FCC § 2.1093 RF EXPOSURE TEST REPORT

(CLASS 2 PERMISSIVE CHANGE)

FOR

WirelessHD SOURCE MODULE INTEGRATED IN ENDOSCOPE

MODEL: XpressView Wireless Camera

FCC ID: 2AFNQ63102

REPORT NUMBER: 11501984-E2V1

ISSUE DATE: DECEMBER 6, 2016

Prepared for

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Prepared by

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NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	12/06/2016	Initial Issue	M. Heckrotte

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: TERADEK LLC.
8 MASON
IRVINE, CA 92618 U.S.A.

EUT DESCRIPTION: WirelessHD SOURCE MODULE INTEGRATED IN ENDOSCOPE

MODEL: XpressView Wireless Camera

SERIAL NUMBER: 00:D0:BD:A0:25:6A:00

DATE TESTED: OCTOBER 31 - NOVEMBER 15, 2016

APPLICABLE STANDARDS AND RF EXPOSURE SUMMARY	
STANDARD	**TEST RESULTS**
§1.1310 as referenced by §2.1093	Pass
MPE Limit	1.0 mW/cm^2
Maximum MPE at 5 cm Separation Distance	0.088 mW/cm^2

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

Approved & Released For
UL Verification Services Inc. By:

MICHAEL HECKROTTE
PRINCIPAL ENGINEER
UL Verification Services Inc.

Tested By:

TONY SOARES
WiSE LABORATORY TECHNICIAN
UL Verification Services Inc.

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with IEEE Std C95.3-2002, “IEEE Recommended Practice for Measurements and Computations of Radio Frequency Electromagnetic Fields With Respect to Human Exposure to Such Fields, 100 kHz–300 GHz.”

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 Benicia Street, Fremont, California, USA.

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at http://ts.nist.gov/standards/scopes/2000650.htm.

4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

4.2. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	UNCERTAINTY	
Power Density	+/- 19.58 %	+/- 1.70 dB

Uncertainty figures are valid to a confidence level of 95%.

5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF CLASS 2 PERMISSIVE CHANGE

The EUT is a WirelessHD Source radio module integrated into a portable end product Endoscope, operating at a source-based duty cycle of 22.6%.

The EUT transmits High Definition Audio/Video data on a single High Rate (HRP) channel at either 60.48 GHz or 62.64 GHz. The integral HRP transmit antenna is an adaptive beam-steering array with a maximum gain of 18 dBi.

The EUT transmits and receives control and management signals on one of five Low Rate (LRP) channels for each HRP channel. The integral LRP transmit/receive antenna is a scanning beam-steering array with a maximum gain of 16 dBi.

The MRP mode is not implemented.

5.2. SOFTWARE AND FIRMWARE

The test software used during testing was SWAM3

The test firmware used during testing was
SiliconImage SiI63XX_0.3, SOURCE-0.3, RF-SiI6310-A4, Pkg: SDK_3.4.12,
Ver.: 3_4_12_2015-10-29a_trunk_SVN54125_External_base_source,
Built: Oct 29 2015 23:48:29.

5.3. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

PERIPHERAL SUPPORT EQUIPMENT LIST				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID**
Laptop	Lenovo	Thinkpad	L3-DBW6W	
Laptop Adapter	Lenovo	42T4426	11S42T4426Z1ZF3F0 7G0UG	
HDMI LED Monitor + Adapter	Upstar	M240A2	ZH157E000M00318	
Debug Board	Paralinx	PXASR	--	
WirelessHD Sink Receiver	Silicon Image	SII-SK63101	00:D0:BD:B0:22:33:00	UK2-SII-SK63101
Receiver 12 VDC Adapter	V-Infinity	EMSA 120050-PSP-SZ	--	
12 VDC Adapter	V-Infinity	EMSA120150-PSP-SZ	--	

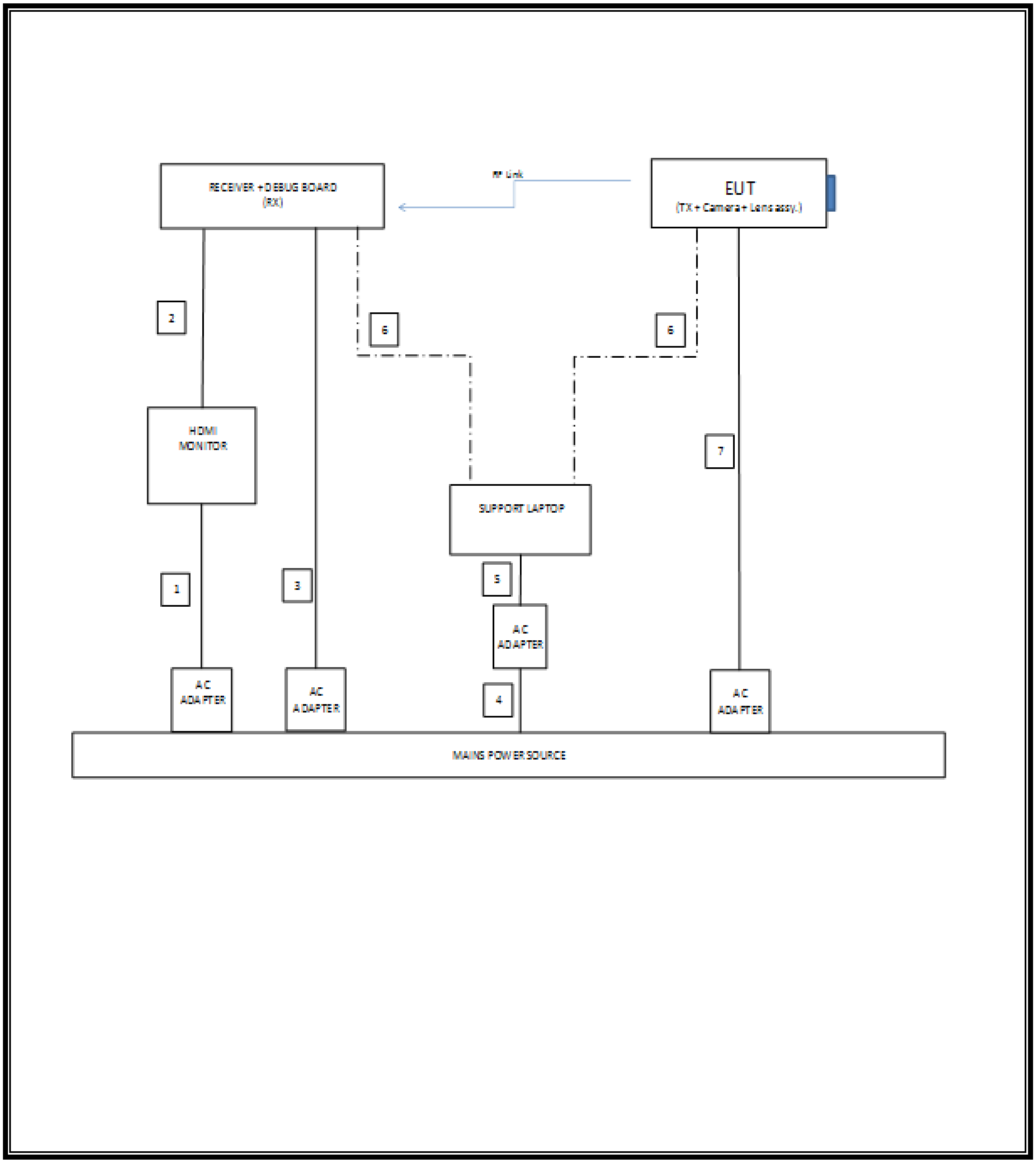
I/O CABLES

I/O Cable List						
Cable No	**Port**	**# of identical ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	DC	1	Barrel	Unshielded	1.5	HDMI Monitor adapter
2	VIDEO	1	HDMI	Shielded	1.8 - 5	--
3	DC	1	Barrel	Unshielded	1.5	Receiver Adapter
4	AC	1	3-Prong	Unshielded	0.8	Support Laptop
5	DC	1	Barrel	Shielded	1.8	Support Laptop
6	USB	2	USB	Shielded	3 - 6	For setting test mode only
7	DC	1	Barrel	Unshielded	1	EUT 12VDC Power

TEST SETUP

A laptop computer was utilized to adjust the EUT for testing purposes. The EUT was set up in an operating link with a WirelessHD Sink support device, and continuously transmitting images.

SETUP DIAGRAM FOR TEST



6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

Description	Manufacturer	Model	Asset	Cal Date	Cal Due
Power Sensor	Agilent	V8486A-H01	T234	9/2/2016	9/2/2017
Power Meter	Agilent	N1913A	T412	8/8/2016	8/8/2017
Aperture Probe Antenna	UL	60 GHz Probe	Copper	9/23/2016	9/23/2017

Cal Date 9/23/2016			Distance (m) --->	0.1
Channel	Freq (GHz)	Power Tx (dBm)		Free Space Path Loss (dB)
2	60.48	10.08		48.07

Channel	Freq (GHz)	Tx Antenna	Rx Antenna	Power Rx (dBm)	Pr Minus Pt (dB)	Gain of Pair ([dBi]^2)
2	60.48	Brass Probe 1	Brass Probe 2	-24.32	-34.4	13.67
2	60.48	Brass Probe 1	60 GHz Probe	-6.29	-16.37	31.70
2	60.48	Brass Probe 2	60 GHz Probe	-6.11	-16.19	31.88

Channel	Freq (GHz)	Antenna	Gain (dBi)
2	60.48	60 GHz Probe	24.96
2	60.48	Brass Probe 1	6.75
2	60.48	Brass Probe 2	6.93

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7. RF EXPOSURE LIMITS AND TEST RESULTS

7.1. LIMITS

FCC RULES

§1.1310 The criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3–3.0	614	1.63	*(100)	6
3.0–30	1842/f	4.89/f	*(900/f^2)	6
30–300	61.4	0.163	1.0	6
300–1500			f/300	6
1500–100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	30
1.34–30	824/f	2.19/f	*(180/f^2)	30

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

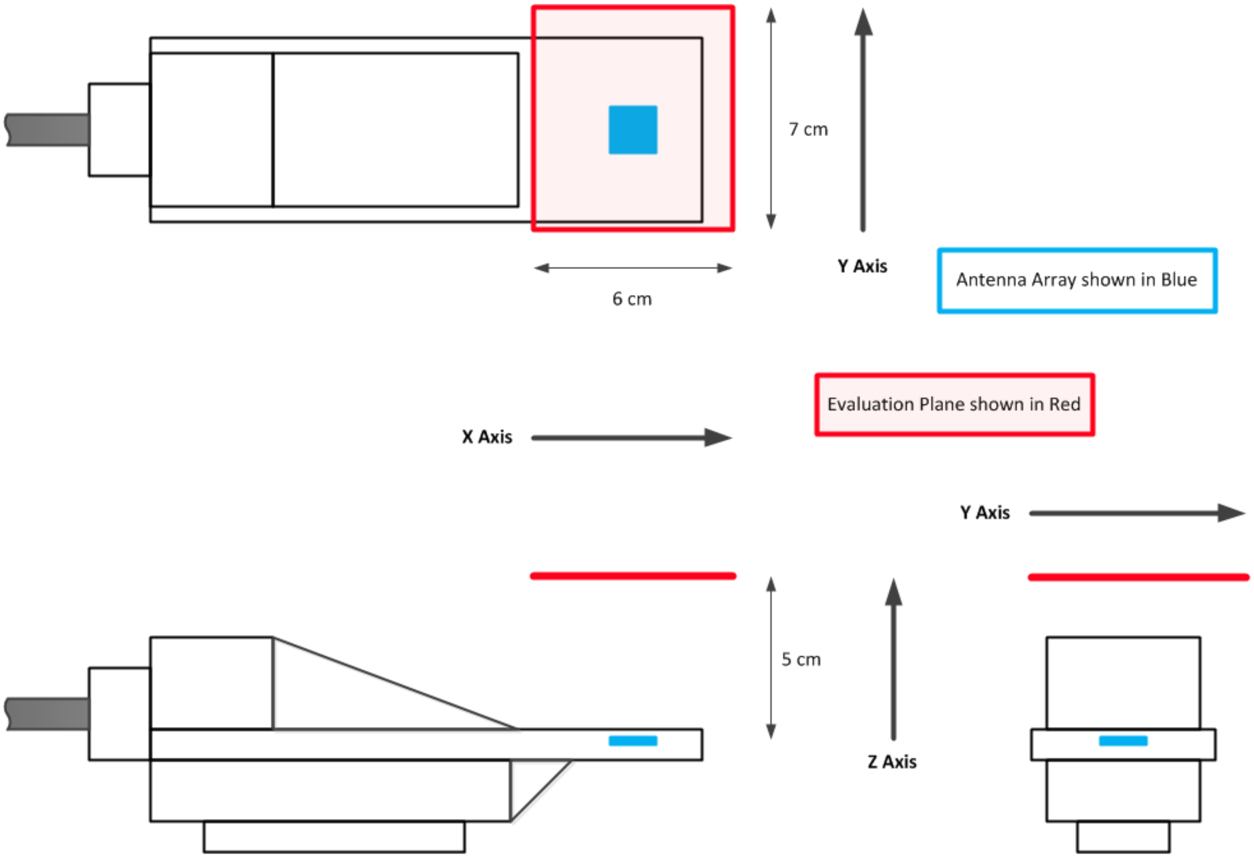
Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
30–300	27.5	0.073	0.2	30
300–1500			f/1500	30
1500–100,000			1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density

NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

7.2. RF EXPOSURE EVALUATION PLANE / MEASUREMENT REGION



The size of the evaluation plane / measurement region is selected as 6 by 6 cm, or as required such that the power density at the edge(s) of the region is less than or equal to 10% of the highest measured value in the region. The measurement region with dimensions 6 by 7 cm meets both of these requirements.

7.3. EQUATIONS

POWER DENSITY

The radiated emission level is measured with the aperture probe antenna connected to a power sensor.

Measurements are made at a distance greater than or equal to the far field boundary distance of the aperture probe antenna.

The measured power level is converted to $(P_T * G_T)$ using the Friis equation:

$$(P_T * G_T) = (P_R / G_R) * (4 * \pi * D_m / \lambda)^2$$

where:

G_R is the gain of the receive measurement antenna
D_m is the measurement distance
λ is the wavelength

$(P_T * G_T)$ is converted to Power Density using the equation:

$$P_D = (P_T * G_T) / (4 * \pi * D_S^2)$$

where:

D_S is the separation distance

The measurement distance D_m is equal to the RF Exposure evaluation distance D_s.

Scalar measurements in three orthogonal orientations of the probe are assumed to be in phase. Therefore the 3-Axis Power Density at each measurement location is calculated as the root-sum-square (RSS) of the X, Y and Z axis power density measurements, thus:

3-Axis Power Density
$$= \sqrt{[(\text{X Axis Power Density})^2 + (\text{Y Axis Power Density})^2 + (\text{Z Axis Power Density})^2]}$$

DUTY FACTOR

The 22.6% duty factor is included in the test signal. Measurements are made across ON and OFF times with an average-responding power sensor. No correction for duty factor is made.

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FAR FIELD BOUNDARY CALCULATIONS

The far-field boundary is given as:

$R_{far\ field} = (2 * L^2) / \lambda$

where:

L = Largest Antenna Dimension, in meters
λ = wavelength in meters

RESULTS

Frequency (GHz)	L (m)	Lambda (m)	R (Far Field) (m)
60.48	0.0042	0.0050	0.007

The measurement distance D_m is greater than the Far-field boundary distance of the aperture probe measurement antenna.

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7.4. SETUP AND PROCEDURE

Optical-grade linear and rotation stages enable fine adjustments of X / Y / Z / Polarization, and are used to maintain a consistent and accurate placement of probe.

Absorber material is placed around the support structures and alignment fixture to reduce reflections, scattering and perturbations.

The Aperture Probe is aligned with the probe axis normal to the EUT antenna, at a distance of 5.0 cm, for Z Axis measurements.

The Aperture Probe is aligned to four cardinal radial orientations, each at a right angle to the normal vector from the EUT antenna, at a distance of 5.0 cm from the EUT antenna as measured along the normal (Z Axis), for -X Axis, +X Axis, -Y Axis and +Y Axis measurements.

For each measurement axis the probe is scanned over the X/Y evaluation plane located 5 cm from the EUT antenna, for X = -3 to +3 cm and for Y = -3 to +4 cm. The scanning increment is equal to one-half wavelength, or 0.25 cm.

The power at each measurement location along each measurement axis, is measured and recorded, then the power density is calculated as described above.

The highest of the -X Axis and +X Axis power density measurements, at each measurement location, is selected for the X Axis power density.

The highest of the -Y Axis and +Y Axis power density measurements, at each measurement location, is selected for the Y Axis power density.

7.5. CONSIDERATION OF LRP EMISSIONS

LRP and HRP emissions are interleaved within a frame period of 20.85 ms. LRP transmissions occupy 74 us of this total period thus have a time-related duty cycle factor of -24.5 dB.

Additionally the LRP modulation has a spatially-related duty cycle as the beam orientation is varied (scanned) to determine the optimum beam orientation for the subsequent HRP frame and transmission of video data. The LRP beam orientation cannot be locked for test purposes.

The HRP beam orientation is locked to the worst-case (highest antenna array gain) beam orientation (center) for test purposes. The HRP test signal includes the 22.6% duty factor.

LRP Bandwidth = ~90 MHz.

HRP Bandwidth = ~1.5 GHz

Maximum LRP radiated power = +30.1 dBm EIRP Peak.

Maximum HRP radiated power = +30.3 dBm EIRP Peak.

Maximum LRP radiated power = -5.1 dBm EIRP Average.

Maximum HRP radiated power = +14.9 dBm EIRP Average.

Furthermore, the LRP modulation is active between each HRP burst. As average power is measured over multiple frame cycles, LRP emissions will inherently be included in HRP measurements.

Given the relative power levels and duty factors HRP is worst-case compared to LRP, and given that HRP measurements will include LRP emissions, HRP RF Exposure results are applied to both HRP and LRP modulations.

7.6. RESULTS

The measured peak Z-axis near-field Pt*Gt is 14.36 dBm EIRP

The calculated 3-Axis peak near-field Pt*Gt Is 14.42 dBm EIRP

The measured far-field Pt*Gt is 14.9 dBm EIRP

All of the above measurements and calculations are based on the HRP test signal that includes the 22.6% Duty Factor. No duty factor corrections are made to any of the above measurements or calculations.

The 5-cm near-field measurements show good agreement with far-field measurements.

The maximum 3-Axis Power Density is 0.088 mW/cm^2.

The maximum Z Axis Power Density is 0.087 mW/cm^2, and corresponds to the location of the maximum 3-Axis Power Density.

The maximum X Axis Power Density at the location of the maximum 3-Axis Power Density is 0.015 mW/cm^2, from the +X Axis orientation.

The maximum Y Axis Power Density at the location of the maximum 3-Axis Power Density is 0.002 mW/cm^2, from the +Y Axis orientation.

The maximum -X Axis Power Density is 0.027 mW/cm^2.

The maximum +X Axis Power Density is 0.019 mW/cm^2.

The maximum -Y Axis Power Density is 0.002 mW/cm^2.

The maximum +Y Axis Power Density is 0.007 mW/cm^2.

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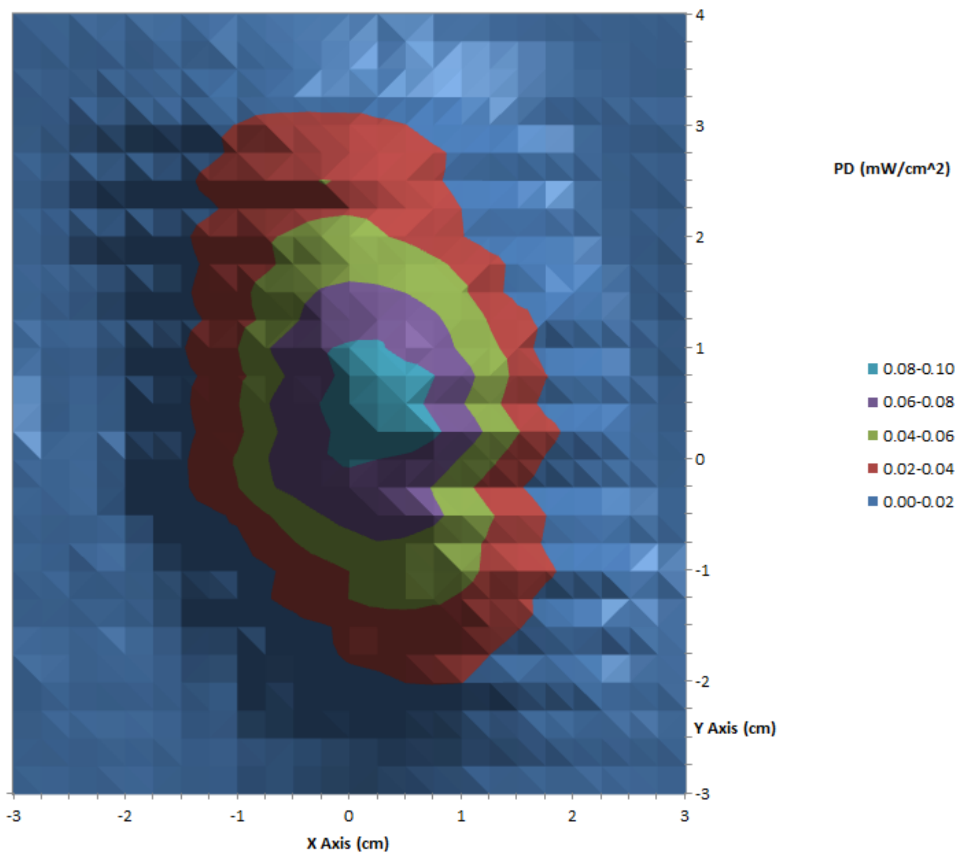
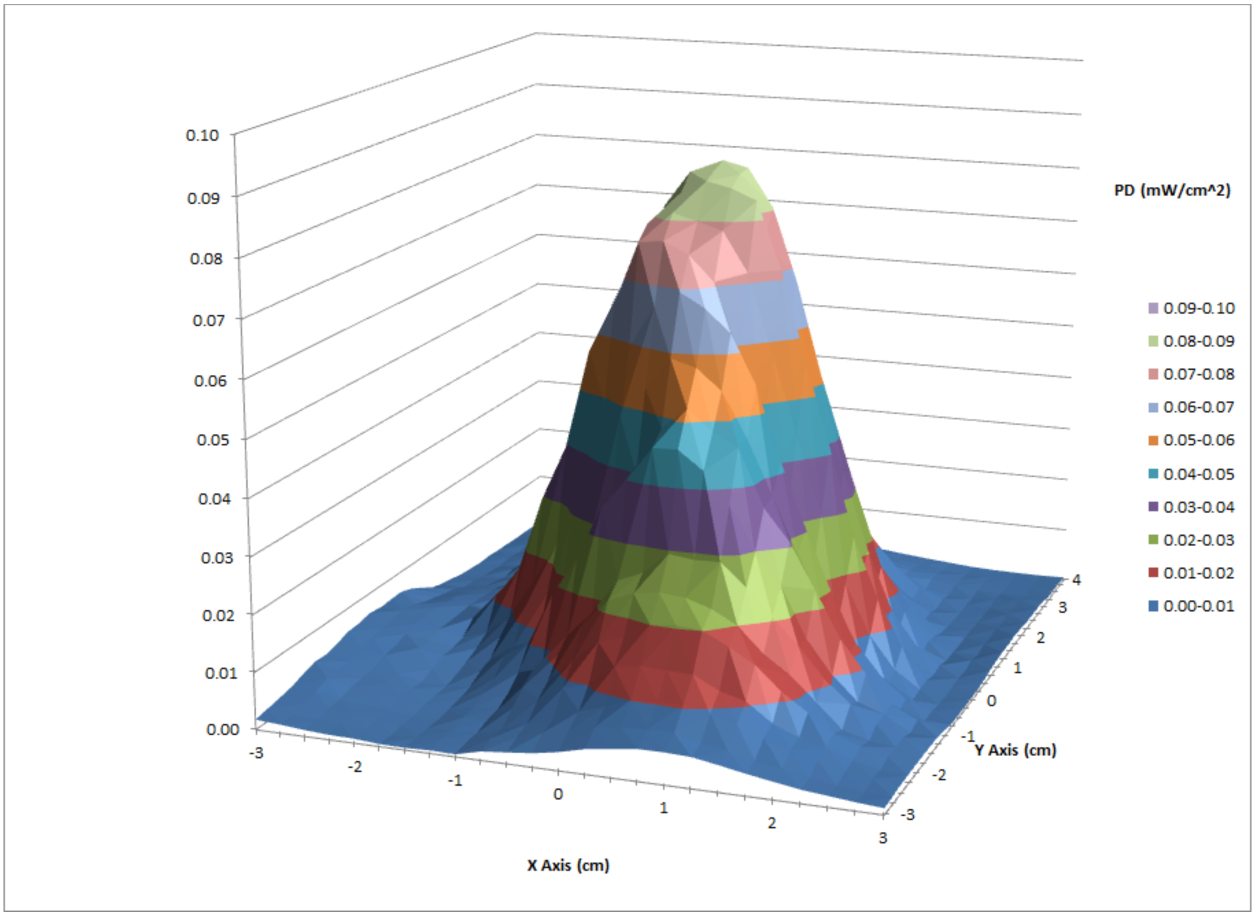
7.7. TEST PLOTS

7.7.1. 3-AXIS PLOTS

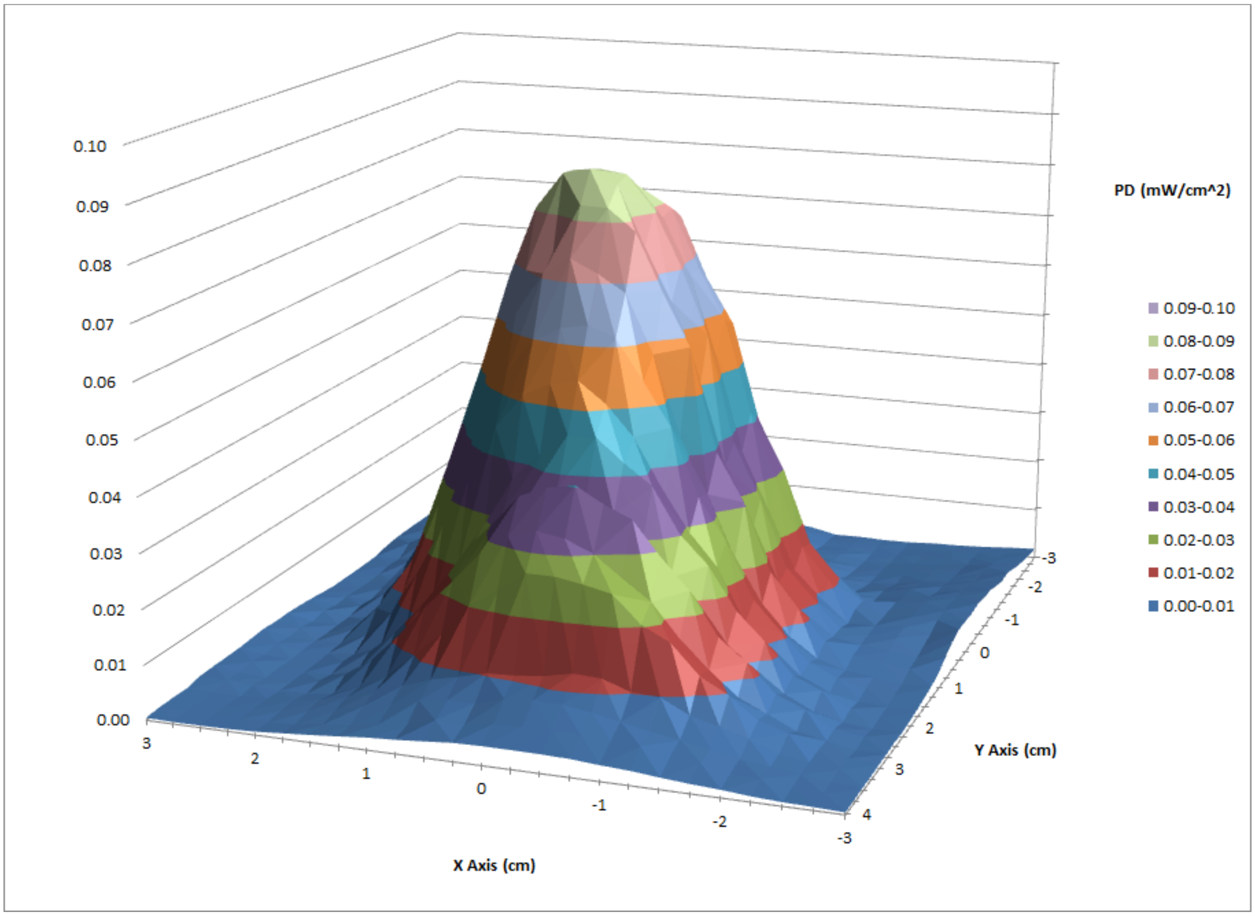
3-Axis Power Density Contour



3-Axis Power Density Surface View

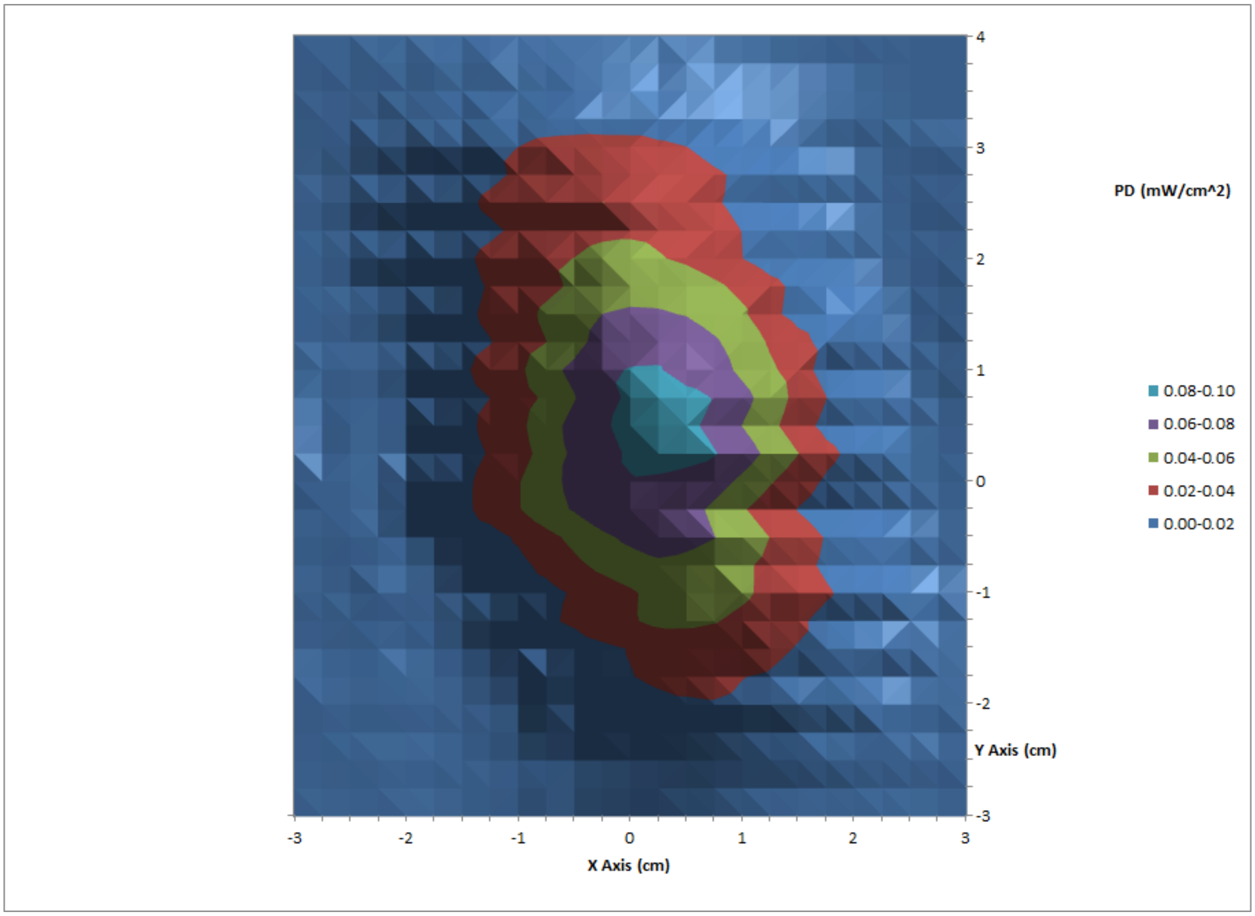


3-Axis Power Density Surface View with X and Y Axes Reversed

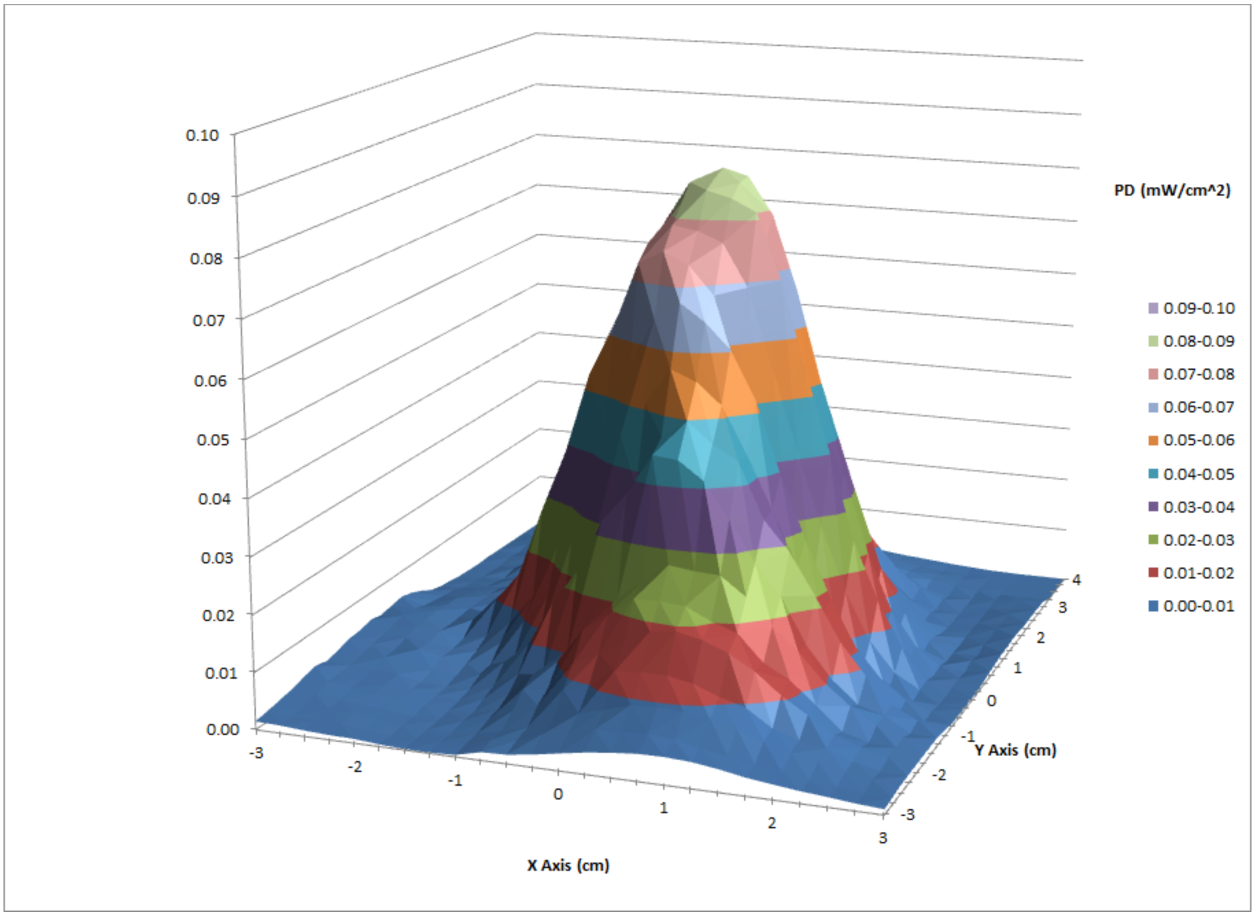


7.7.2. Z AXIS PLOTS

Z Axis Power Density Contour

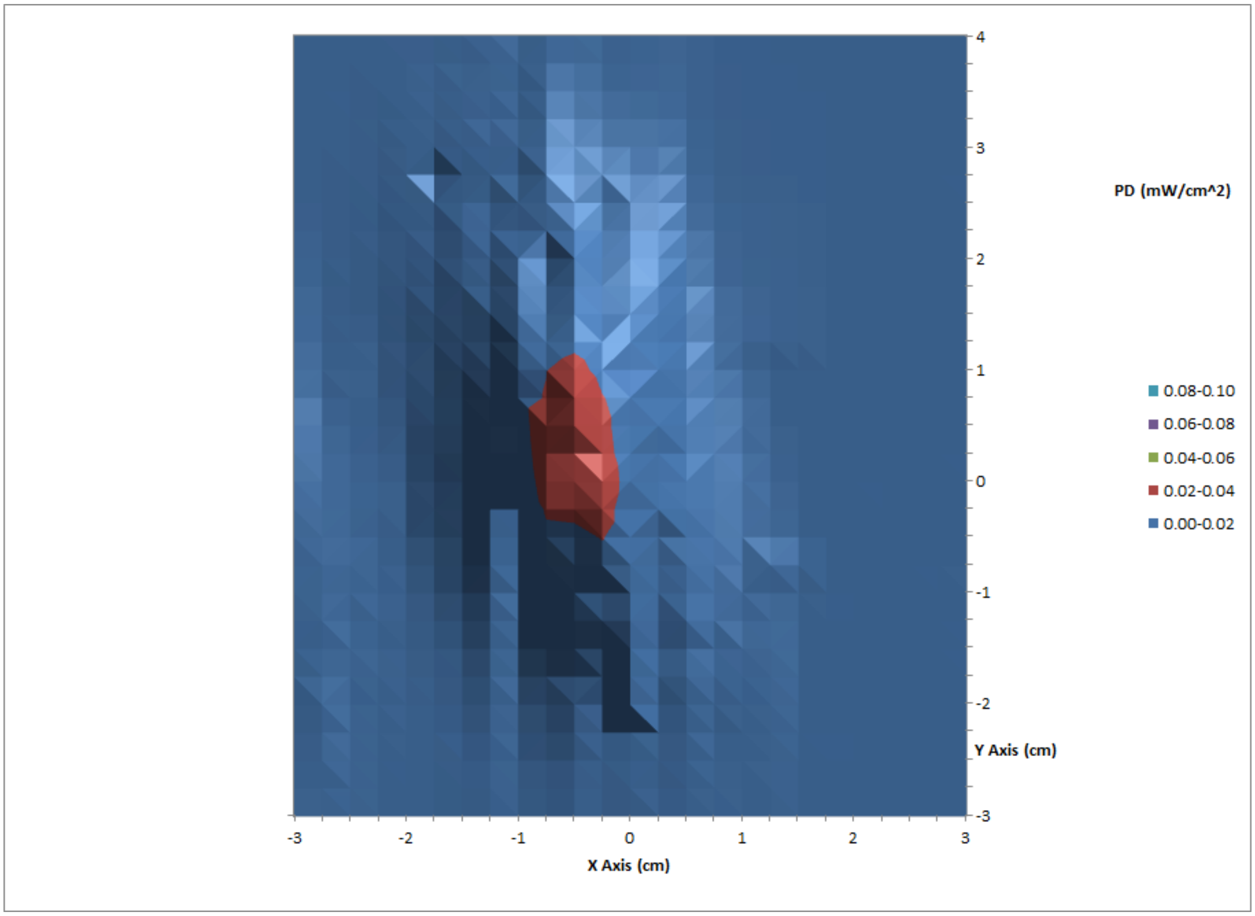


Z Axis Power Density Surface View

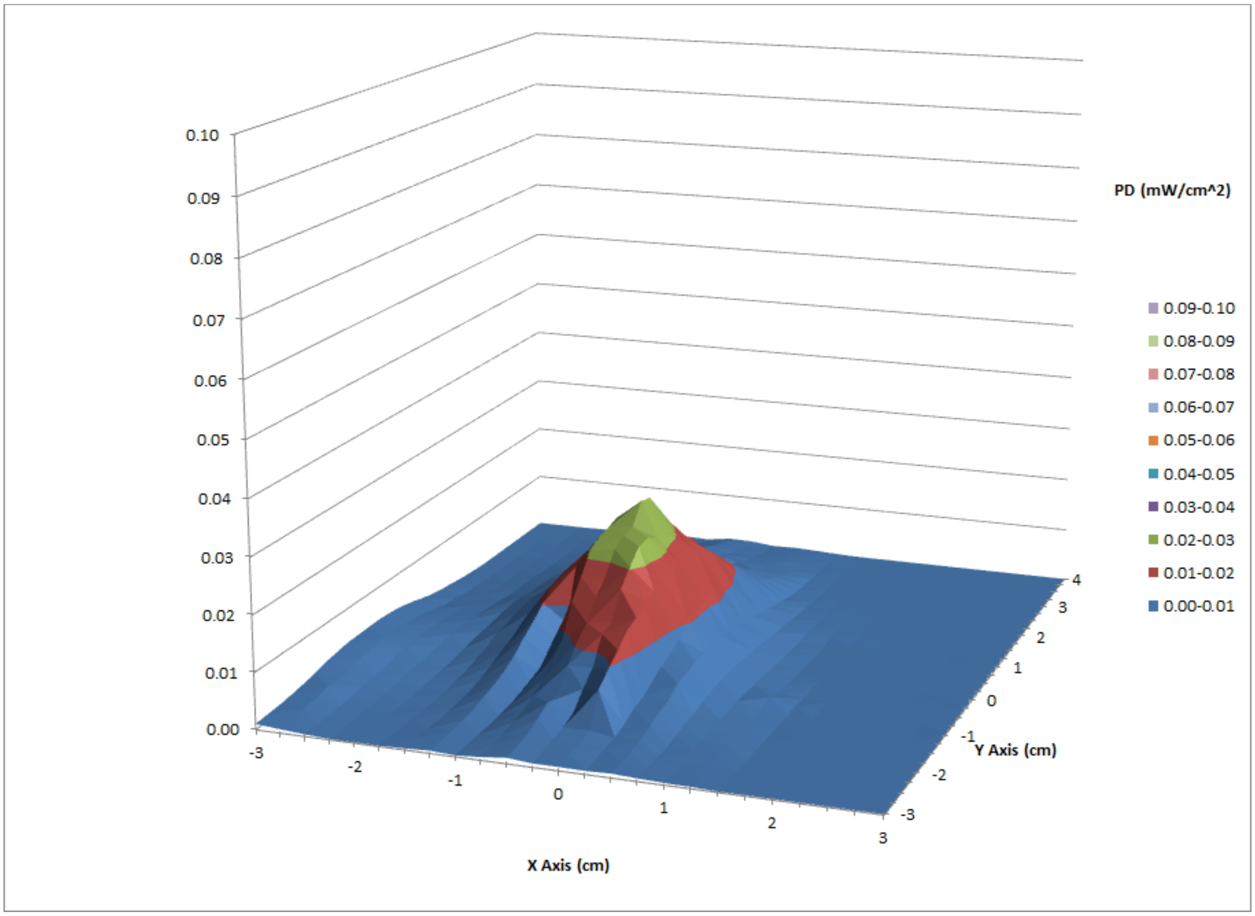


7.7.3. X AXIS PLOTS

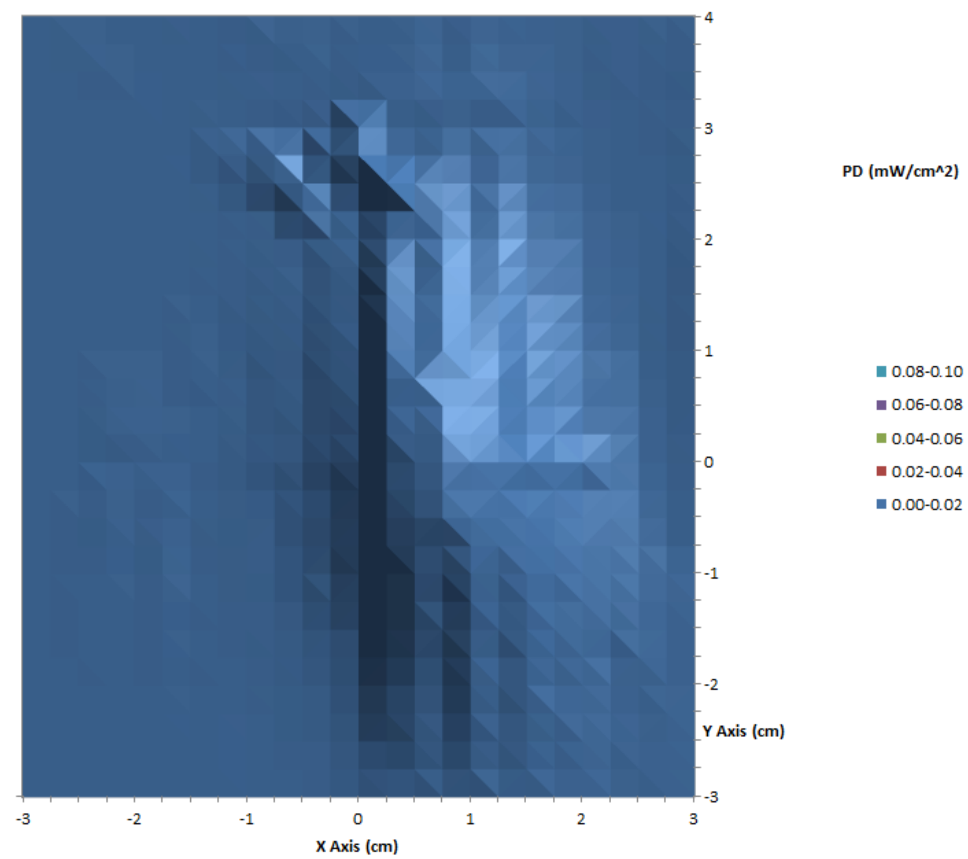
-X Axis Power Density Contour



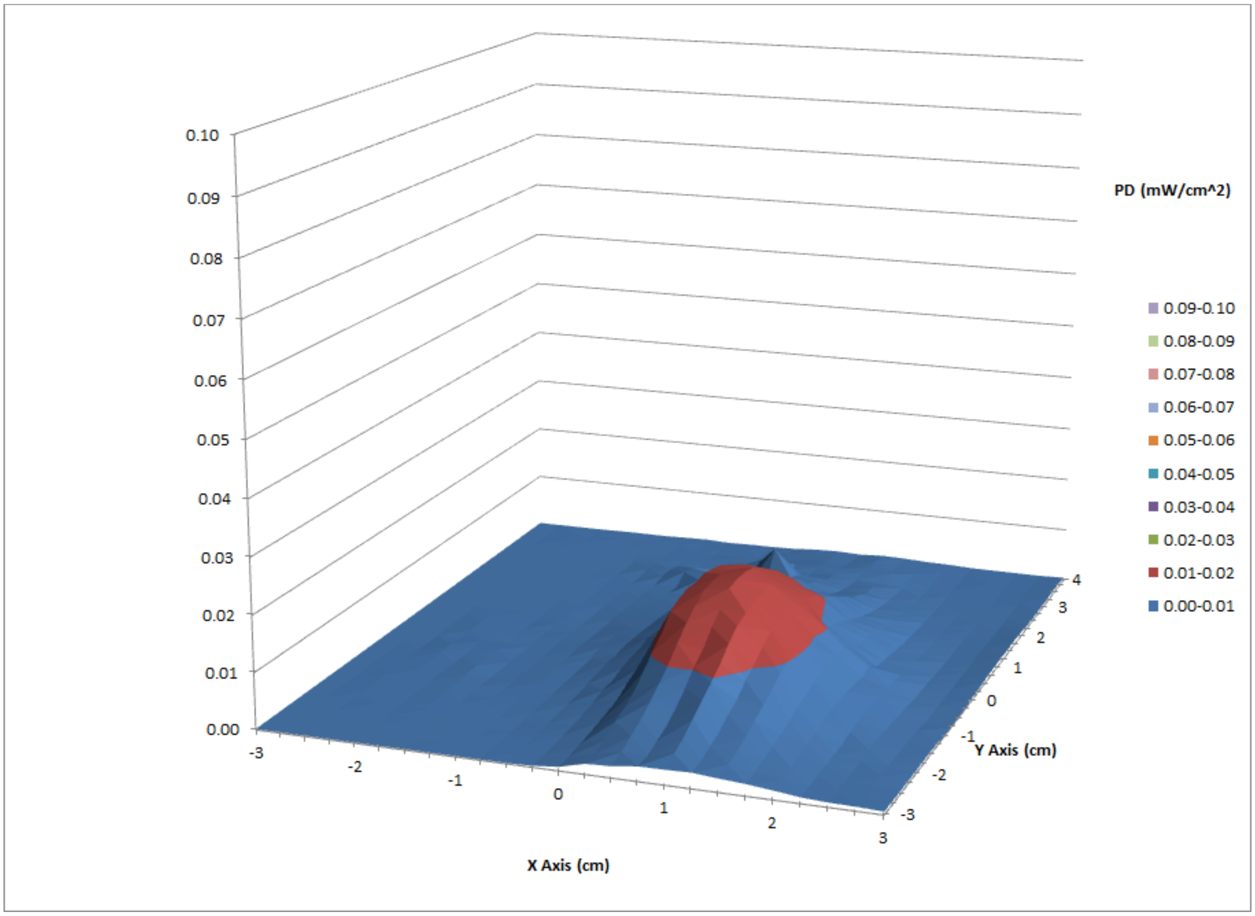
-X Axis Power Density Surface View



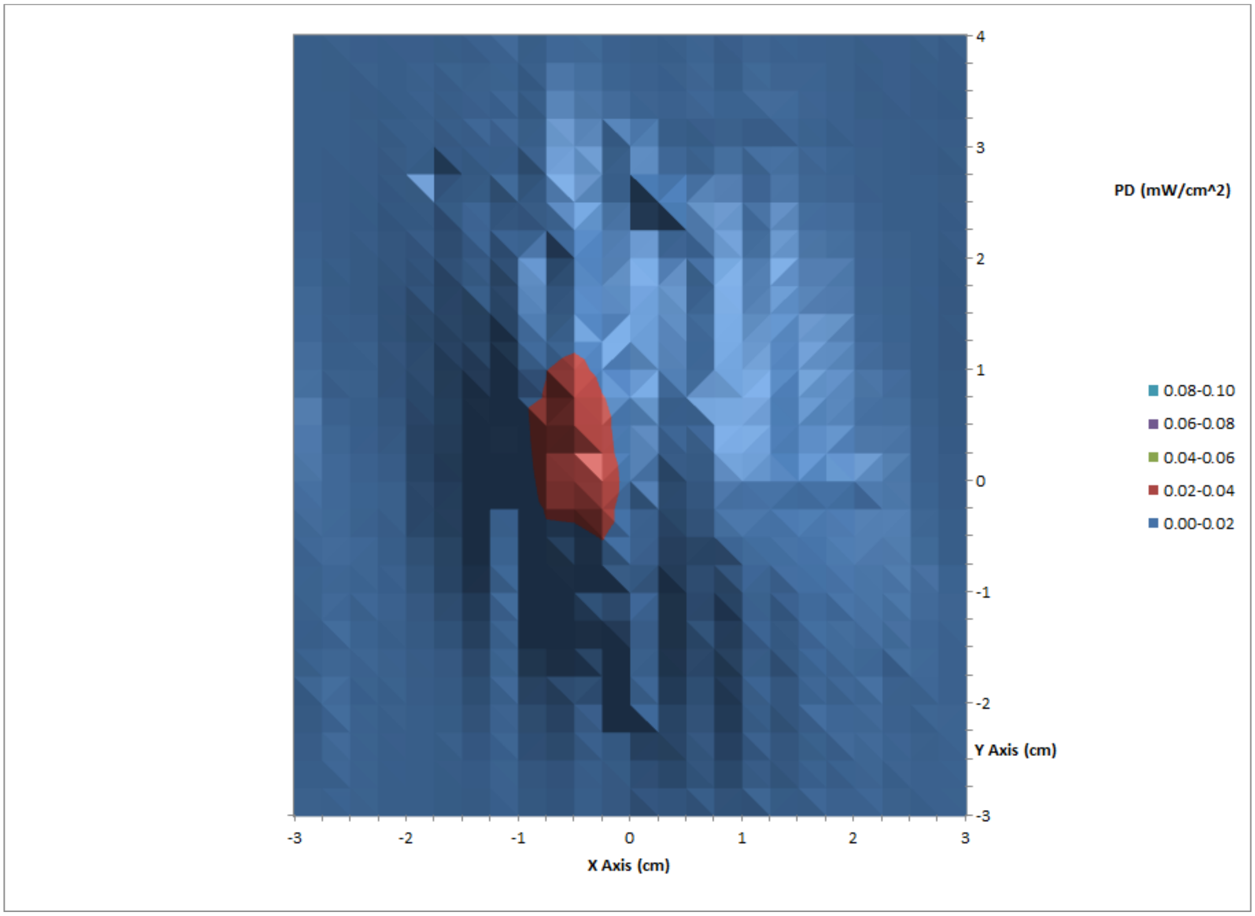
+X Axis Power Density Contour



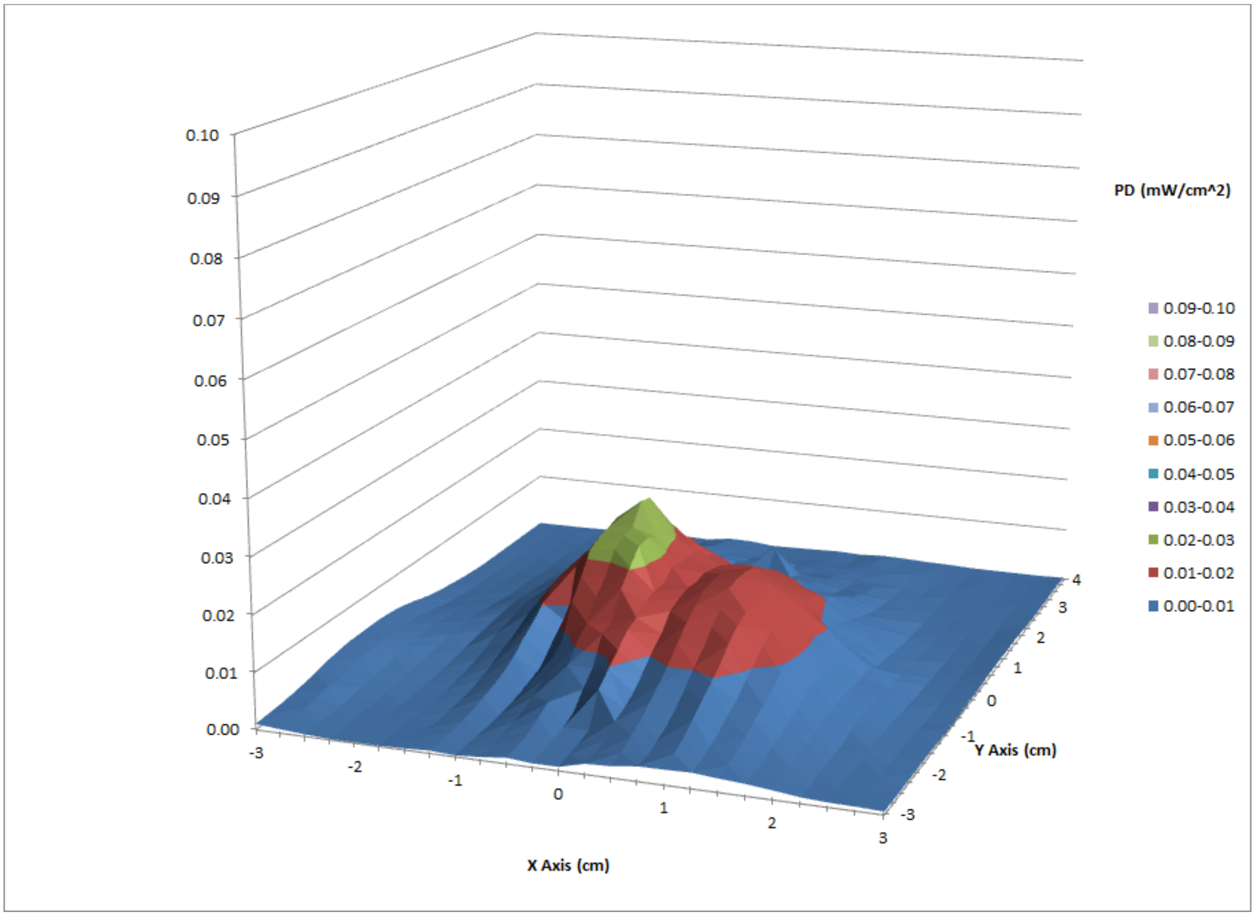
+X Axis Power Density Surface View



X Axis Maximum Power Density Contour

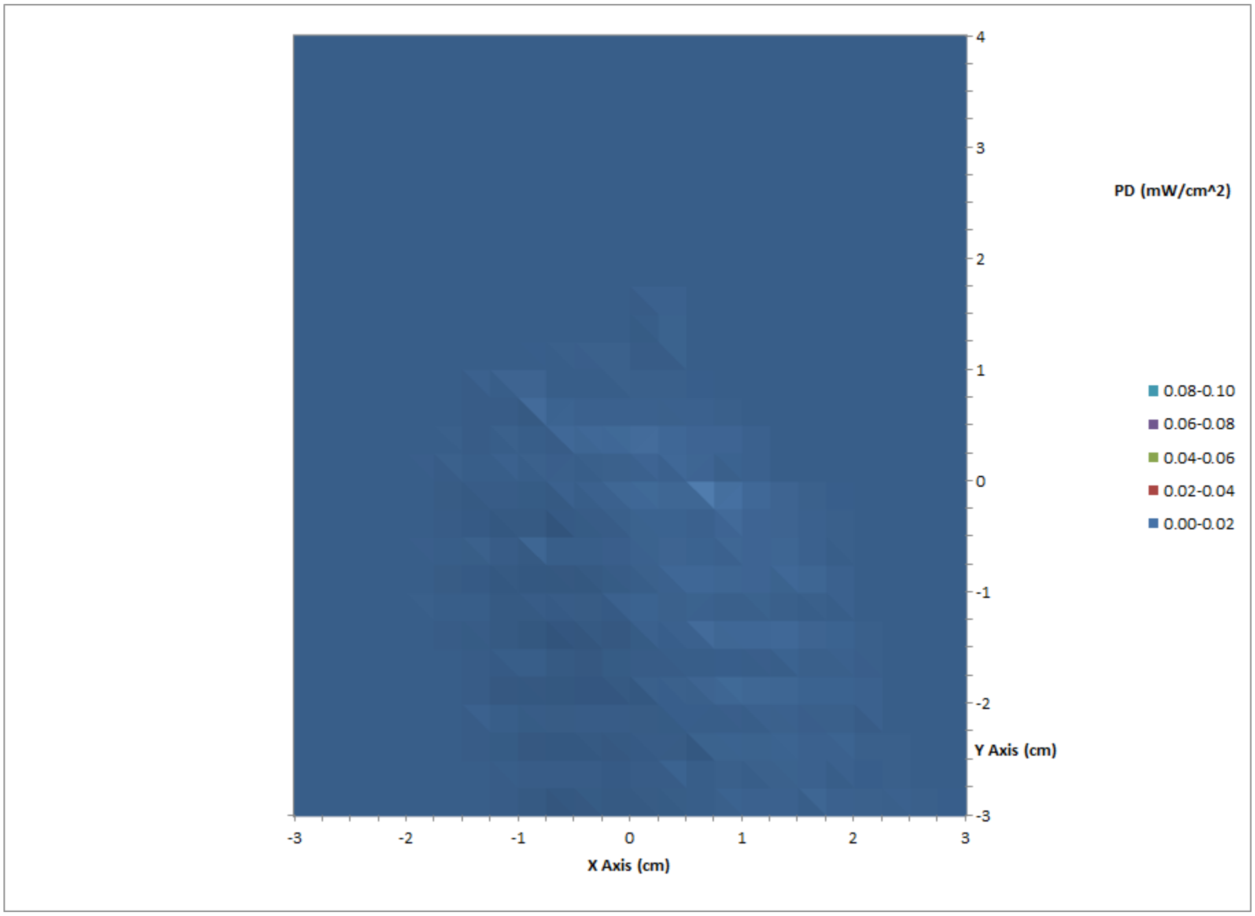


X Axis Maximum Power Density Surface View

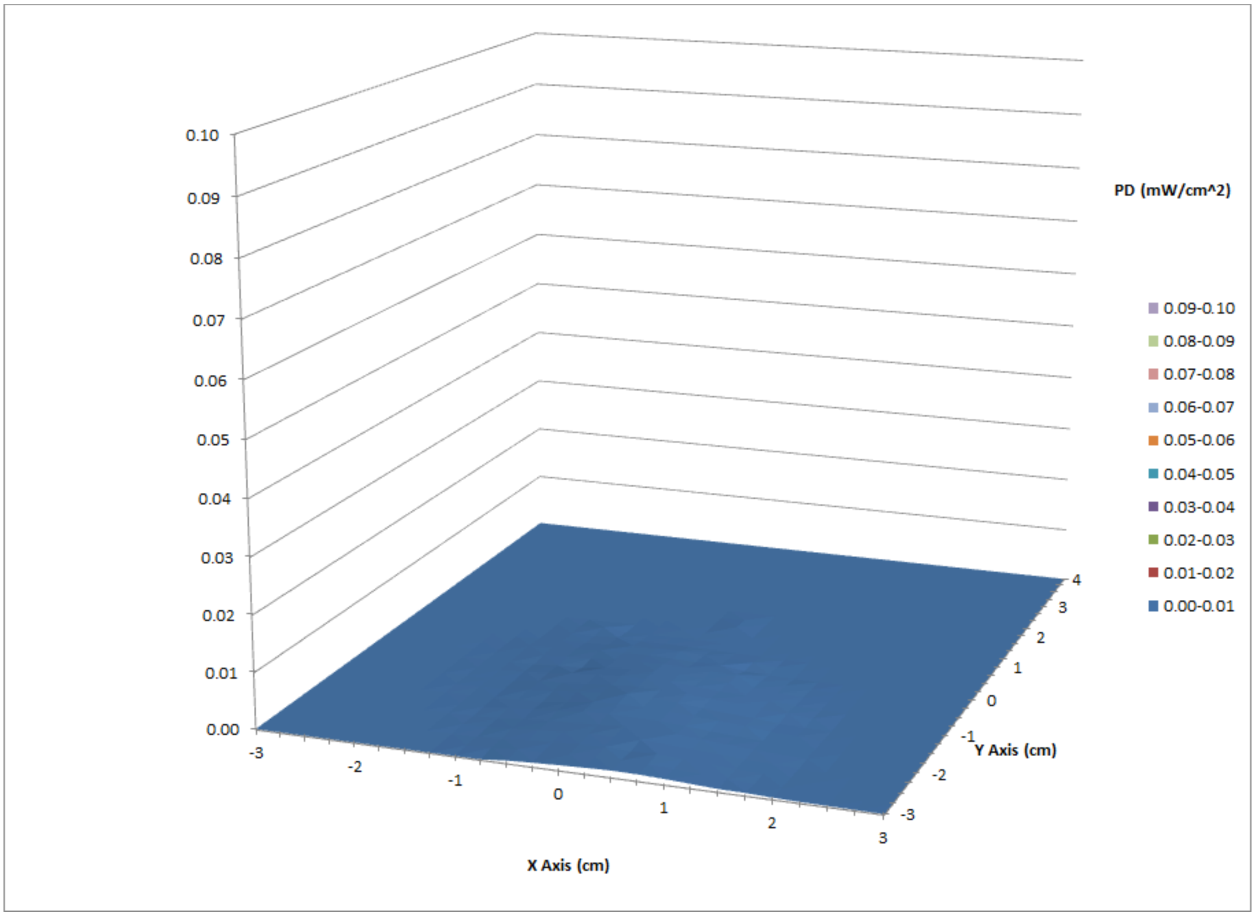


7.7.4. Y AXIS PLOTS

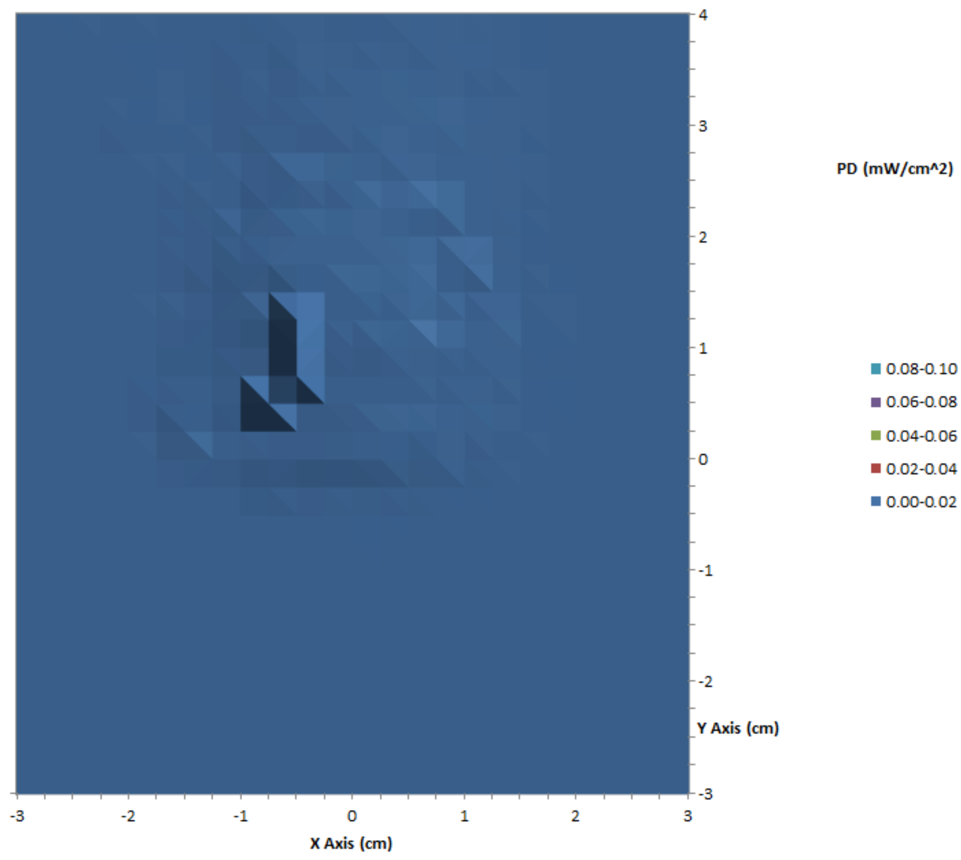
-Y Axis Power Density Contour



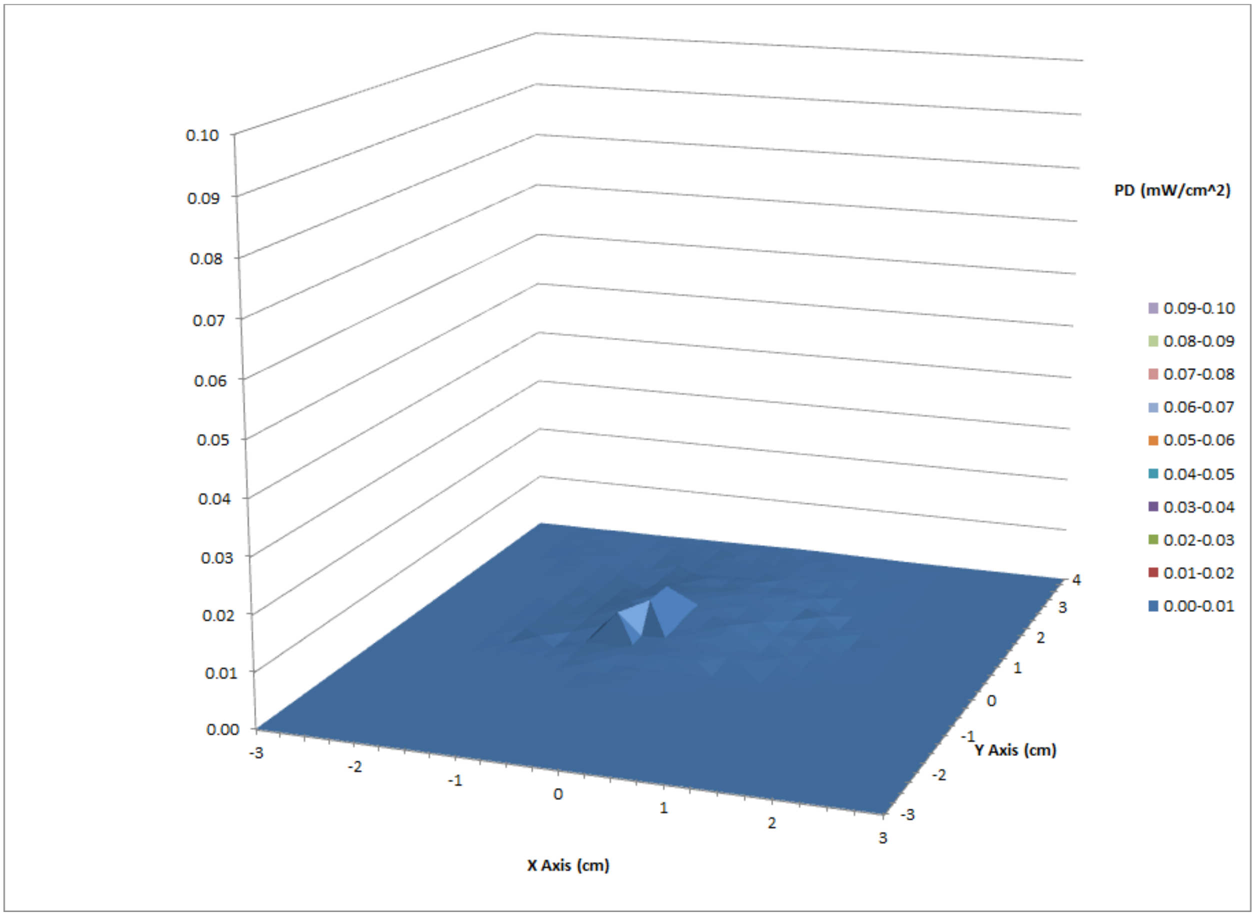
-Y Axis Power Density Surface View



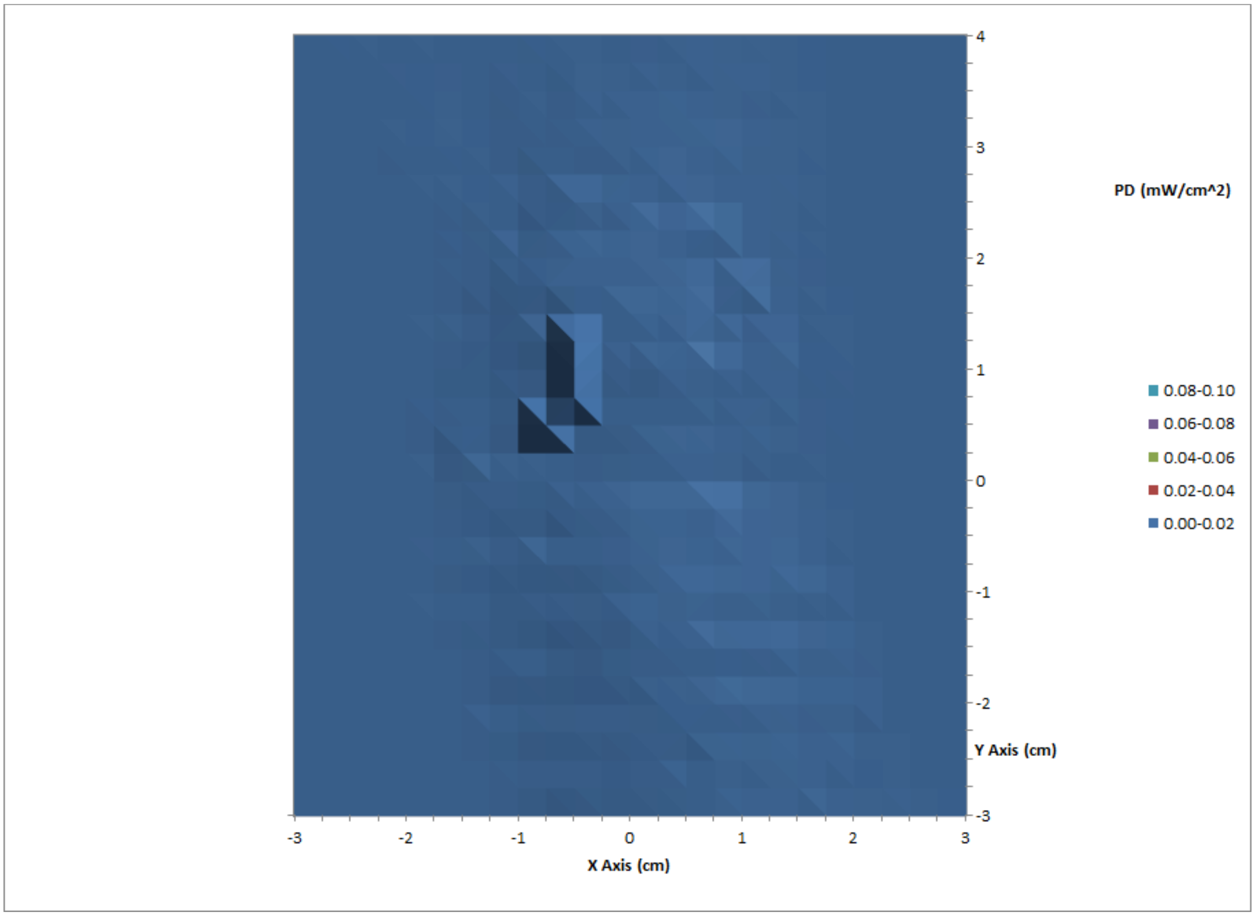
+Y Axis Power Density Contour



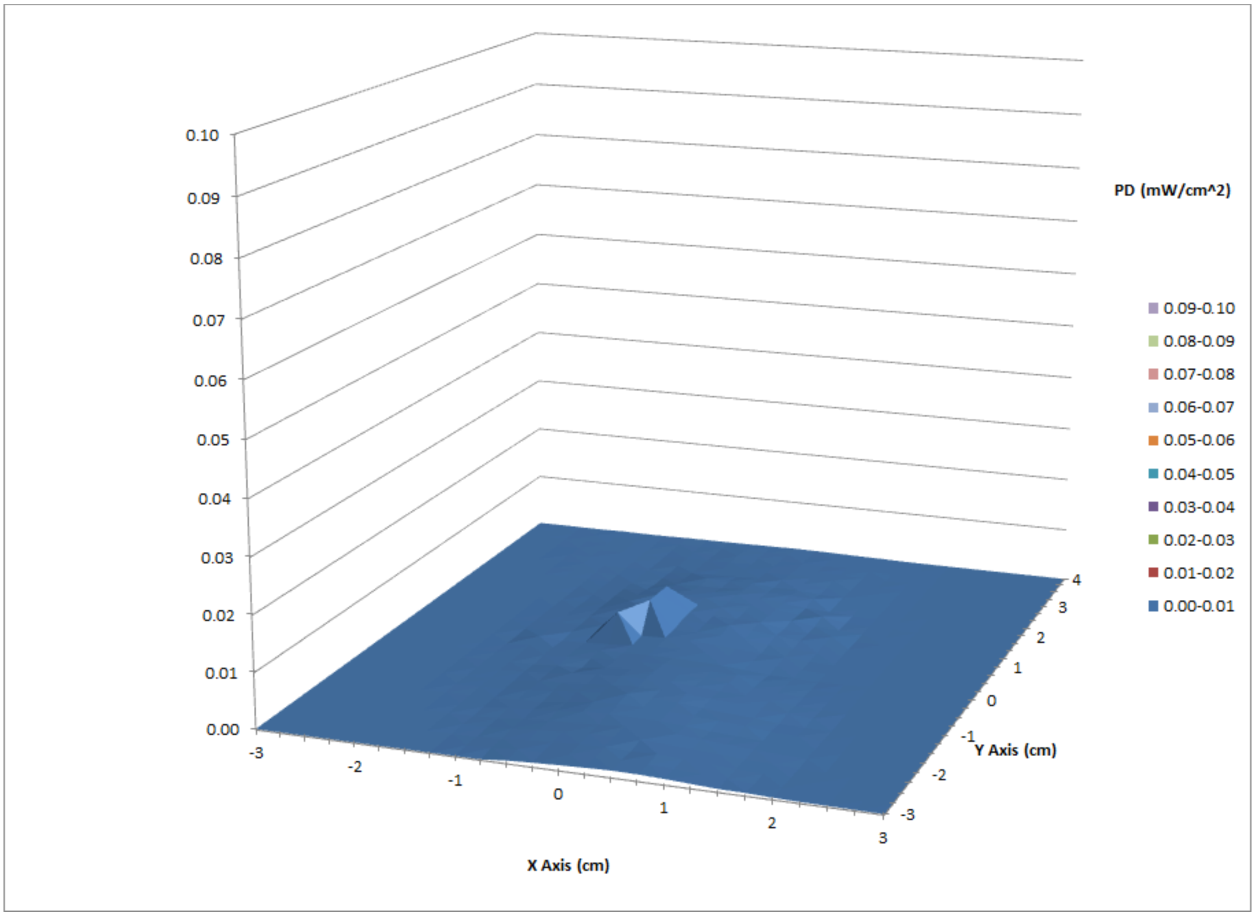
+Y Axis Power Density Surface View



Y Axis Maximum Power Density Contour



Y Axis Maximum Power Density Surface View



8. APERTURE PROBE ANTENNA

8.1. DESCRIPTION OF ANTENNA

The measuring antenna is an open-ended waveguide as specified in IEEE Std C95.3-2002 Clause 5.5.1.1.3 Small apertures. The aperture probe antenna consists of a 20 cm straight section of WR15 rectangular waveguide with a standard UG-385/U flange at one end.

Several improvements to the basic design have been made.

The aperture end is tapered to reduce diffraction and scattering.

An isolator is connected to the output of the probe to reduce reflections and improve matching.

A low noise amplifier (LNA) is connected to the output of the isolator to increase the system sensitivity.

A 16 cm long absorber sleeve is wrapped around the probe to minimize reflections, scattering and coupling. The placement of the absorber sleeve along the probe is optimized by varying the sleeve position upon setting up for the probe calibration. No difference in received power is observed as the sleeve is moved along the probe, as long as the end of the sleeve does not extend past the end of the probe. After the sleeve is extended beyond the probe tip, the power begins to drop. A repeatable sleeve position is established by aligning the end of the sleeve with the corner of the taper and the full-thickness portion of the rectangular waveguide.

8.2. DERIVATION OF CALIBRATION EQUATIONS

The far-field gain of the Aperture Probe is measured in accordance with IEEE Std C95.3-2002, “IEEE Recommended Practice for Measurements and Computations of Radio Frequency Electromagnetic Fields With Respect to Human Exposure to Such Fields, 100 kHz–300 GHz.”

IEEE Std C95.3, Clause 5.5.1.1.2 Antenna gain determination, states that the power transmitted between a pair of antennas is measured in the far field then apply C95.3 Equation (2), excerpted as follows:

$G_T * G_R = (P_R / P_T) * (4 * \pi * d / \lambda)^2$

Converting to the log form yields:

$G_T + G_R = P_R - P_T + 20*\text{Log}(4 * \pi * d / \lambda)$

$G_T + G_R = P_R - P_T + 21.98 + 20*\text{Log}(d) - 20*\text{Log}(\lambda)$

Denoting distance by D rather than d, and converting from wavelength in meters to frequency in GHz yields:

$G_T + G_R = P_R - P_T + 21.98 + 20*\text{Log}(D) - 20*\text{Log}(0.3 / f)$

$G_T + G_R = P_R - P_T + 32.44 + 20*\text{Log}(D) + 20*\text{Log}(f)$ Equation (1)

Where

G_T is the gain of the transmit antenna (dBi)
G_R is the gain of the receive antenna (dBi)
P_R is the power received (dBm)
P_T is the power transmitted (dBm)
D is the distance between the antennas (m)
f is the frequency (GHz)

Although a single path loss measurement of (P_R - P_T) is insufficient to solve for two unknowns G_T and G_R, the individual far-field gain of each of three different antennas is determined from three path loss measurements made under identical far-field conditions using the three different antennas taken in pairs. Three path loss measurements (P_{R12} - P_T), (P_{R13} - P_T) and (P_{R23} - P_T) are sufficient to simultaneously solve for three unknowns G_1, G_2 and G_3.

Equation (1) is applied to each of the three path loss measurements as follows:

$(G_1 + G_2) = (P_{R12} - P_T) + 32.44 + 20*\text{Log}(D) + 20*\text{Log}(f)$ Equation (2)

$(G_1 + G_3) = (P_{R13} - P_T) + 32.44 + 20*\text{Log}(D) + 20*\text{Log}(f)$ Equation (3)

$(G_2 + G_3) = (P_{R23} - P_T) + 32.44 + 20*\text{Log}(D) + 20*\text{Log}(f)$ Equation (4)

Where

$(G_1 + G_2)$ is the sum of the gains of Antennas 1 and 2
$(G_1 + G_3)$ is the sum of the gains of Antennas 1 and 3
$(G_2 + G_3)$ is the sum of the gains of Antennas 2 and 3
P_{R12} is the power received when measuring Antennas 1 and 2 (dBm)
P_{R13} is the power received when measuring Antennas 1 and 3 (dBm)
P_{R23} is the power received when measuring Antennas 2 and 3 (dBm)
P_T is the power transmitted (dBm)
D is the distance between the antennas (m)
f is the frequency (GHz)

The gain of each individual antenna is calculated as follows:

$G_1 = [(G_1 + G_2) + (G_1 + G_3) - (G_2 + G_3)] / 2$ Equation (5)

$G_2 = [(G_1 + G_2) + (G_2 + G_3) - (G_1 + G_3)] / 2$ Equation (6)

$G_3 = [(G_1 + G_3) + (G_2 + G_3) - (G_1 + G_2)] / 2$ Equation (7)

Where:

G_1 is the gain of Antenna 1 (dBi)
G_2 is the gain of Antenna 2 (dBi)
G_3 is the gain of Antenna 3 (dBi)
$(G_1 + G_2)$ is the result of applying Equation (2)
$(G_1 + G_3)$ is the result of applying Equation (3)
$(G_2 + G_3)$ is the result of applying Equation (4)

8.3. CALIBRATION PROCEDURE

1. Allow the signal source, power sensor and power meter to warm up as specified by the manufacturer of the instruments.

2. Adjust the instruments to the applicable frequency. Connect the power sensor to the output of the source. Measure and record Power Transmitted.

3. Connect the first pair of antennas to their respective source (Tx antenna) and power sensor (Rx antenna). Place the antennas at the selected far-field separation distance in a bore-sight configuration using a laser level to align the antennas. Measure and record Power Received.

4. Repeat step 3 for each pair of antennas.

5. Calculate the antenna gains by applying Equations (2) through (7).

8.4. CALIBRATION RESULTS

8.4.1. FAR-FIELD DISTANCE

IEEE Std C95.3 Clause 5.5.1.1.2 Figure 5 gives the estimated gain reduction (relative to the far-field gain G_∞) of an antenna as a function of normalized distance. The normalized distance is given in terms of $n = d\lambda/a^2$ where d is distance, λ is wavelength and a is the largest aperture dimension. IEEE Std C95.3 further states that the far-field gain holds for distances greater than about $(8a^2)/\lambda$ ($n > 8$).

For WR15 waveguide, a = 0.0038 m

For Channel 1 (58.32 GHz), λ = 0.0051 m, thus a^2/λ = 0.0028 m

For Channel 2 (60.48 GHz), λ = 0.0050 m, thus a^2/λ = 0.0029 m

For Channel 3 (62.64 GHz), λ = 0.0048 m, thus a^2/λ = 0.0030 m

The probe is calibrated in the far field at a 0.1 m distance, corresponding to normalized distances as follows:

$(35.6a^2)/\lambda$ ($n > 35$) for 58.32 GHz

$(34.5a^2)/\lambda$ ($n > 34$) for 60.48 GHz

$(33.3a^2)/\lambda$ ($n > 33$) for 62.64 GHz

The selected calibration distance of 0.1 m is greater than the minimum distance indicated by IEEE Std C95.3.

8.4.2. STANDALONE PROBE

Distance (m) --->			0.1
Channel	Freq (GHz)	Power Tx (dBm)	Free Space Path Loss = 32.44 + 20*Log (D) + 20*Log (f) (dB)
1	58.32	11.62	47.76
2	60.48	11.65	48.07
3	62.64	12.29	48.38

Channel	Freq (GHz)	Tx Antenna	Rx Antenna	Power Rx (dBm)	Pr Minus Pt (dB)	Gain of Pair ([dBi]^2)
1	58.32	Probe Under Cal	Brass Probe 1	-24.16	-35.78	11.98
2	60.48	Probe Under Cal	Brass Probe 1	-23.68	-35.33	12.74
3	62.64	Probe Under Cal	Brass Probe 1	-25.06	-37.35	11.03
1	58.32	Brass Probe 2	Brass Probe 1	-24.55	-36.17	11.59
2	60.48	Brass Probe 2	Brass Probe 1	-24.22	-35.87	12.20
3	62.64	Brass Probe 2	Brass Probe 1	-24.47	-36.76	11.62
1	58.32	Brass Probe 2	Probe Under Cal	-23.96	-35.58	12.18
2	60.48	Brass Probe 2	Probe Under Cal	-23.45	-35.1	12.97
3	62.64	Brass Probe 2	Probe Under Cal	-24.61	-36.9	11.48

Channel	Freq (GHz)	Antenna	Gain (dBi)
1	58.32	Probe Under Cal	6.28
2	60.48	Probe Under Cal	6.76
3	62.64	Probe Under Cal	5.44
1	58.32	Brass Probe 1	5.69
2	60.48	Brass Probe 1	5.99
3	62.64	Brass Probe 1	5.58
1	58.32	Brass Probe 2	5.89
2	60.48	Brass Probe 2	6.22
3	62.64	Brass Probe 2	6.03

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8.4.3. PROBE/ISOLATOR/LNA ASSEMBLY

The aperture probe antenna is configured as a receive-only antenna assembly consisting of the WR15 Aperture Probe, Isolator, LNA and Absorber Sleeve.

		Distance (m) --->	0.1
Channel	Freq (GHz)	Power Tx (dBm)	Free Space Path Loss = 32.44 + 20*Log (D) + 20*Log (f) (dB)
1	58.32	10.39	47.76
2	60.48	10.52	48.07
3	62.64	11.11	48.38

Channel	Freq (GHz)	Tx Antenna	Rx Antenna	Power Rx (dBm)	Pr Minus Pt (dB)	Gain of Pair ([dBi]^2)
1	58.32	Brass Probe 1	Brass Probe 2	-25.6	-35.99	11.77
2	60.48	Brass Probe 1	Brass Probe 2	-25.84	-36.36	11.71
3	62.64	Brass Probe 1	Brass Probe 2	-25.45	-36.56	11.82
1	58.32	Brass Probe 1	Probe Under Cal	-5.41	-15.8	31.96
2	60.48	Brass Probe 1	Probe Under Cal	-6.01	-16.53	31.54
3	62.64	Brass Probe 1	Probe Under Cal	-6.75	-17.86	30.52
1	58.32	Brass Probe 2	Probe Under Cal	-5.46	-15.85	31.91
2	60.48	Brass Probe 2	Probe Under Cal	-5.72	-16.24	31.83
3	62.64	Brass Probe 2	Probe Under Cal	-6.01	-17.12	31.26

Channel	Freq (GHz)	Antenna	Gain (dBi)	Isolator/LNA Gain (dB)	Effective Gain of Probe (dBi)
1	58.32	Probe Under Cal	26.05	17.78	8.27
2	60.48	Probe Under Cal	25.83	17.78	8.05
3	62.64	Probe Under Cal	24.98	17.45	7.53
1	58.32	Brass Probe 1	5.91		
2	60.48	Brass Probe 1	5.71		
3	62.64	Brass Probe 1	5.54		
1	58.32	Brass Probe 2	5.86		
2	60.48	Brass Probe 2	6.00		
3	62.64	Brass Probe 2	6.28		

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8.5. VALIDATION OF EQUATIONS AND DESIGN CHANGE

8.5.1. VALIDATION OF EQUATIONS

The measured gain of the original probe antenna is compared to the realized gain from a theoretical model of an open ended V-band rectangular waveguide provided by Zhong Chen of ETS-Lindgren.

Frequency (GHz)	Measured Gain Standalone Probe (dBi)	Theoretical Model Gain Standalone Probe (dBi)	Delta to Model (dB)
58.32	6.3	6.1	0.2
60.48	6.8	6.3	0.5
62.64	5.4	6.5	-1.1
		Average Delta to Model (dB)	-0.1

8.5.2. VALIDATION OF DESIGN CHANGE

The effectiveness of the isolator is validated by comparing the gain measured with and without the isolator. Since the received power increases when reflections are reduced and matching is improved, an increase in the measured antenna gain indicates that the isolator is effective.

Frequency (GHz)	Effective Gain of Probe (Less Isolator & LNA) (dBi)	Measured Gain of Standalone Probe (dB)	Gain Increase (dB)
58.32	8.3	6.3	2.0
60.48	8.1	6.8	1.3
62.64	7.5	5.4	2.1
		Average Gain Increase (dB)	1.8