manager:	Deepa Shetty
Contact:	Tony Permsombut	Project Engineer:	David Bare
Standard:	FCC Part 15.225, RSS-210, EN 300 330, KS X 3123, Japan ELP	Class:	-

Maximized readings (includes manipulation of EUT interface cables)

Frequency	Level	Pol	FCC 15.209/RSS-GEN		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
120.003	39.0	V	43.5	-4.5	QP	265	1.0	QP (1.00s)
60.007	31.7	V	40.0	-8.3	QP	279	1.0	QP (1.00s)
149.153	30.4	V	43.5	-13.1	QP	265	1.0	QP (1.00s)
91.083	6.8	V	43.5	-36.7	QP	185	4.0	QP (1.00s)
73.764	11.8	V	40.0	-28.2	QP	243	3.5	QP (1.00s)
45.618	16.4	V	40.0	-23.6	QP	316	3.0	QP (1.00s)

Client:	Intuitive Surgical, Inc.	PR Number:	PR136055
Model:	PIE1X01	T-Log Number:	TL136055-RA-PIE1X01
		Project Manager:	Deepa Shetty
Contact:	Tony Permsombut	Project Engineer:	David Bare
Standard:	FCC Part 15.225, RSS-210, EN 300 330, KS X 3123, Japan ELP	Class:	-

RSS-GEN and FCC Part 15.225
Occupied Bandwidth and Frequency Stability

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

General Test Configuration

All measurements are made with a an RF probe located next to the antenna of the EUT connected to the measurement instrument via an attenuator or dc-block if necessary. For frequency stability measurements the EUT was placed inside an environmental chamber.

Radiated measurements are made with the EUT located on a non-conductive table, 3m from the measurement antenna.

Ambient Conditions:

Temperature: 21-22 °C
Rel. Humidity: 38-40 %

Summary of Results

Run #	Test Performed	Limit	Pass / Fail	Result / Margin
1	99% or Occupied Bandwidth	-	-	2Hz
2	Frequency Stability	100 ppm	Pass	3.6ppm

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Client:	Intuitive Surgical, Inc.	PR Number:	PR136055
Model:	PIE1X01	T-Log Number:	TL136055-RA-PIE1X01
		Project Manager:	Deepa Shetty
Contact:	Tony Permsombut	Project Engineer:	David Bare
Standard:	FCC Part 15.225, RSS-210, EN 300 330, KS X 3123, Japan ELP	Class:	-

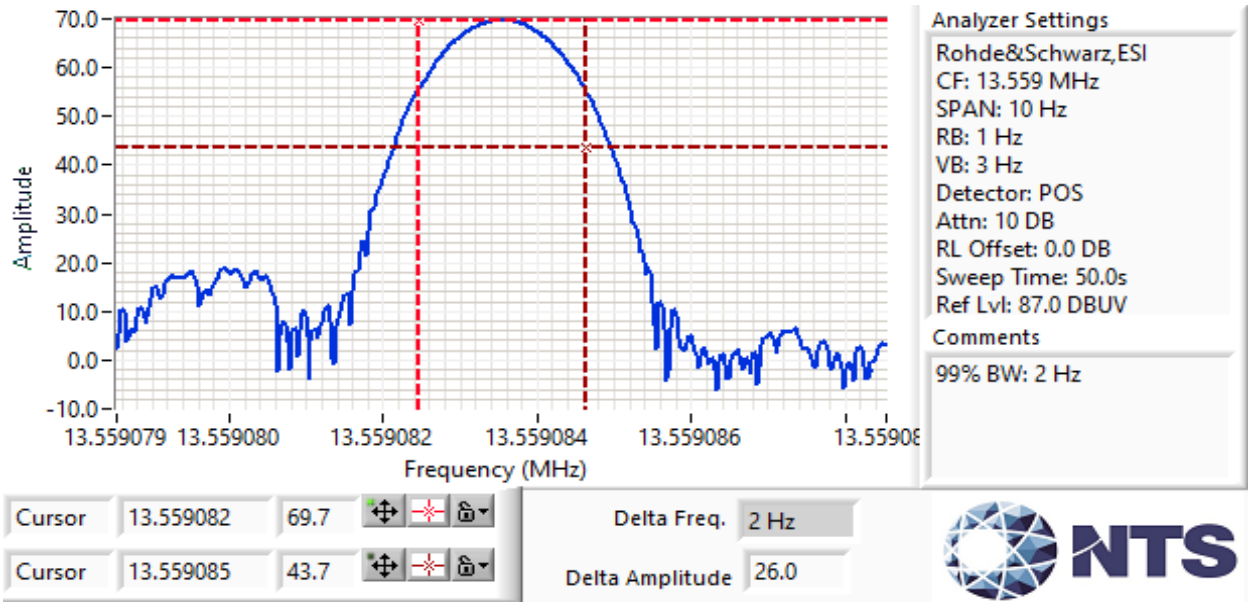
Run #1: Signal Bandwidth

Date of Test: 5/18/2021
Test Engineer: M. Birgani
Test Location: Fremont Chamber #3

Config. Used: 1
Config Change: None
EUT Voltage:

Frequency (MHz)	Resolution Bandwidth	Bandwidth (Hz)	
			99%
13.559083	1 Hz		2.0

Note 1:	99% bandwidth measured in accordance with ANSI C63.10, with RB between 1% and 5% of the measured bandwidth and VB ≥ 3*RB and Span ≥ 1.5% and ≤ 5% of measured bandwidth.



Client:	Intuitive Surgical, Inc.	PR Number:	PR136055
Model:	PIE1X01	T-Log Number:	TL136055-RA-PIE1X01
		Project Manager:	Deepa Shetty
Contact:	Tony Permsombut	Project Engineer:	David Bare
Standard:	FCC Part 15.225, RSS-210, EN 300 330, KS X 3123, Japan ELP	Class:	-

Run #2: Frequency Stability

Date of Test: 5/18/2021 Config. Used: -

Test Engineer: M. Birgani Config Change: -

Test Location: Fremont EMC Lab #4B EUT Voltage: 3.3VDC

Nominal Frequency: 13.559083 MHz

Frequency Stability Over Temperature

The EUT was soaked at each temperature for a minimum of 30 minutes prior to making the measurements to ensure the EUT and chamber had stabilized at that temperature.

Temperature	Frequency Measured	Drift	
(Celsius)	(MHz)	(Hz)	(ppm)
-20	13.559034	-49	-3.6
-10	13.559077	-6	-0.4
0	13.559103	20	1.5
10	13.559104	21	1.5
20	13.559081	-2	-0.1
30	13.559085	2	0.1
40	13.559078	-5	-0.4
50	13.559082	-1	-0.1
	Worst case:	-49	-3.6

Frequency Stability Over Input Voltage

Nominal Voltage of host unit is 3.3V

Voltage	Frequency Measured	Drift	
(AC)	(MHz)	(Hz)	(ppm)
85%	13.559081	-2	-0.1
115%	13.559087	4	0.3
	Worst case:	4	0.3

End of Report

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