



# APPLICATION SPECIFICATION

## TITLE

### WIFI 6E FLEX CABLED SIDE-FED ANTENNA

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REVISION:	ECR/ECN INFORMATION:	TITLE:	SHEET No.
<b>E</b>	EC No: 644338 DATE: 2020/08/31	<b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	<b>1 of 32</b>
DOCUMENT NUMBER:	CREATED / REVISED BY:	CHECKED BY:	APPROVED BY:
<b>AS-2069940100</b>	Hai Liu 2020/08/31	Cheng Kang 2020/08/31	Andy Zhang 2020/08/31



# APPLICATION SPECIFICATION

## WIFI 6E FLEX CABLED SIDE-FED ANTENNA

### 1.0 SCOPE

This specification describes the antenna application and surrounding. The information in this document is for reference and benchmark purposes only. The user is responsible for validating antenna RF performance based on the user's actual implementation.

Antenna illustrations in this document are generic representations. They are not intended to be an image of any antenna listed in the scope.

### 2.0 PRODUCT DESCRIPTION

#### 2.1 PRODUCT NAME AND SERIES NUMBER (S)

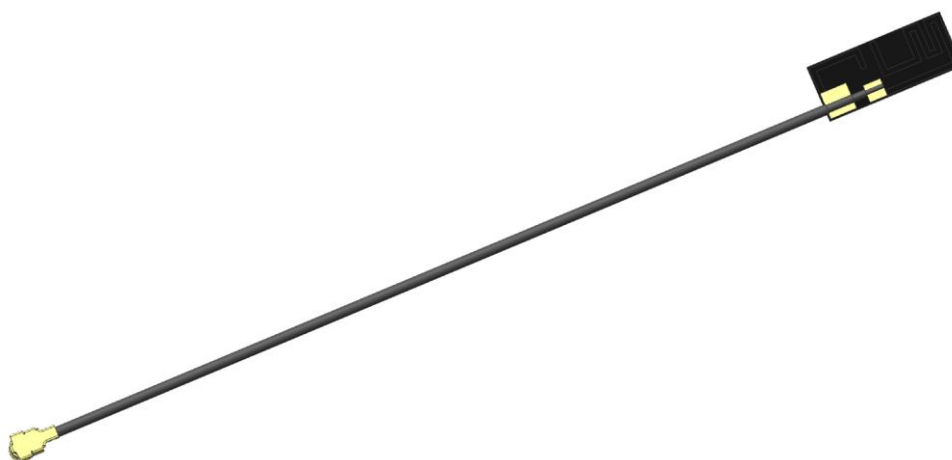
Product name: WiFi 6E Flex Cabled Side-fed Antenna  
Series Number: 206994

#### 2.2 DESCRIPTION

Series 206994 is a small monopole flexible antenna for 2.4/5/6GHz dual band. This antenna is made from poly-flexible material with small size 15.4\*6.4\*0.15mm, and has double-sided adhesive tape for easy "peel and stick" mounting.

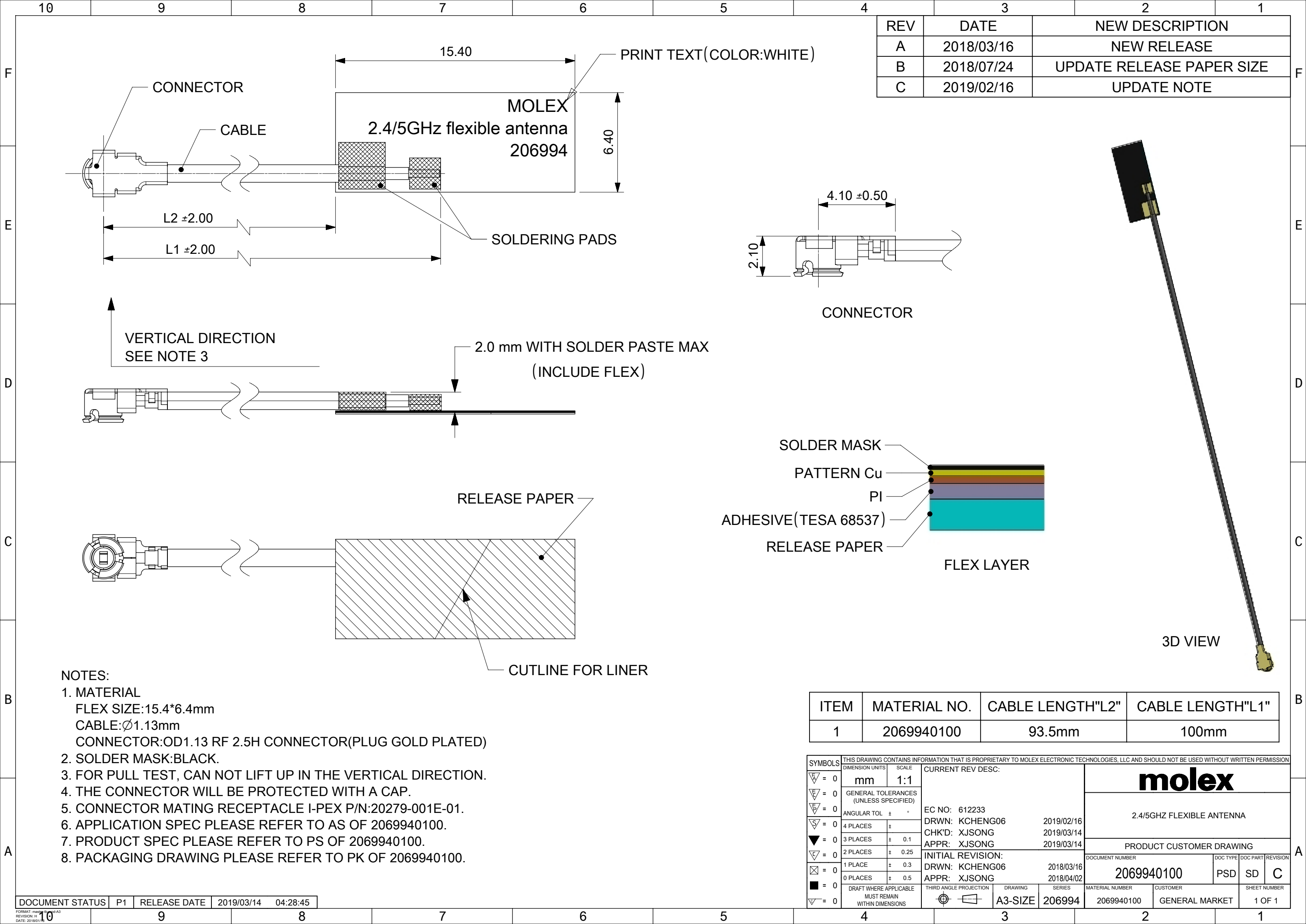
#### 2.3 PRODUCT STRUCTURE INFORMATION

Please refer to PS-2069940100 for full information.

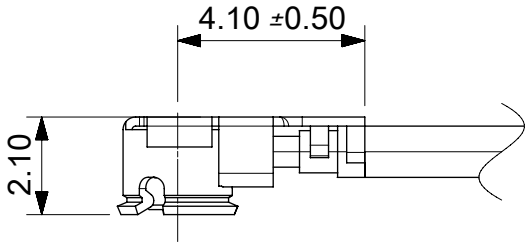


Molex Antenna 3D View

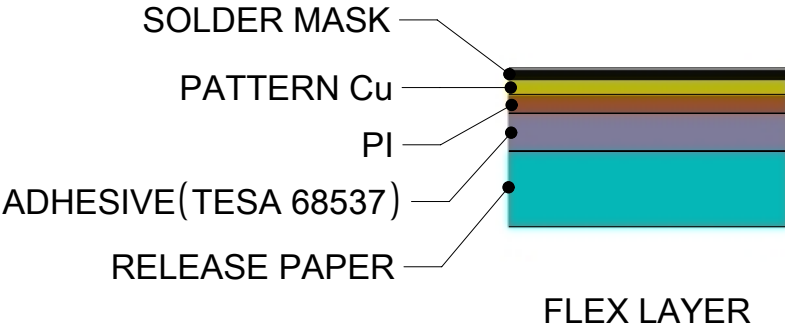
REVISION: <b>E</b>	ECR/ECN INFORMATION: EC No: 644338 DATE: 2020/08/31	TITLE: <b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	SHEET No. <b>2 of 32</b>
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REV	DATE	NEW DESCRIPTION
A	2018/03/16	NEW RELEASE
B	2018/07/24	UPDATE RELEASE PAPER SIZE
C	2019/02/16	UPDATE NOTE



CONNECTOR



3D VIEW

- NOTES:
1. MATERIAL  
FLEX SIZE:15.4\*6.4mm  
CABLE:Ø1.13mm  
CONNECTOR:OD1.13 RF 2.5H CONNECTOR(PLUG GOLD PLATED)
  2. SOLDER MASK:BLACK.
  3. FOR PULL TEST, CAN NOT LIFT UP IN THE VERTICAL DIRECTION.
  4. THE CONNECTOR WILL BE PROTECTED WITH A CAP.
  5. CONNECTOR MATING RECEPTACLE I-PEX P/N:20279-001E-01.
  6. APPLICATION SPEC PLEASE REFER TO AS OF 2069940100.
  7. PRODUCT SPEC PLEASE REFER TO PS OF 2069940100.
  8. PACKAGING DRAWING PLEASE REFER TO PK OF 2069940100.

ITEM	MATERIAL NO.	CABLE LENGTH"L2"	CABLE LENGTH"L1"
1	2069940100	93.5mm	100mm

SYMBOLS	THIS DRAWING CONTAINS INFORMATION THAT IS PROPRIETARY TO MOLEX ELECTRONIC TECHNOLOGIES, LLC AND SHOULD NOT BE USED WITHOUT WRITTEN PERMISSION		CURRENT REV DESC:				molex			
	DIMENSION UNITS	SCALE								
▽ = 0	mm	1:1	GENERAL TOLERANCES (UNLESS SPECIFIED)				EC NO: 612233 DRWN: KCHENG06 2019/02/16 CHK'D: XJSONG 2019/03/14 APPR: XJSONG 2019/03/14			
▽ = 0										
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▽ = 0			INITIAL REVISION:				PRODUCT CUSTOMER DRAWING			
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▽ = 0										
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▽ = 0										
▽ = 0										
DOCUMENT STATUS			P1	RELEASE DATE	2019/03/14	04:28:45				

## 3.0 APPLICABLE DOCUMENTS

DOCUMENT	NUMBER	DESCRIPTION
Sale Drawing (SD)	SD-2069940100	Mechanical Dimension of the product
	SD-2069941100	
Product Specification (PS)	PS-2069940100	Product Specification
Packing Drawing (PK)	PK-2069940100	Product packaging specifications
	PK-2069941100	

## 4.0 ANTENNA PERFORMANCE

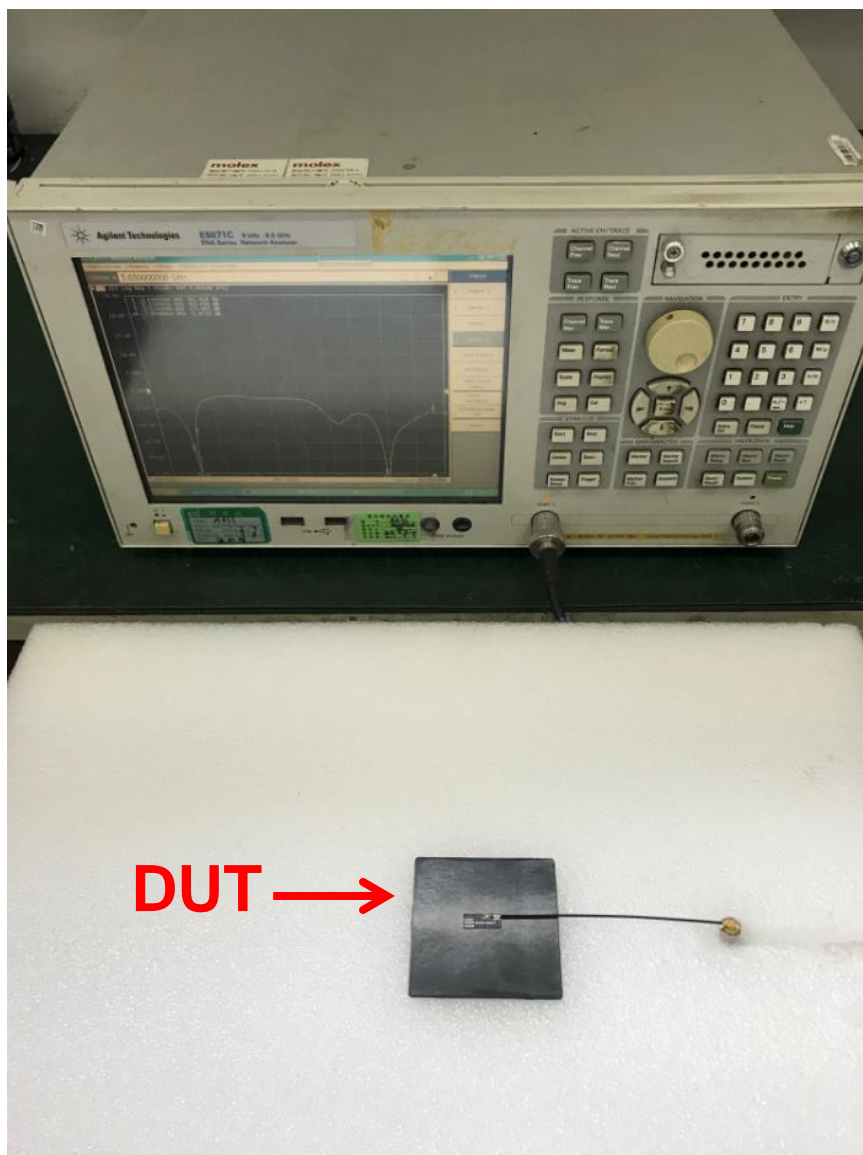
### 4.1 RF TEST CONDITIONS

All measurements are done of the antenna mounted on a PC/ABS material block of 1.5mm thickness with VNA Agilent E5071C and Over-The-Air (OTA) chamber. All measurements in this document are done with the part no.2069940100 with a cable length of 100mm.



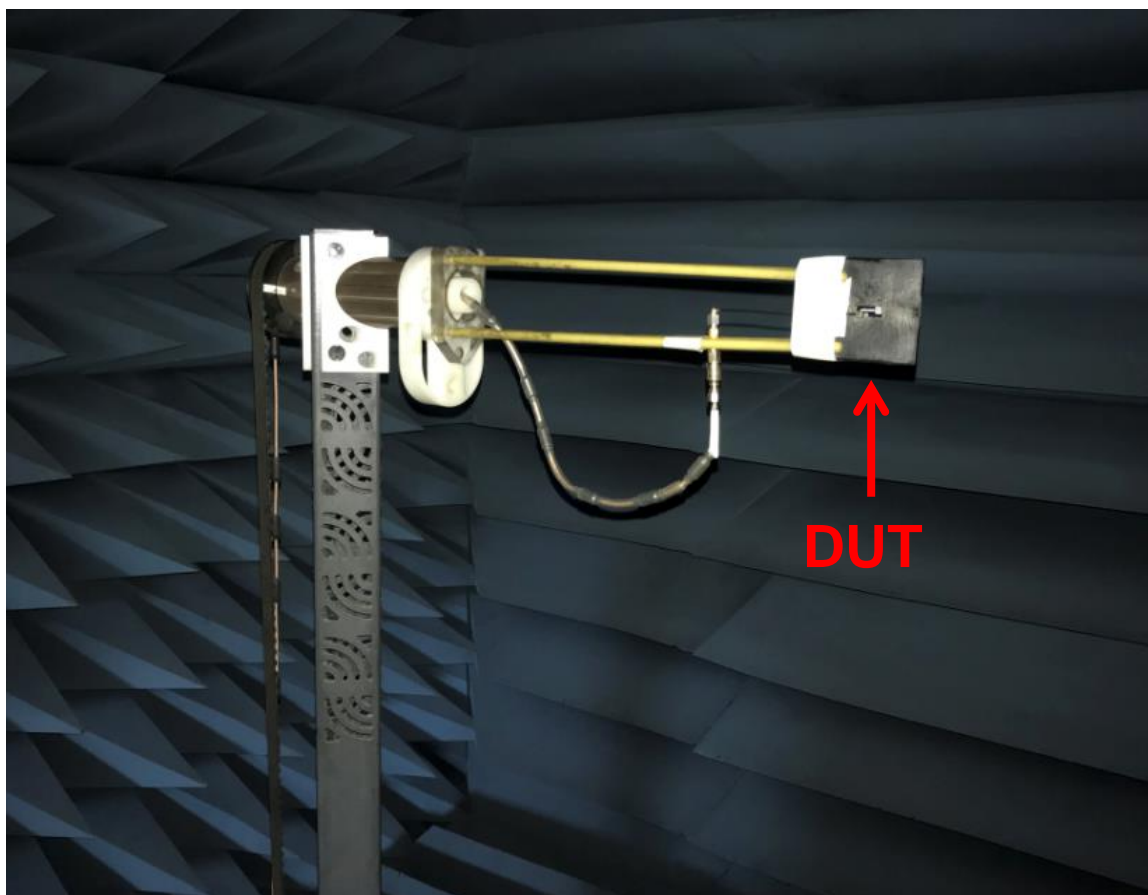
**FIGURE4.1.1 ANTENNA LOADED WITH PC/ABS BLOCK OF 1.5MM THICKNESS**

REVISION: <b>E</b>	ECR/ECN INFORMATION: EC No: 644338 DATE: 2020/08/31	TITLE: <b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	SHEET No. <b>3 of 32</b>
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**FIGURE4.1.2 ANTENNA LOADED WITH PC/ABS BLOCK OF 1.5MM THICKNESS  
TESTED WITH VNA E5071C**

REVISION: <b>E</b>	ECR/ECN INFORMATION: EC No: 644338 DATE: 2020/08/31	TITLE: <b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	SHEET No. <b>4 of 32</b>
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**FIGURE4.1.3 ANTENNA LOADED WITH PC/ABS BLOCK OF 1.5MM THICKNESS  
TESTED IN OTA CHAMBER**

<b>REVISION:</b>  <b>E</b>	<b>ECR/ECN INFORMATION:</b> <b>EC No:</b> 644338 <b>DATE:</b> 2020/08/31	<b>TITLE:</b> <b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>			<b>SHEET No.</b>  <b>5 of 32</b>
<b>DOCUMENT NUMBER:</b> <b>AS-2069940100</b>		<b>CREATED / REVISED BY:</b> Hai Liu 2020/08/31	<b>CHECKED BY:</b> Cheng Kang 2020/08/31	<b>APPROVED BY:</b> Andy Zhang 2020/08/31	



# APPLICATION SPECIFICATION

## 4.2 ANTENNA PERFORMANCE

DESCRIPTION	EQUIPMENT	REQUIREMENT		
Frequency Range	VNA E5071C	2.4-2.5GHz	5.15-5.85GHz	5.925-7.125GHz
Return Loss	VNA E5071C	< -10 dB	<-5dB	<-3dB
Peak Gain (Max)	OTA Chamber	3.6dBi	3.6dBi	2.7dBi
Average Total Efficiency	OTA Chamber	>55%	>70%	>40%
Polarization	OTA Chamber	Linear		
Input Impedance	VNA E5071C	50 ohms		

Note that the above antenna performance is measured with just the antenna mounted on a PC/ABS block to similar a free-space condition. When implement into the system, the frequency resonant might be off-tune due to the loading of surrounding components especially metal plane. This off-tune can be compensated through matching. Although module manufacturers specify a peak gain limit, it is based on free-space conditions. The peak gain will be degraded by 1 to 2dBi in the actual implementation as the radiation pattern will change due to the surround components. As such, during selection of antenna, you can select one with high peak gain to compensate for the loss. Molex can offer assistant to choose the best location and best tuning in-order to meet this peak gain requirement.

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DOCUMENT NUMBER:	CREATED / REVISED BY:	CHECKED BY:	APPROVED BY:
<b>AS-2069940100</b>	Hai Liu 2020/08/31	Cheng Kang 2020/08/31	Andy Zhang 2020/08/31

## 4.3 RETURN LOSS PLOT

All measurements in this document are done with a cable length of 100mm.

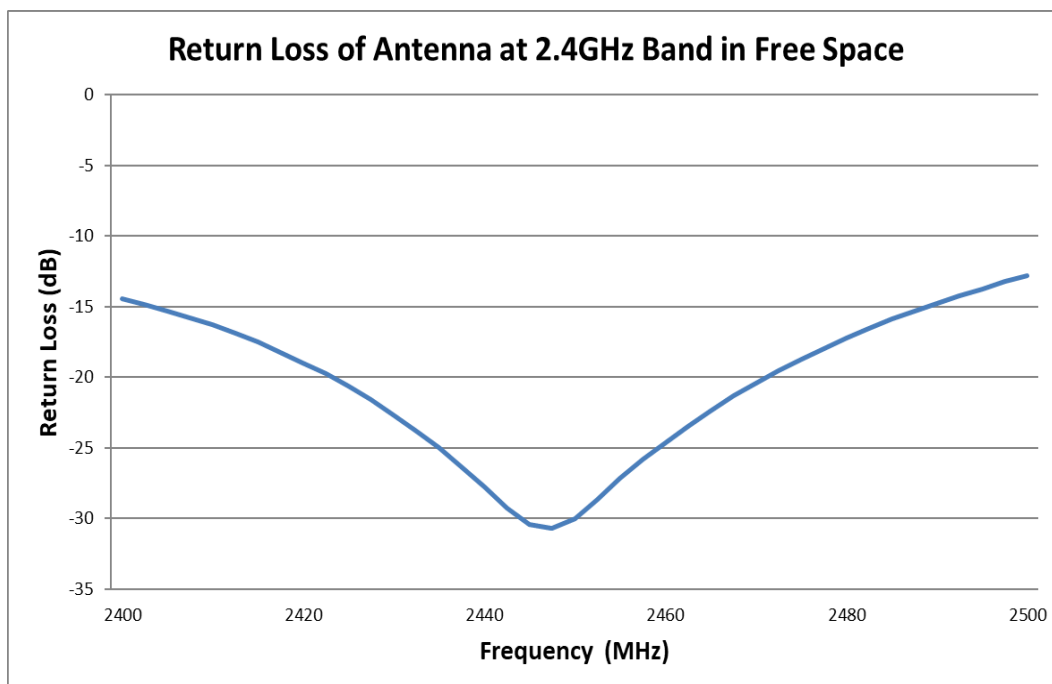


FIGURE 4.3.1 RETURN LOSS OF ANTENNA AT WIFI 2.4GHZ BAND IN FREE SPACE

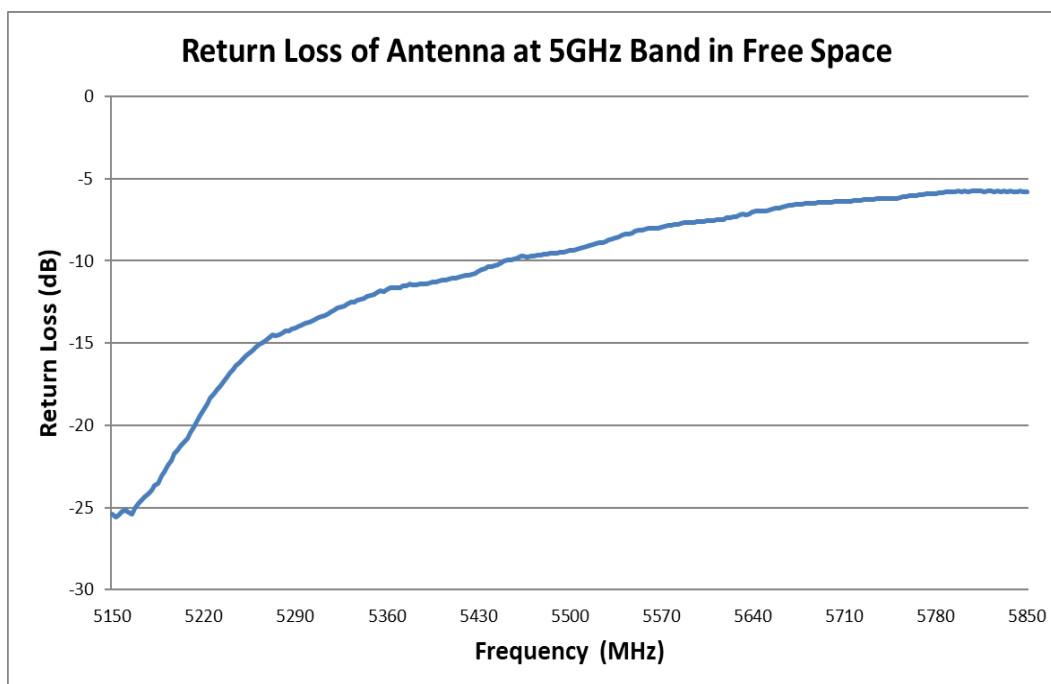
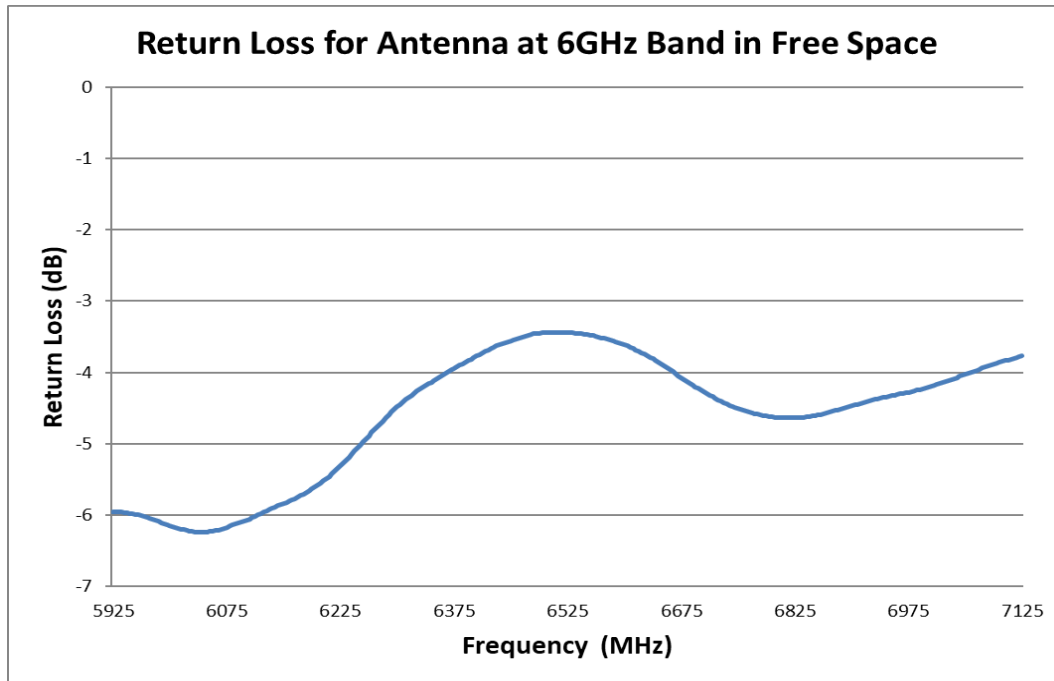


FIGURE 4.3.2 RETURN LOSS OF ANTENNA AT WIFI 5GHZ BAND IN FREE SPACE

REVISION: <b>E</b>	ECR/ECN INFORMATION: EC No: 644338 DATE: 2020/08/31	TITLE: <b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	SHEET No. <b>7 of 32</b>
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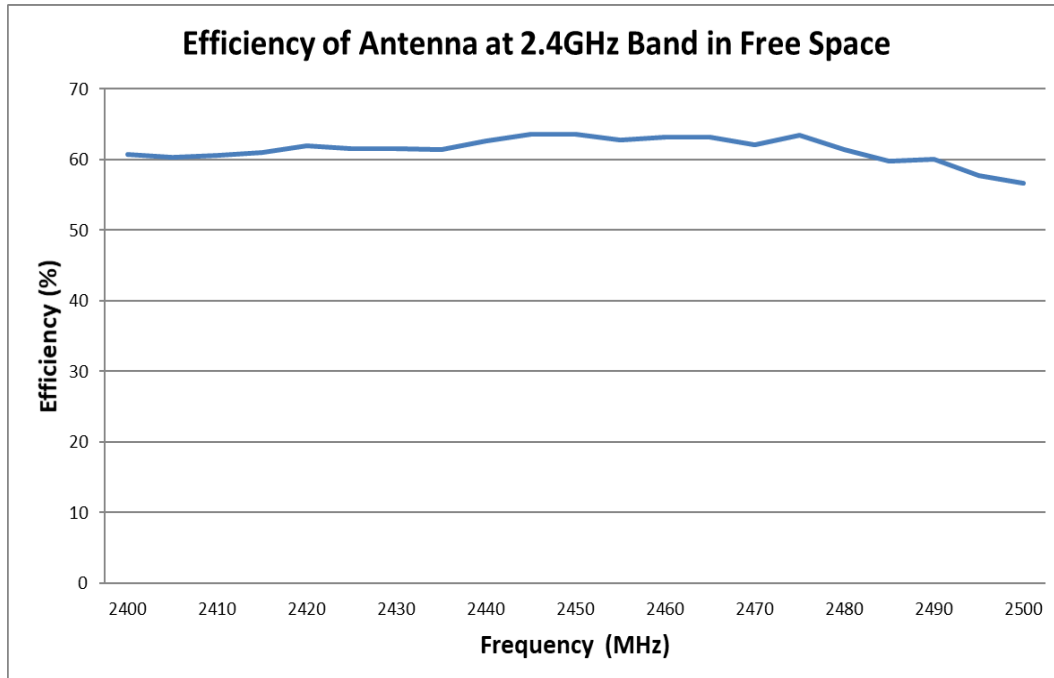




**FIGURE 4.3.3 RETURN LOSS OF ANTENNA AT WIFI 6GHZ BAND IN FREE SPACE**

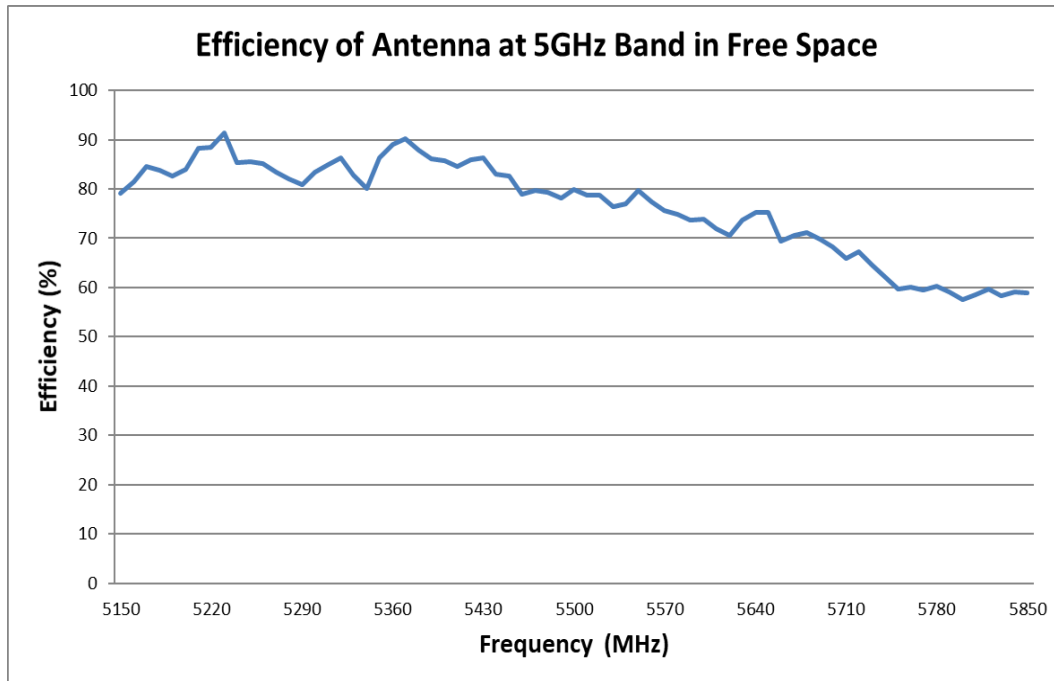
## 4.4 EFFICIENCY PLOT

All measurements in this document are done with a cable length of 100mm.

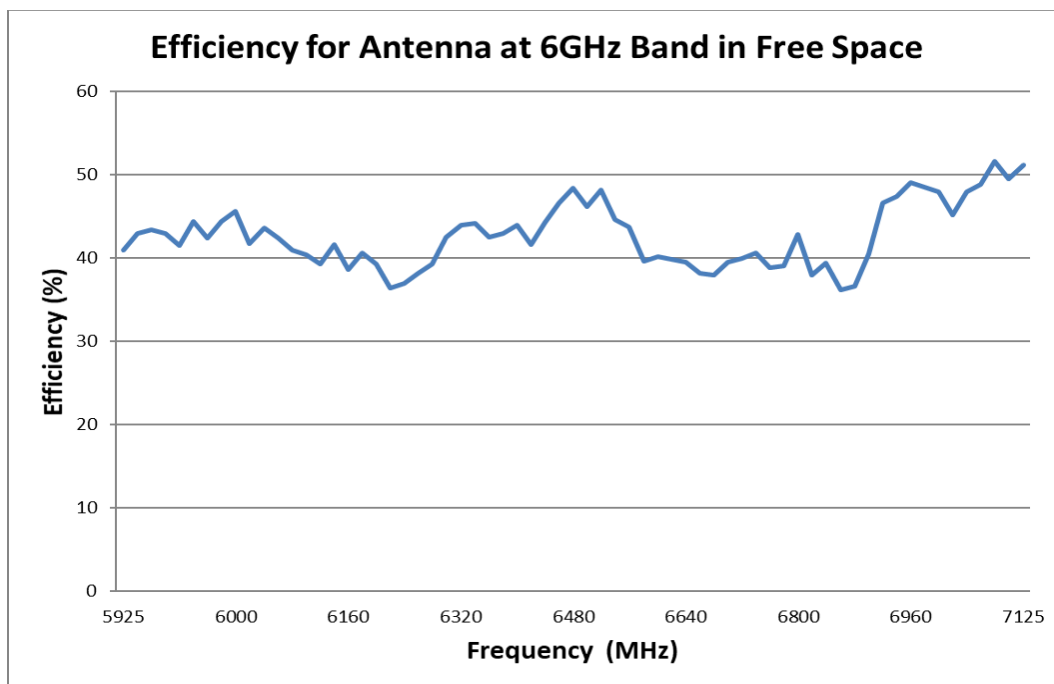


**FIGURE 4.4.1 EFFICIENCY OF ANTENNA AT WIFI 2.4GHZ BAND IN FREE SPACE**

REVISION: <b>E</b>	ECR/ECN INFORMATION: EC No: 644338 DATE: 2020/08/31	TITLE: <b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	SHEET No. <b>8 of 32</b>
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**FIGURE 4.4.2 EFFICIENCY OF ANTENNA AT WIFI 5GHZ BAND IN FREE SPACE**



**FIGURE 4.4.3 EFFICIENCY OF ANTENNA AT WIFI 6GHZ BAND IN FREE SPACE**

REVISION:  <b>E</b>	ECR/ECN INFORMATION: EC No: <b>644338</b> DATE: <b>2020/08/31</b>	TITLE:  <b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>			SHEET No.  <b>9 of 32</b>
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## 4.5 RADIATION PATTERN

All measurements in this document are done with a cable length of 100mm.

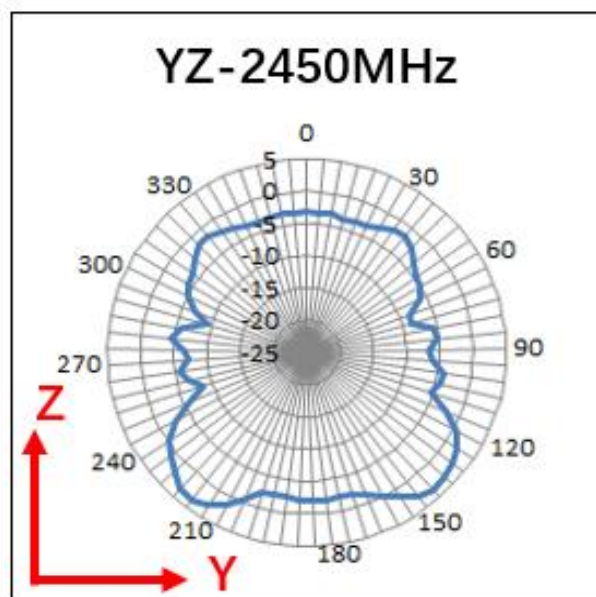
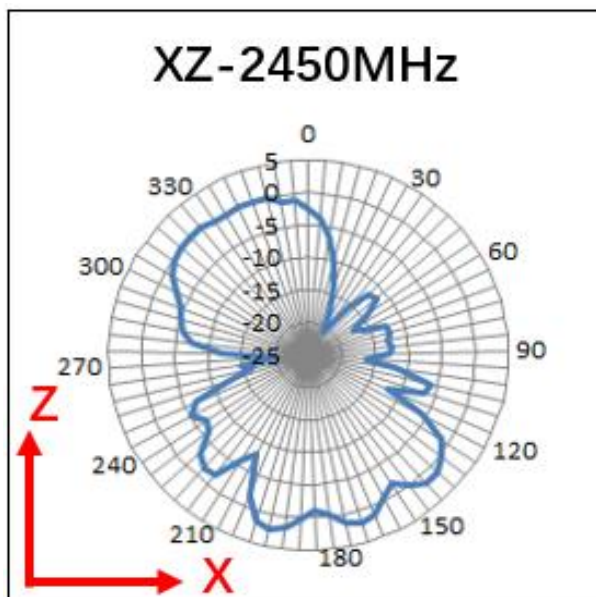
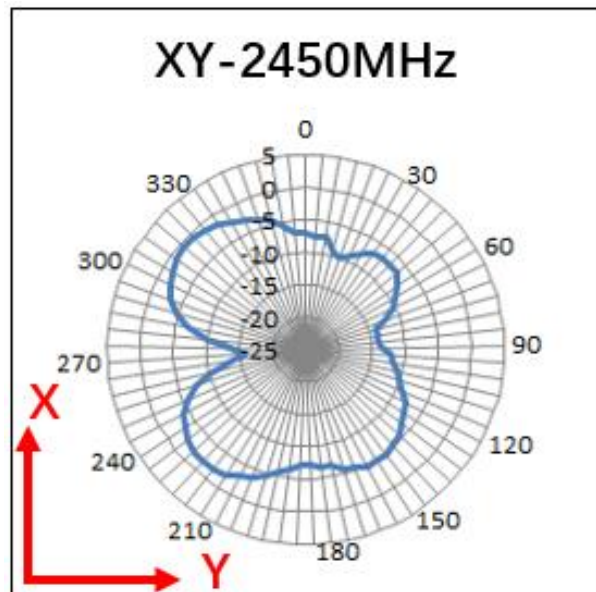
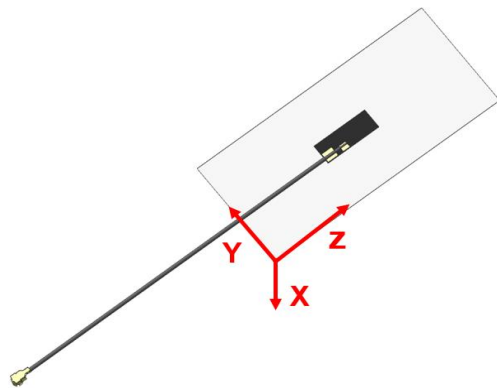
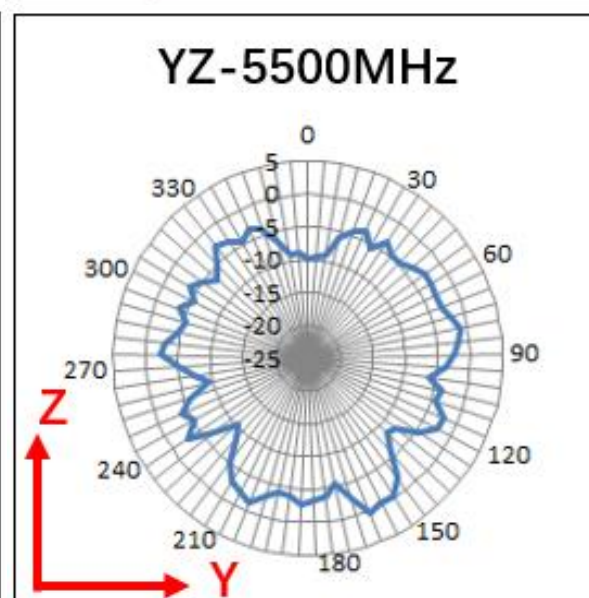
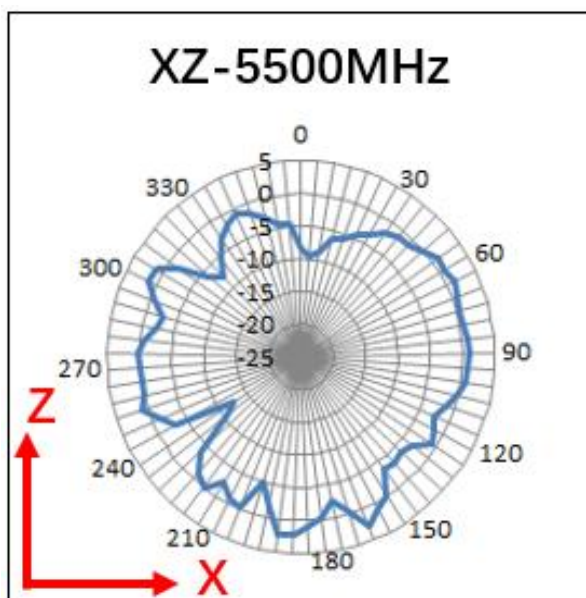
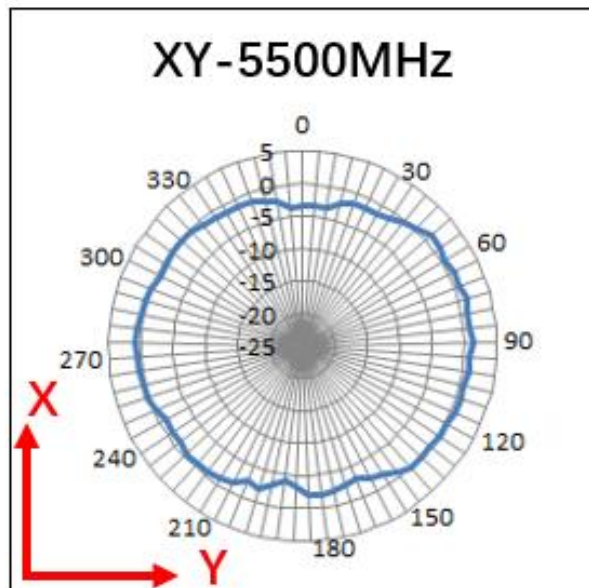
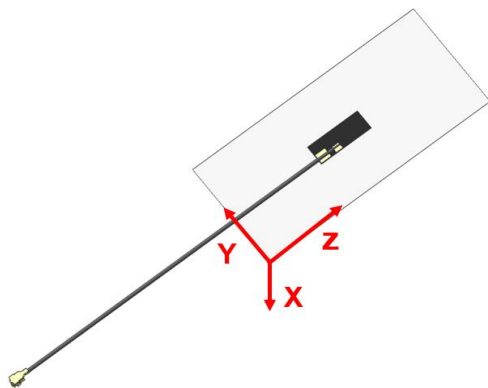


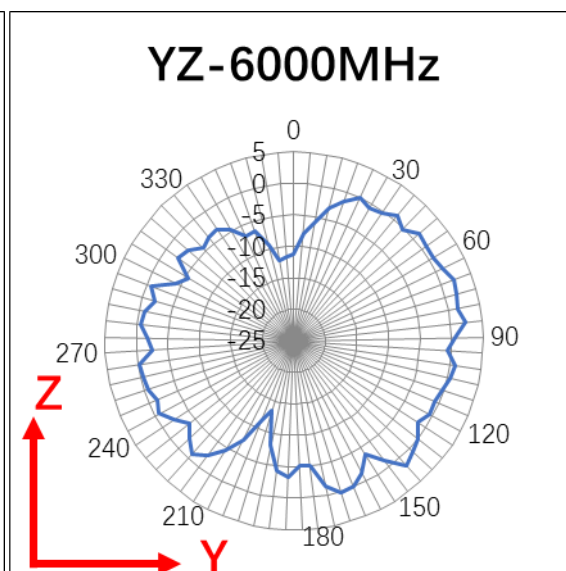
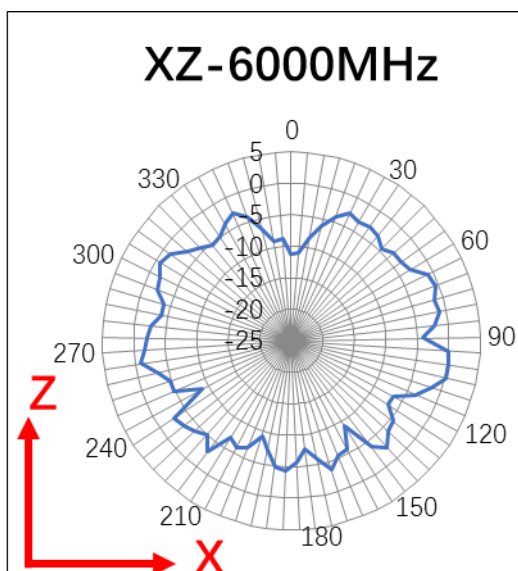
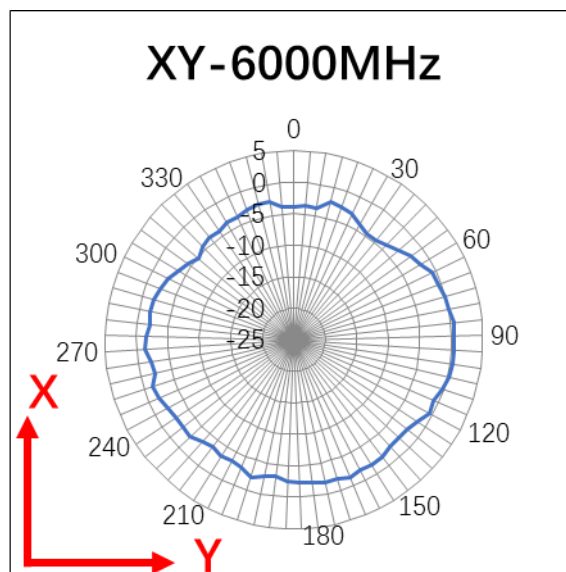
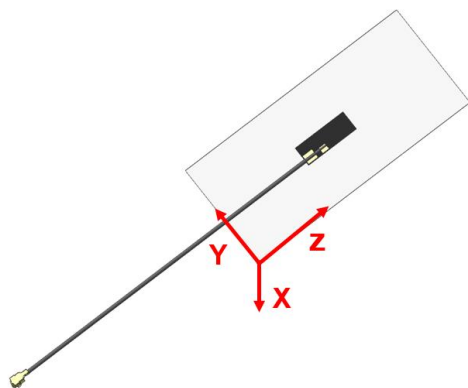
FIGURE 4.5.1 2D RADIATION PATTERN OF ANTENNA AT 2450MHZ IN FREE SPACE

REVISION:	ECR/ECN INFORMATION:	TITLE:	SHEET No.
<b>E</b>	EC No: 644338 DATE: 2020/08/31	<b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	<b>10 of 32</b>
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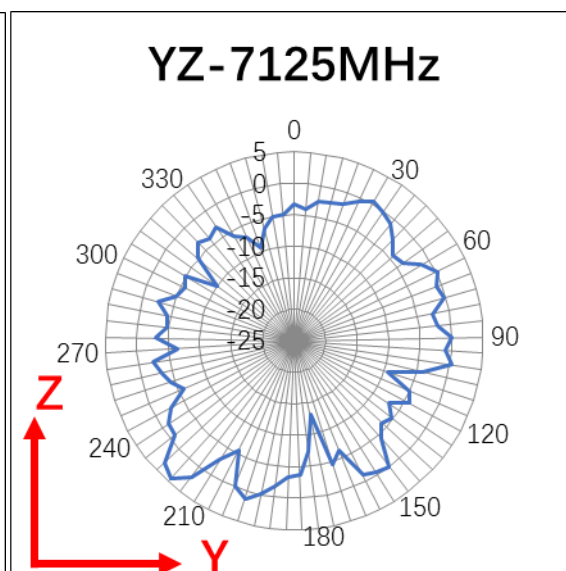
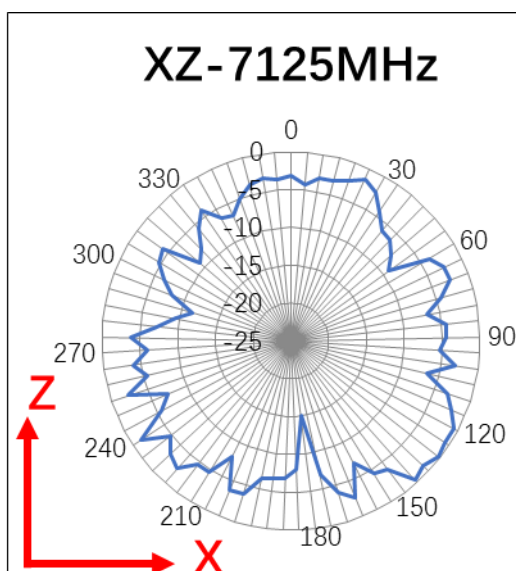
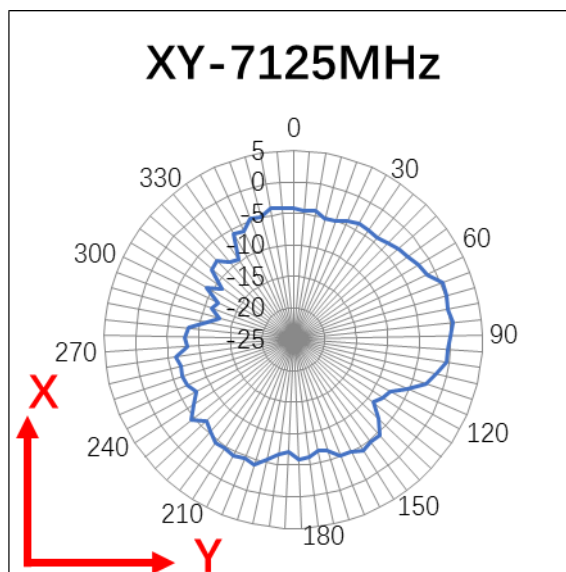
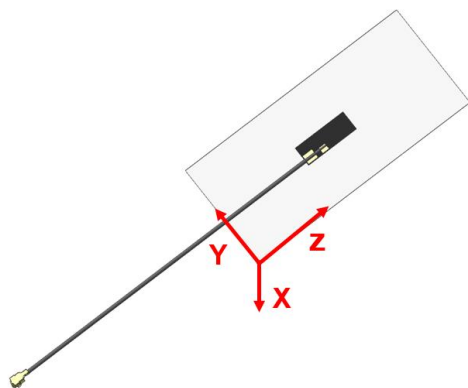
**FIGURE 4.5.2 2D RADIATION PATTERN OF ANTENNA AT 5500MHZ IN FREE SPACE**

REVISION:	ECR/ECN INFORMATION:	TITLE:	SHEET No.
<b>E</b>	EC No: 644338 DATE: 2020/08/31	<b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	<b>11 of 32</b>
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**FIGURE 4.5.3 2D RADIATION PATTERN OF ANTENNA AT 6000MHZ IN FREE SPACE**

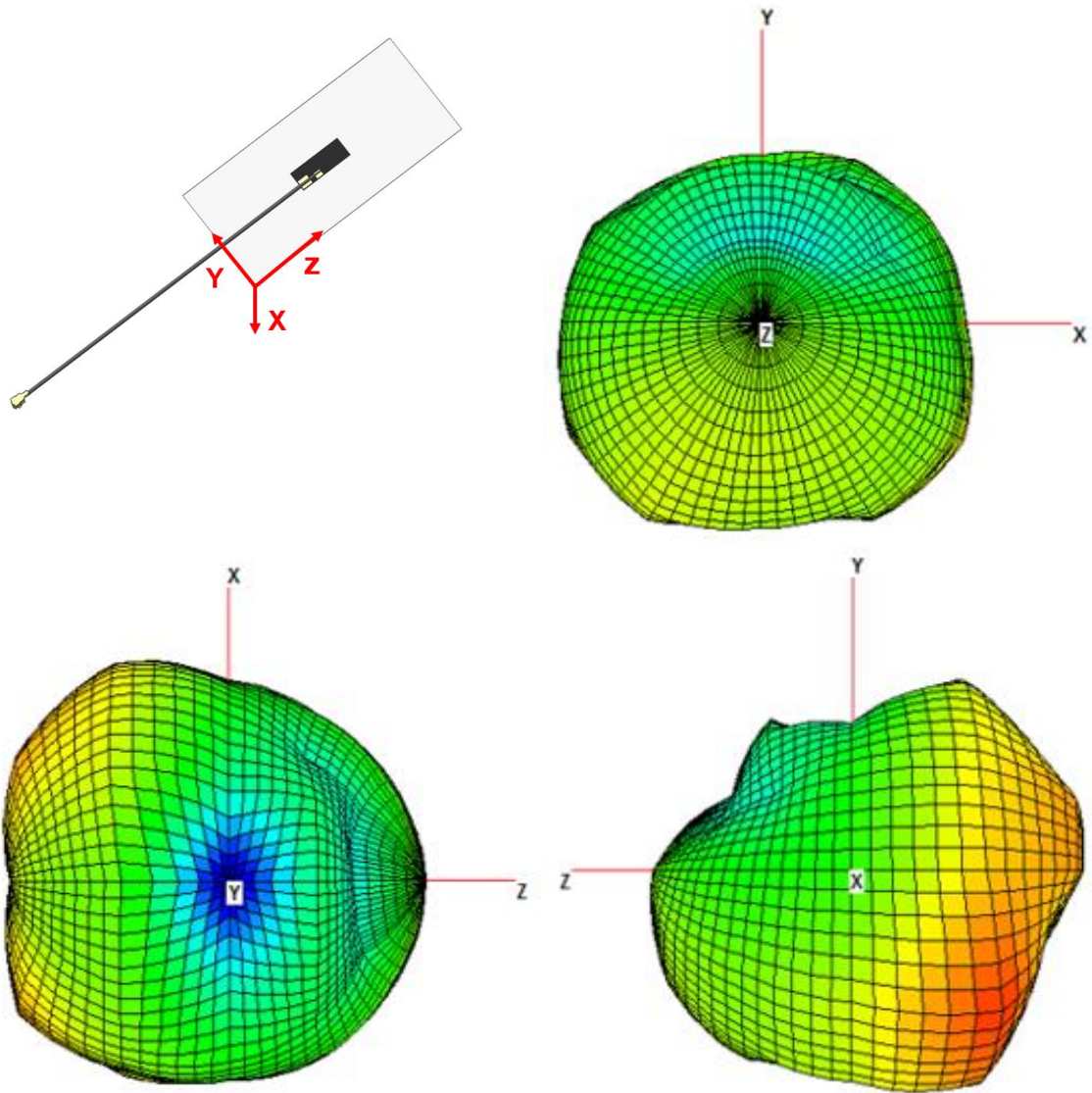
REVISION:	ECR/ECN INFORMATION:	TITLE:	SHEET No.
<b>E</b>	EC No: 644338 DATE: 2020/08/31	<b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	<b>12 of 32</b>
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**FIGURE 4.5.4 2D RADIATION PATTERN OF ANTENNA AT 7125MHZ IN FREE SPACE**

REVISION: <b>E</b>	ECR/ECN INFORMATION: EC No: 644338 DATE: 2020/08/31	TITLE: <b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	SHEET No. <b>13 of 32</b>
DOCUMENT NUMBER: <b>AS-2069940100</b>	CREATED / REVISED BY: Hai Liu 2020/08/31	CHECKED BY: Cheng Kang 2020/08/31	APPROVED BY: Andy Zhang 2020/08/31





**FIGURE 4.5.5 3D RADIATION PATTERN OF ANTENNA AT 2450MHZ IN FREE SPACE**

REVISION:	ECR/ECN INFORMATION:	TITLE:	SHEET No.
<b>E</b>	EC No: 644338 DATE: 2020/08/31	<b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	<b>14 of 32</b>
DOCUMENT NUMBER:	CREATED / REVISED BY:	CHECKED BY:	APPROVED BY:
<b>AS-2069940100</b>	Hai Liu 2020/08/31	Cheng Kang 2020/08/31	Andy Zhang 2020/08/31

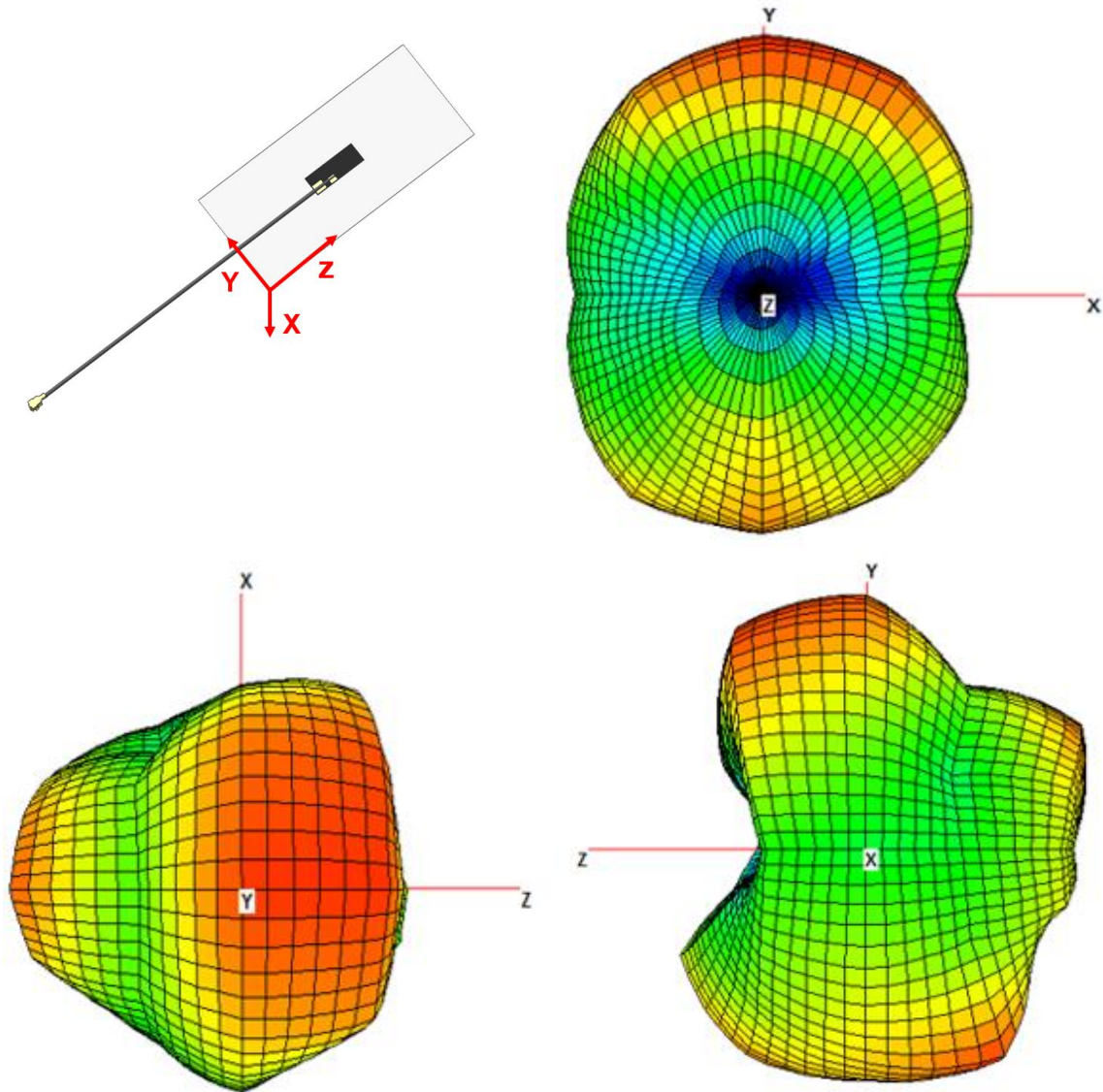


FIGURE 4.5.6 3D RADIATION PATTERN OF ANTENNA AT 5500MHZ IN FREE SPACE

REVISION:	ECR/ECN INFORMATION:	TITLE:		SHEET No.
<b>E</b>	EC No: 644338 DATE: 2020/08/31	<b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>		<b>15 of 32</b>
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<b>AS-2069940100</b>		Hai Liu 2020/08/31	Cheng Kang 2020/08/31	Andy Zhang 2020/08/31



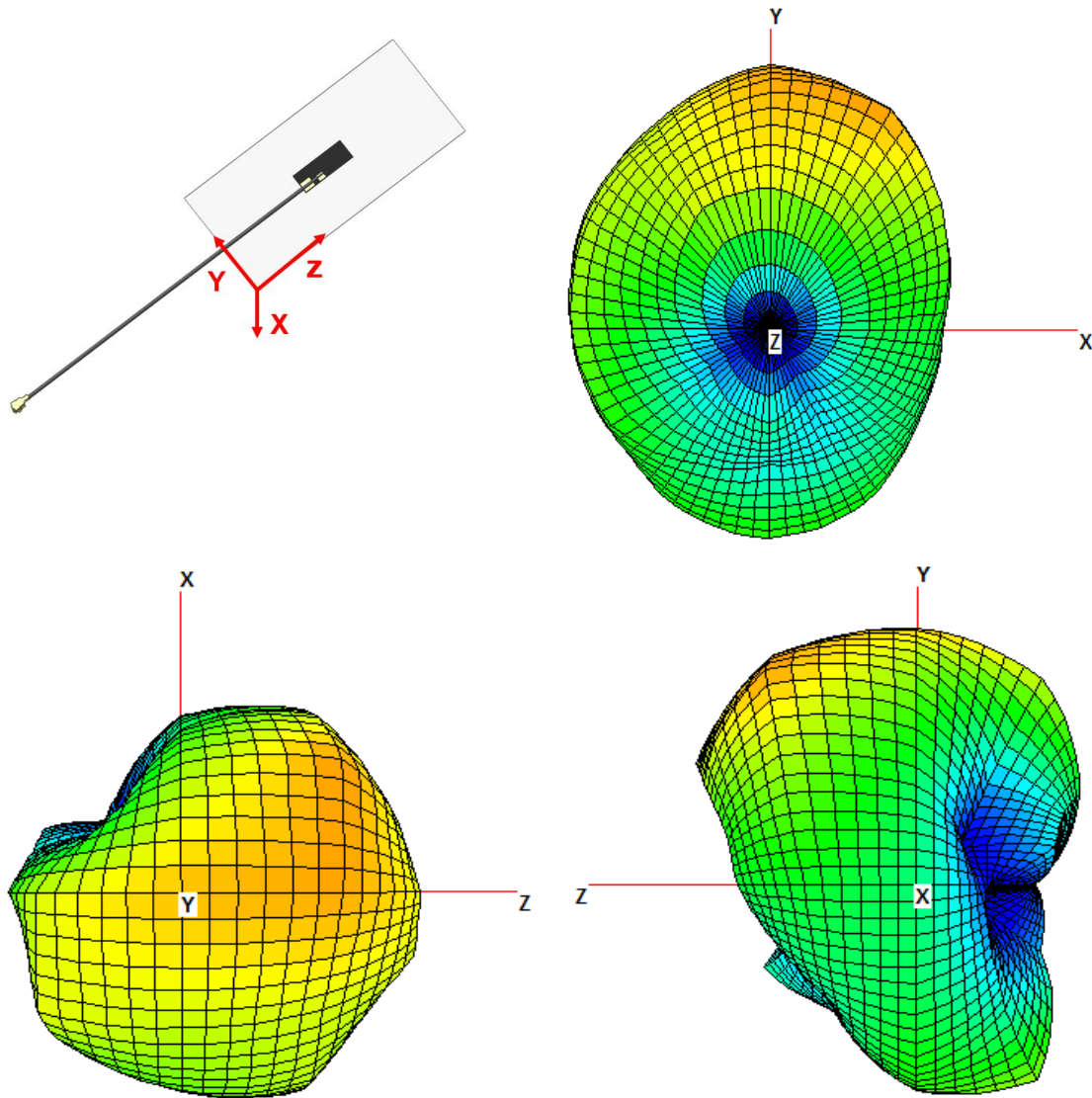
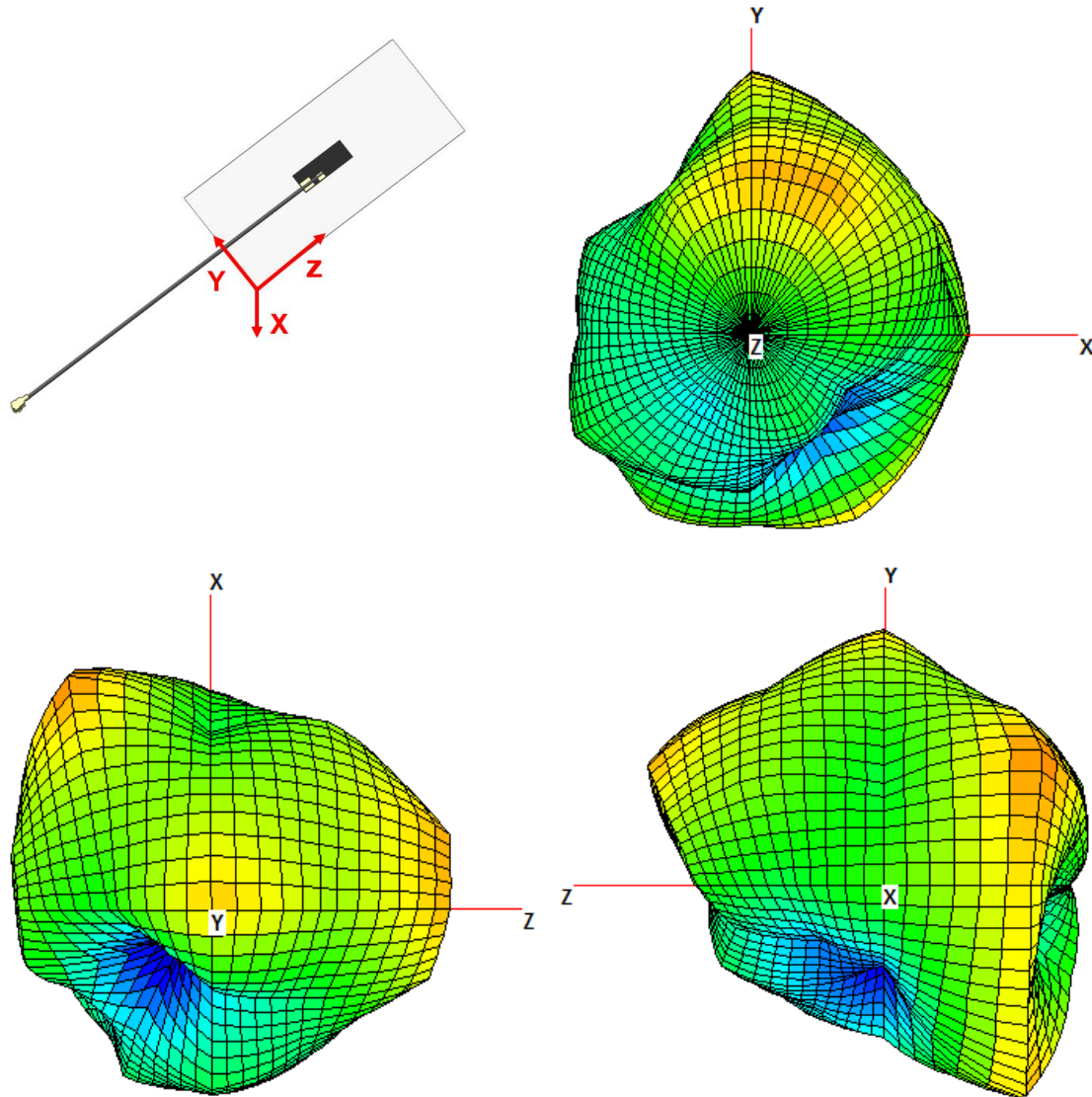


FIGURE 4.5.7 3D RADIATION PATTERN OF ANTENNA AT 6000MHZ IN FREE SPACE

REVISION:	ECR/ECN INFORMATION:	TITLE:	SHEET No.
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**FIGURE 4.5.8 3D RADIATION PATTERN OF ANTENNA AT 7125MHZ IN FREE SPACE**

REVISION:	ECR/ECN INFORMATION:	TITLE:	SHEET No.
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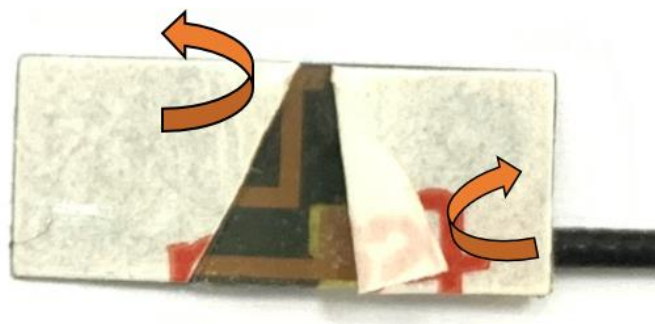
## 5.0 ASSEMBLY GUIDELINE

The flex antenna comes with an adhesive TESA 68537 for assemble onto the plastic wall of the system. The surface should be smooth with  $Ra < 1.6\mu m$  and need to clean the surface before sticking this product. The antenna cannot be placed on a metallic surface.

### 5.1 HOW TO TEAR FLEX RELEASE PAPER



1. Find cut line on flex back side, Bend flex slight along cut line



2. Tear release paper

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## 5.2 CABLE BENDING

During the assembly of the antenna in a device, the cable needs to be positioned away from the antenna flex to achieve best performance. The cable must be away from the pattern at least 5mm as shown in figure 5.2.1. If the cable crosses into the antenna flex, the antenna performance will be degraded.



FIGURE 5.2.1 RECOMMENDED CABLE BENDING RANGE

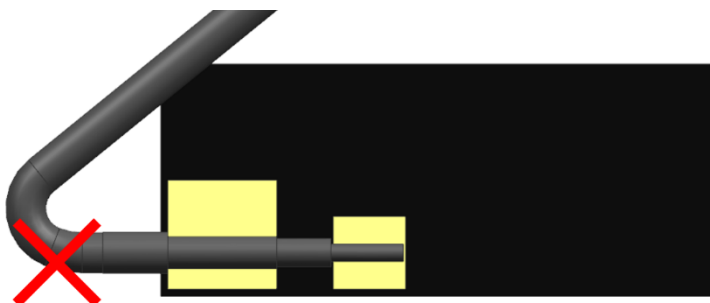


FIGURE 5.2.2 UNRECOMMENDED CABLE BENDING RANGE



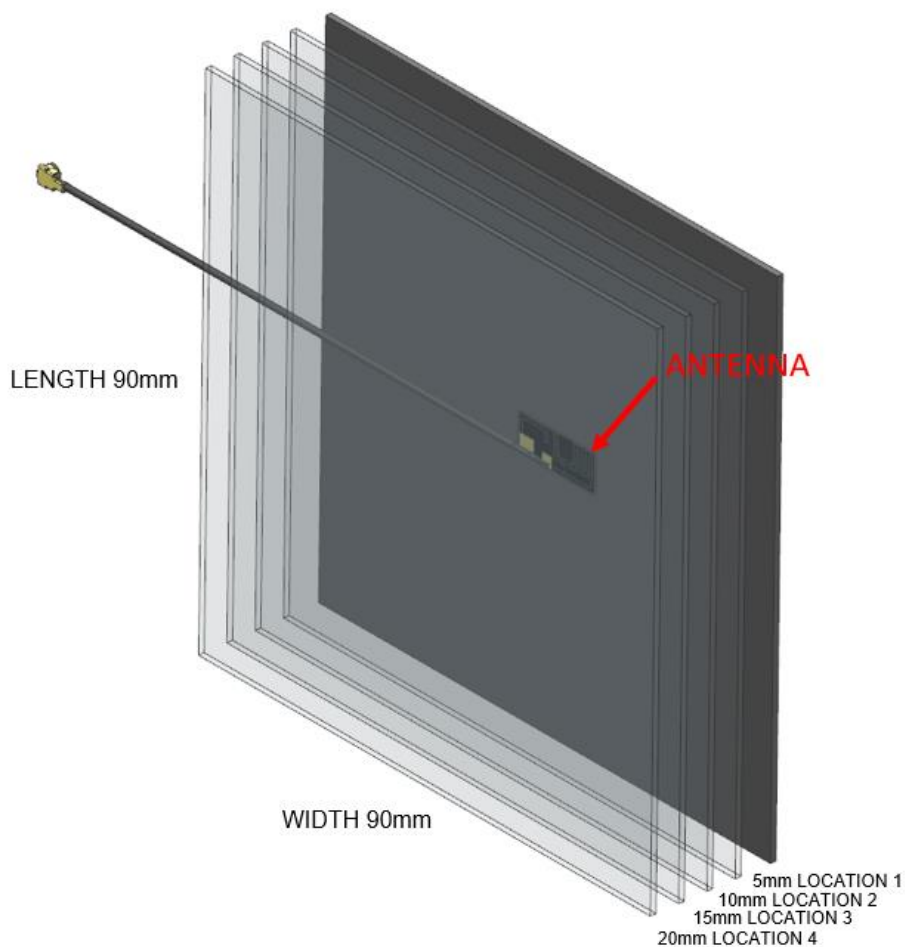
FIGURE 5.2.3 MULTIPLE BENDING OF CABLES IS NOT RECOMMENDED

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<b>AS-2069940100</b>	Hai Liu 2020/08/31	Cheng Kang 2020/08/31	Andy Zhang 2020/08/31

## 6.0 RF PERFORMANCE AS A FUNCTION OF IMPLEMENTATION

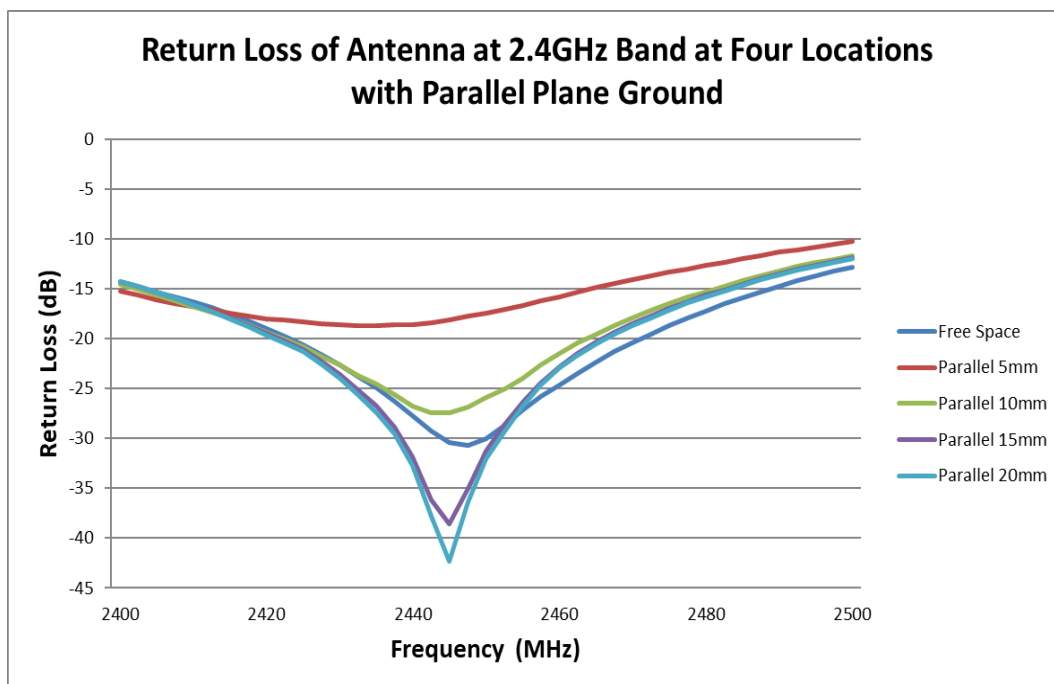
### 6.1 ANTENNA RF PERFORMANCE AS A FUNCTION OF DIFFERENT LOCATIONS WITH PARALLEL PLANE GROUND

Antenna performance will be degraded if the antenna is placed too close to a ground plane. Four locations from 5mm, 10mm, 15mm and 20mm with a parallel plane ground have been evaluated. The locations are shown in figure 6.1.1. The plane ground size is 90mm\*90mm. The antenna performance is better with larger distance between antenna and parallel plane ground. The minimum distance between antenna and plane ground is recommended to be at least 10mm to achieve acceptable RF performance.

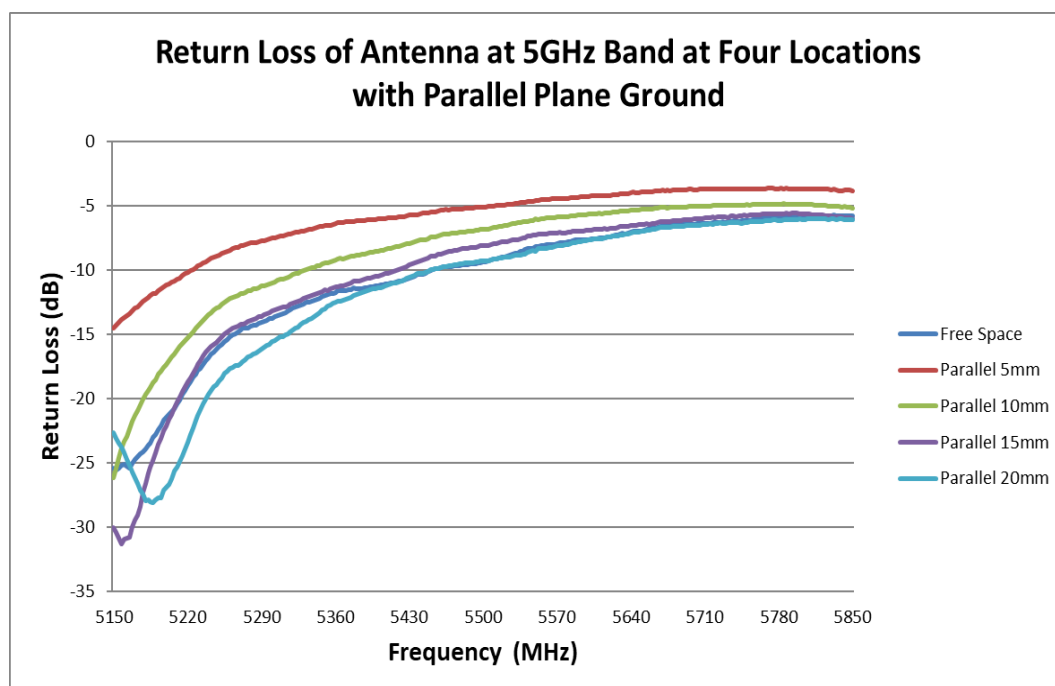


**FIGURE 6.1.1 FOUR LOCATIONS WITH PARALLEL PLANE GROUND**

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<b>E</b>	EC No: 644338 DATE: 2020/08/31	<b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	<b>20 of 32</b>
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<b>AS-2069940100</b>	Hai Liu 2020/08/31	Cheng Kang 2020/08/31	Andy Zhang 2020/08/31

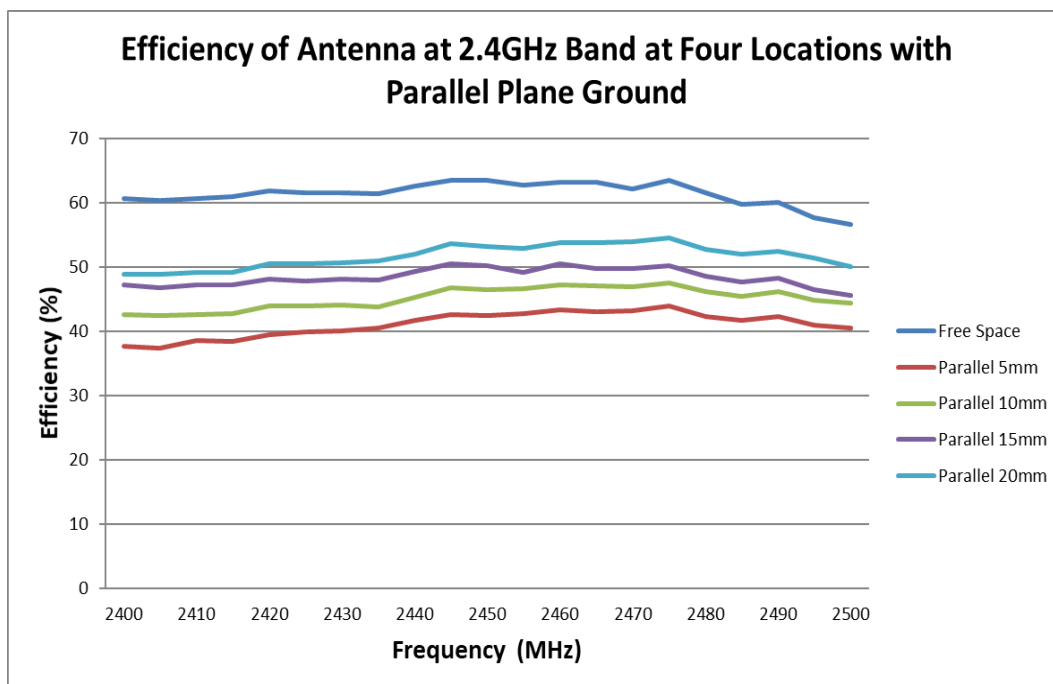


**FIGURE 6.1.2 RETURN LOSS OF ANTENNA AT WIFI 2.4GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND**

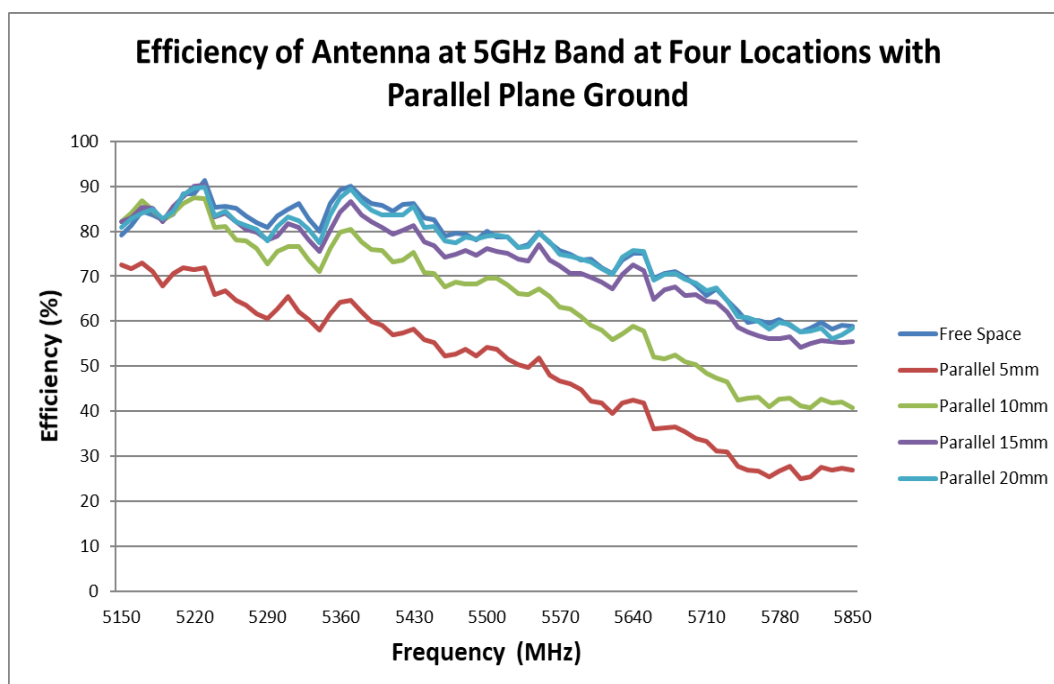


**FIGURE 6.1.3 RETURN LOSS OF ANTENNA AT WIFI 5GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND**

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**FIGURE 6.1.4 EFFICIENCY OF ANTENNA AT WIFI 2.4GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND**

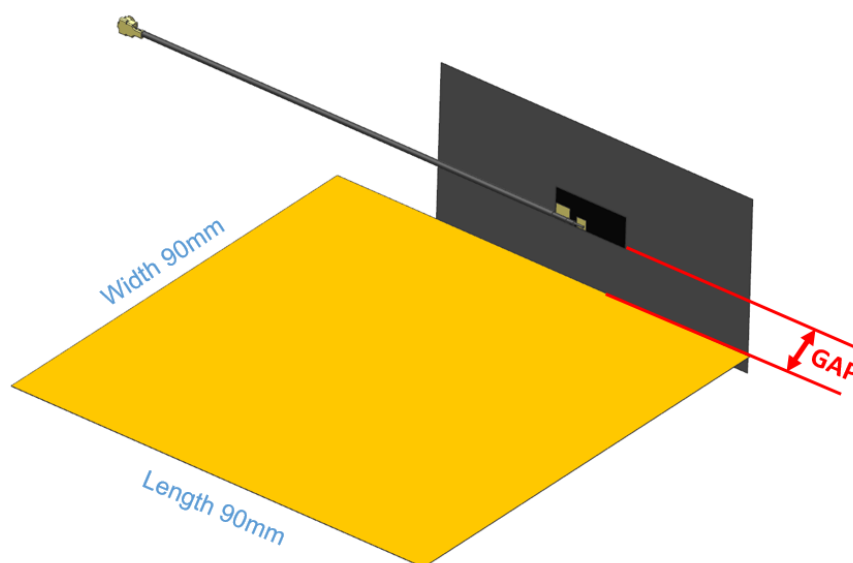


**FIGURE 6.1.5 EFFICIENCY OF ANTENNA AT WIFI 5GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND**

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## 6.2 ANTENNA RF PERFORMANCE AS A FUNCTION OF DIFFERENT LOCATIONS WITH VERTICAL PLANE GROUND

Antenna performance will be degraded if the antenna is placed too close to a ground plane. Four locations of 5mm, 10mm, 15mm and 20mm away from the vertical plane ground have been evaluated. These locations are shown in figure 6.2.1. The plane ground size is 90mm\*90mm. The antenna performance is better with larger distance between antenna and vertical plane ground. The minimum distance between antenna and plane ground is recommended to be at least 5mm to achieve acceptable RF performance.



**FIGURE 6.2.1 FOUR LOCATIONS WITH VERTICAL PLANE GROUND**

Ground size: 90mm\*90mm;

Location 1: Distance between antenna and plane (GAP) ground is about 5mm;

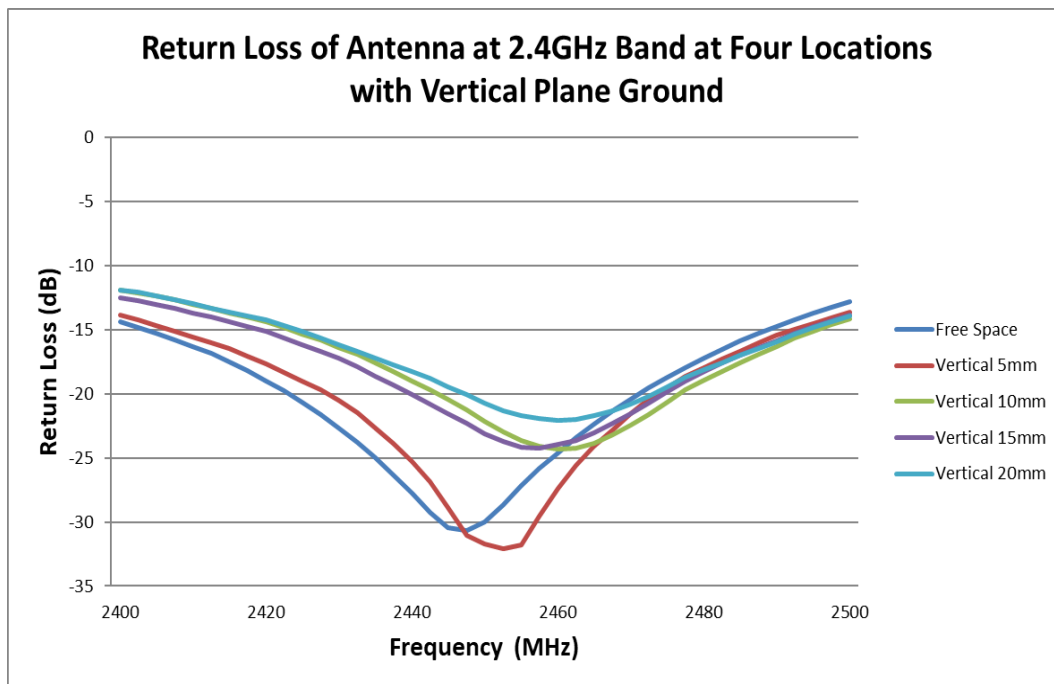
Location 2: Distance between antenna and plane (GAP) ground is about 10mm;

Location 3: Distance between antenna and plane (GAP) ground is about 15mm;

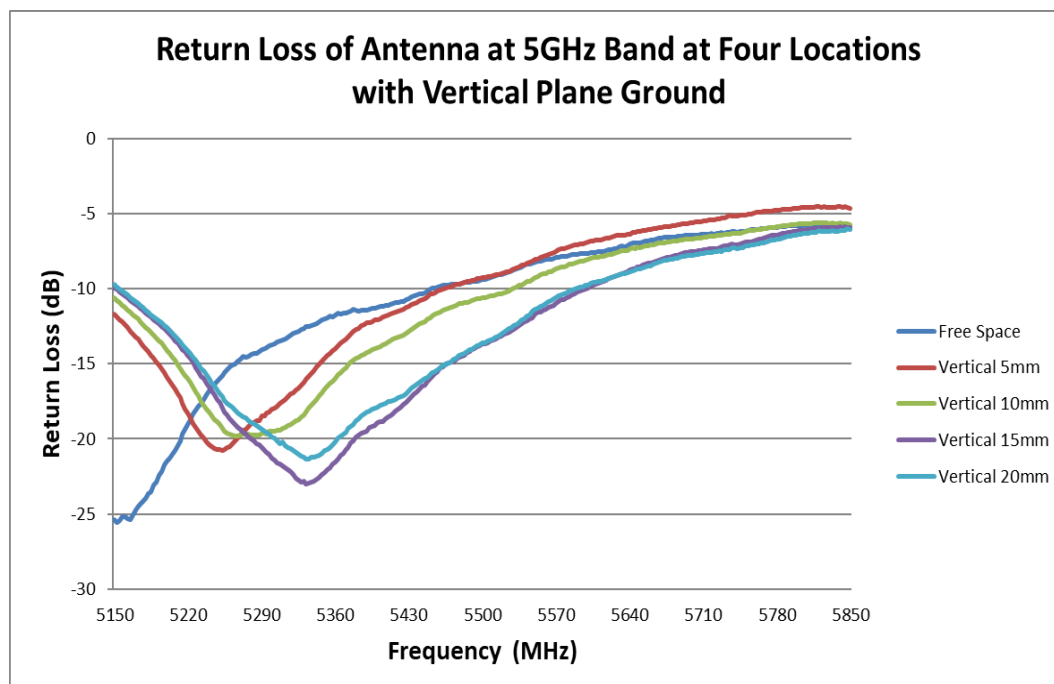
Location 4: Distance between antenna and plane (GAP) ground is about 20mm.

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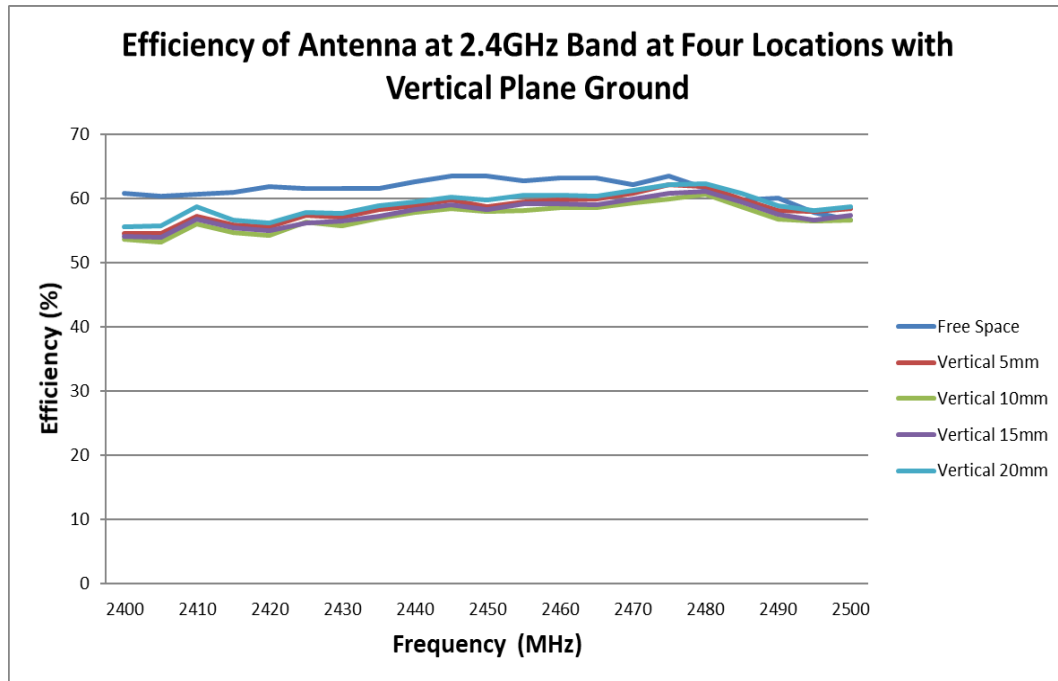


**FIGURE 6.2.2 RETURN LOSS OF ANTENNA AT WIFI 2.4GHZ BAND AT FOUR LOCATIONS WITH VERTICAL PLANE GROUND**

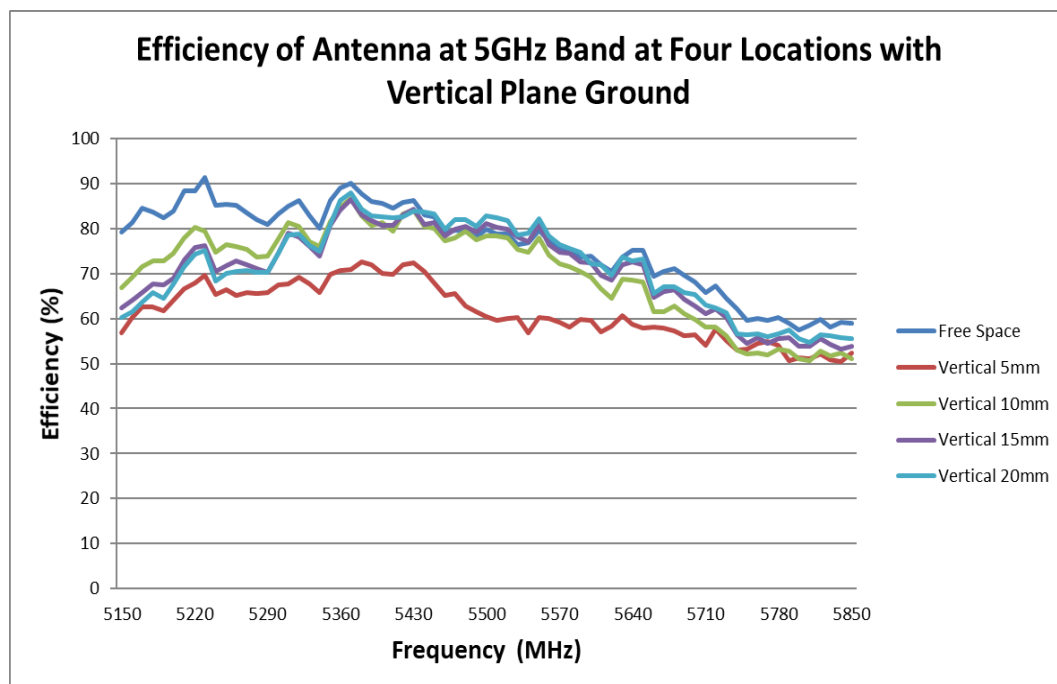


**FIGURE 6.2.3 RETURN LOSS OF ANTENNA AT WIFI 5GHZ BAND AT FOUR LOCATIONS WITH VERTICAL PLANE GROUND**

REVISION: <b>E</b>	ECR/ECN INFORMATION: EC No: 644338 DATE: 2020/08/31	TITLE: <b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	SHEET No. <b>24 of 32</b>
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**FIGURE 6.2.4 EFFICIENCY OF ANTENNA AT WIFI 2.4GHZ BAND AT FOUR LOCATIONS WITH VERTICAL PLANE GROUND**

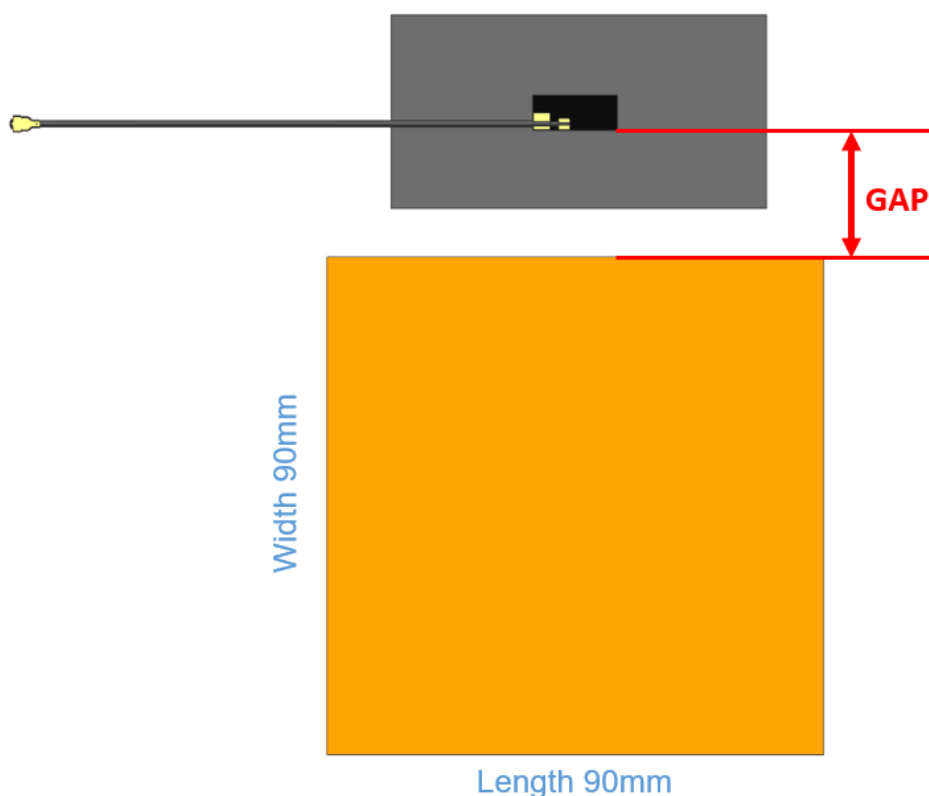


**FIGURE 6.2.5 EFFICIENCY OF ANTENNA AT WIFI 5GHZ BAND AT FOUR LOCATIONS WITH VERTICAL PLANE GROUND**

REVISION: <b>E</b>	ECR/ECN INFORMATION: EC No: 644338 DATE: 2020/08/31	TITLE: <b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	SHEET No. <b>25 of 32</b>
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## 6.3 ANTENNA RF PERFORMANCE AS A FUNCTION OF DIFFERENT DISTANCES WITH PARALLEL PLANE GROUND

Antenna performance will be degraded if the antenna is placed too close to a ground plane. Four locations 5mm, 10mm, 15mm and 20mm from a parallel plane ground have been evaluated. These locations are shown in figure 6.3.1. The plane ground size is 90mm\*90mm. The antenna performance is better with larger distance between the antenna and the parallel plane ground. The minimum distance between the antenna and the plane ground is recommended to be at least 5mm to achieve acceptable RF performance.



**FIGURE 6.3.1 FOUR LOCATIONS WITH PARALLEL PLANE GROUND**

Ground Size: 90mm\*90mm;

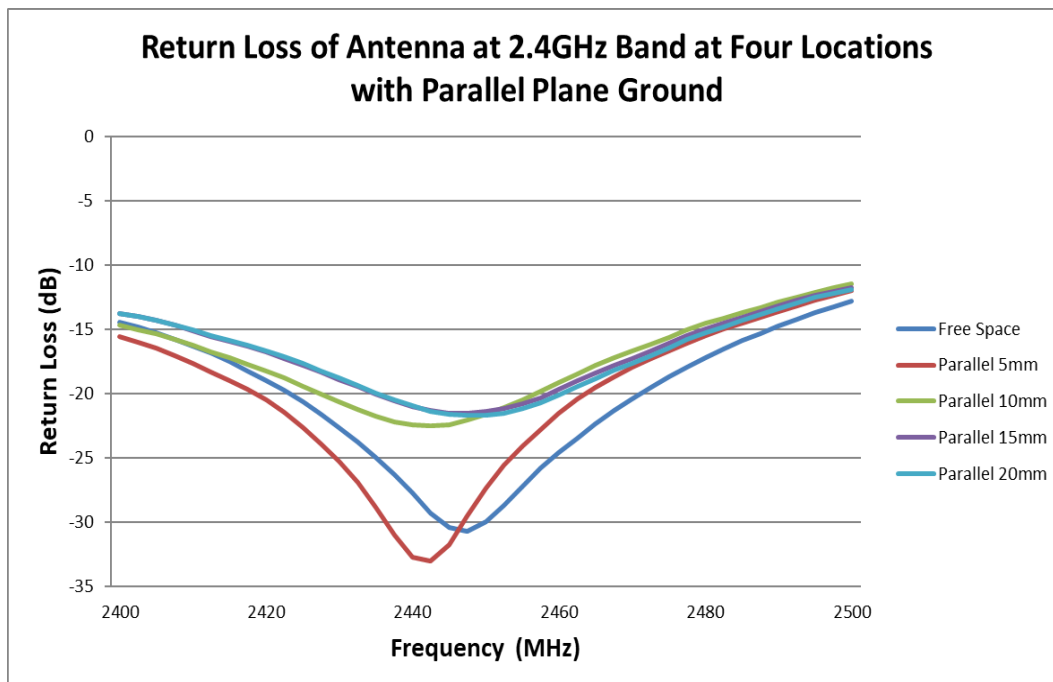
Location 1: Distance between antenna and plane (GAP) ground is about 5mm;

Location 2: Distance between antenna and plane (GAP) ground is about 10mm;

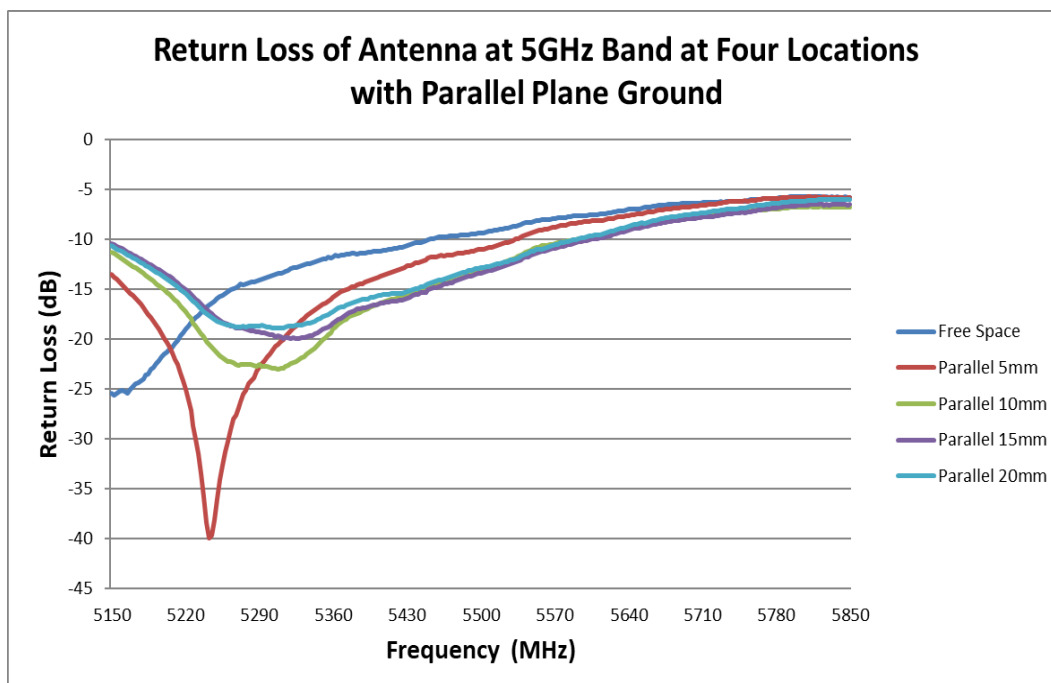
Location 3: Distance between antenna and plane (GAP) ground is about 15mm;

Location 4: Distance between antenna and plane (GAP) ground is about 20mm

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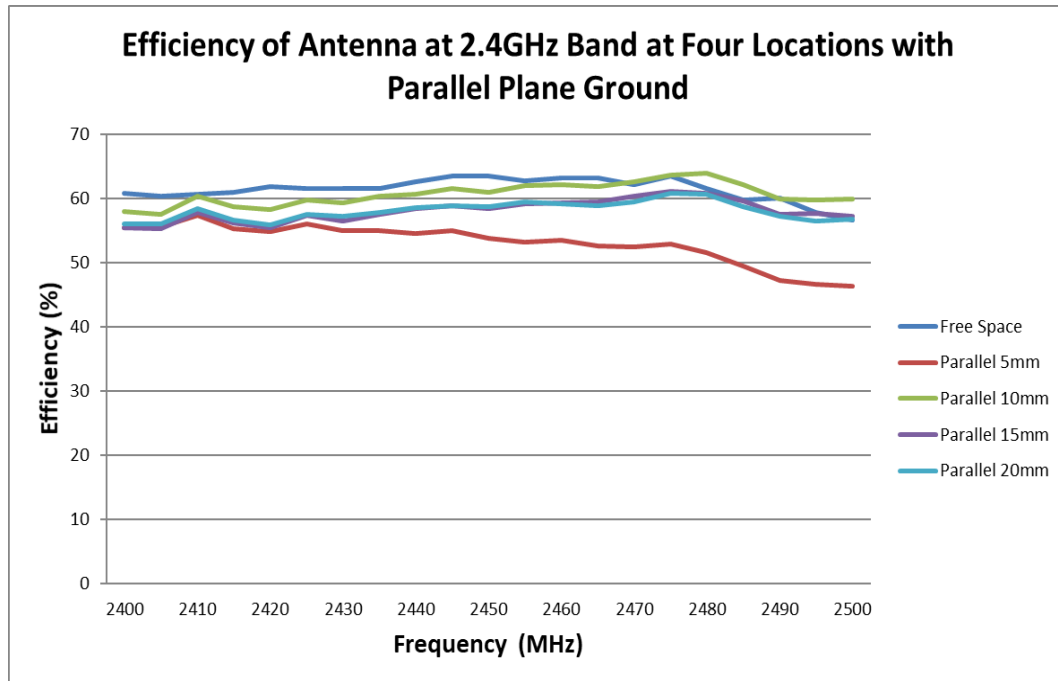


**FIGURE 6.3.2 RETURN LOSS OF ANTENNA AT WIFI 2.4GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND**

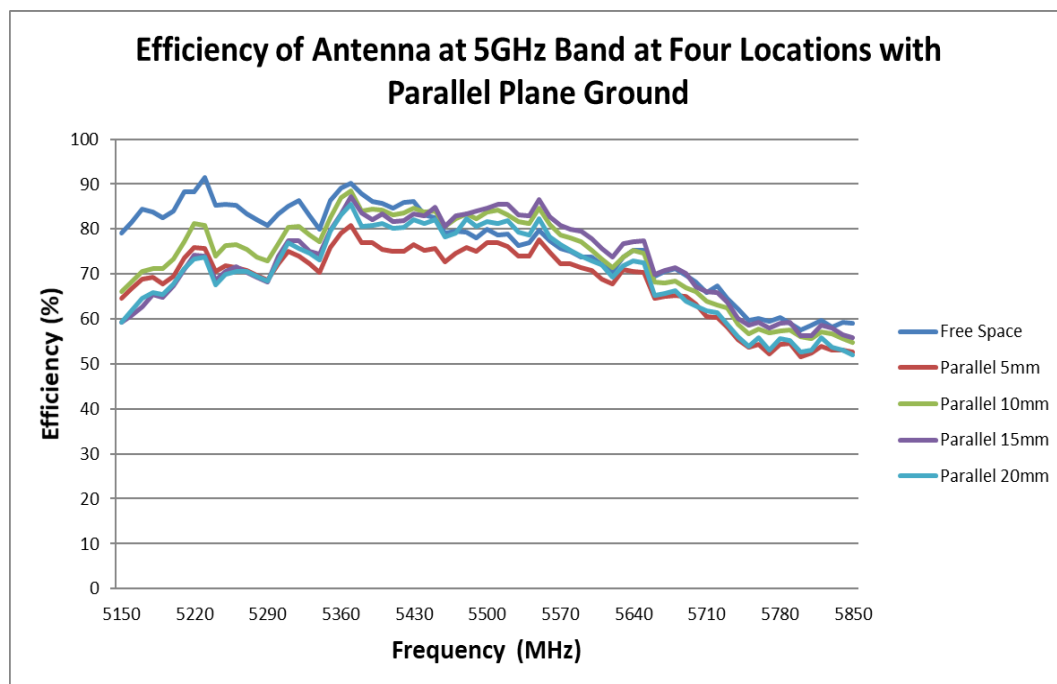


**FIGURE 6.3.3 RETURN LOSS OF ANTENNA AT WIFI 5GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND**

REVISION: <b>E</b>	ECR/ECN INFORMATION: EC No: 644338 DATE: 2020/08/31	TITLE: <b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	SHEET No. <b>27 of 32</b>
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**FIGURE 6.3.4 EFFICIENCY OF ANTENNA AT WIFI 2.4GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND**



**FIGURE 6.3.5 EFFICIENCY OF ANTENNA AT WIFI 5GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND**

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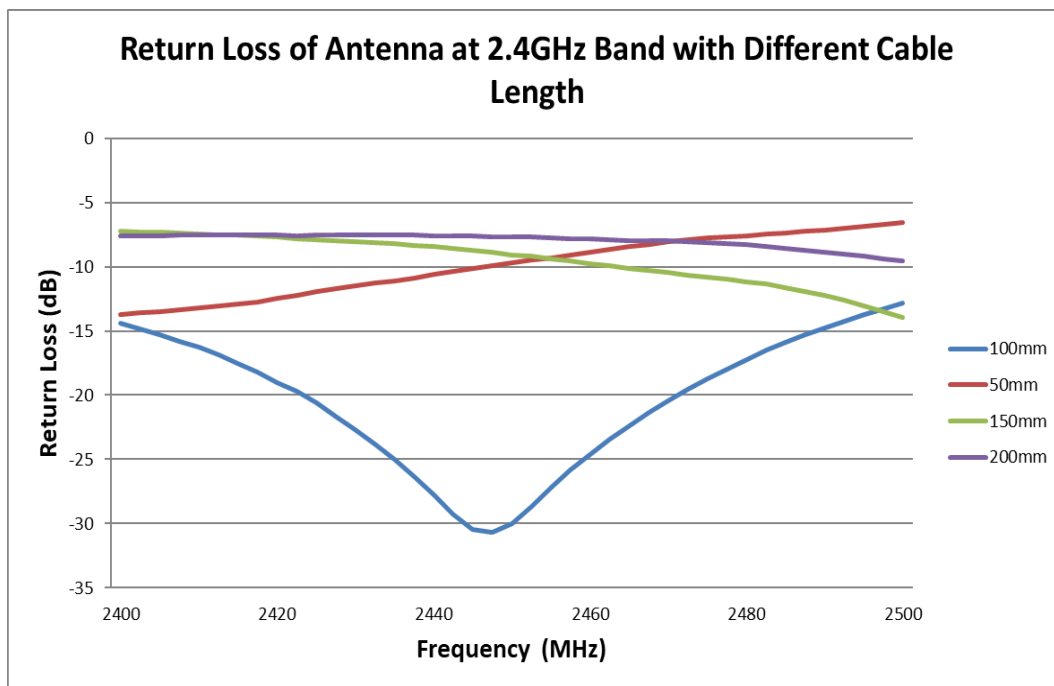
## 6.4 ANTENNA RF PERFORMANCE AS A FUNCTION OF DIFFERENT CABLE LENGTH

Four cable length have been evaluated and these states are shown in figure 6.4.1. The cable length "L" is 200mm, 150mm, 100mm(reference length) and 50mm. The cable length should be more than 50mm and less than 200mm. The resonance frequency shift to lower and the antenna performance will decrease obviously when the cable length is less than 50mm and more than 200mm.

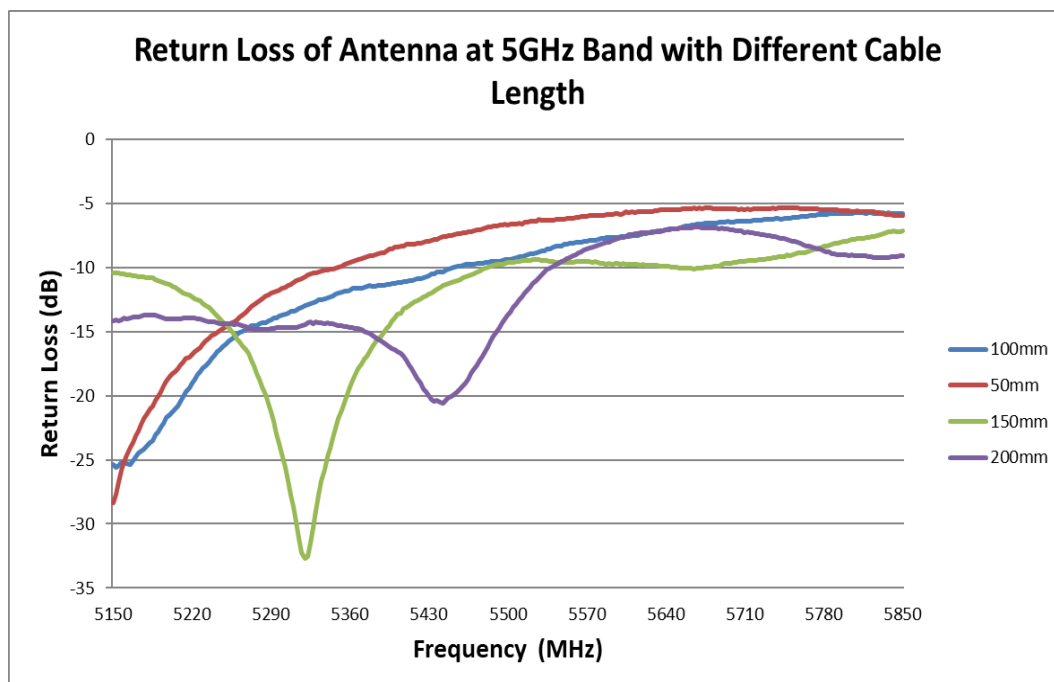


**FIGURE 6.3.1 FOUR DIFFERENT CABLE LENGTH**

REVISION:	ECR/ECN INFORMATION:	TITLE:	SHEET No.
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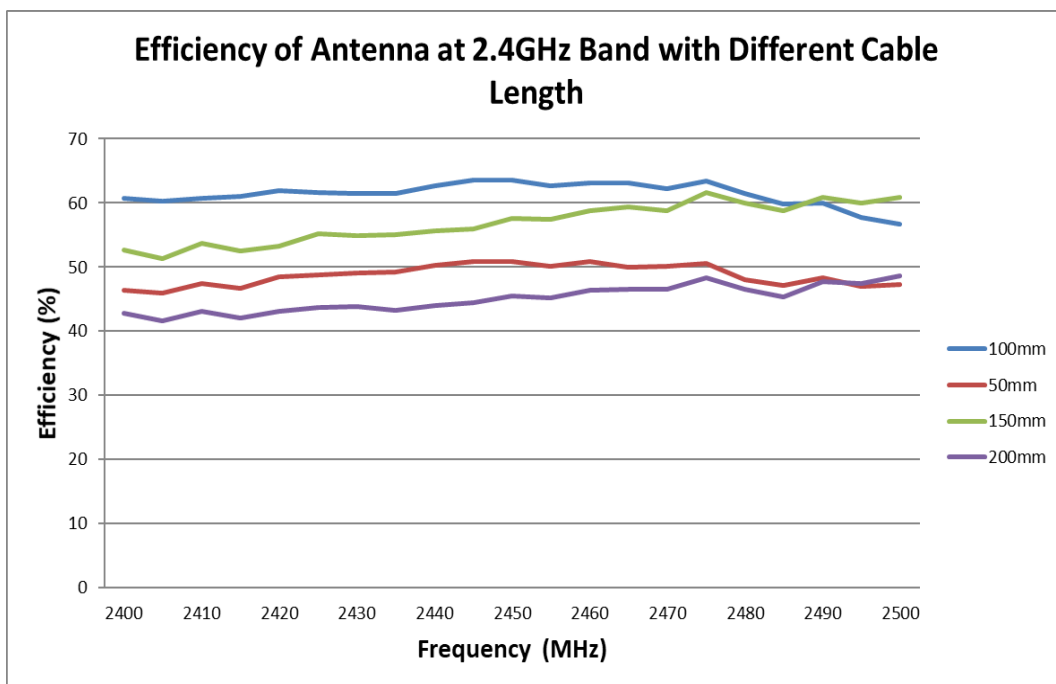


**FIGURE 6.4.2 RETURN LOSS OF ANTENNA AT WIFI 2.4GHZ BAND WITH DIFFERENT CABLE LENGTH**

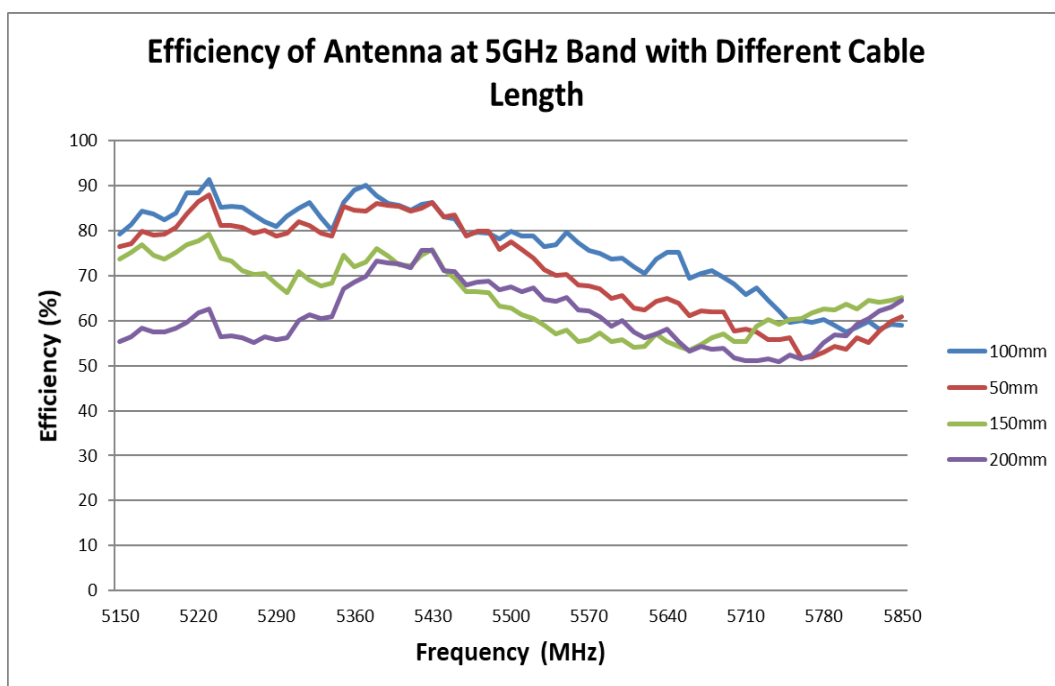


**FIGURE 6.4.3 RETURN LOSS OF ANTENNA AT WIFI 5GHZ BAND WITH DIFFERENT CABLE LENGTH**

REVISION: <b>E</b>	ECR/ECN INFORMATION: EC No: 644338 DATE: 2020/08/31	TITLE: <b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	SHEET No. <b>30 of 32</b>
DOCUMENT NUMBER: <b>AS-2069940100</b>	CREATED / REVISED BY: Hai Liu 2020/08/31	CHECKED BY: Cheng Kang 2020/08/31	APPROVED BY: Andy Zhang 2020/08/31



**FIGURE 6.4.4 EFFICIENCY OF ANTENNA AT WIFI 2.4GHZ BAND WITH DIFFERENT CABLE LENGTH**



**FIGURE 6.4.5 EFFICIENCY OF ANTENNA AT WIFI 5GHZ BAND WITH DIFFERENT CABLE LENGTH**

REVISION: <b>E</b>	ECR/ECN INFORMATION: EC No: <b>644338</b> DATE: <b>2020/08/31</b>	TITLE: <b>WIFI 6E Flex Cabled Side-Fed Antenna Application Specification</b>	SHEET No. <b>31 of 32</b>
DOCUMENT NUMBER: <b>AS-2069940100</b>	CREATED / REVISED BY: <b>Hai Liu 2020/08/31</b>	CHECKED BY: <b>Cheng Kang 2020/08/31</b>	APPROVED BY: <b>Andy Zhang 2020/08/31</b>





# APPLICATION SPECIFICATION

## 7.0 CHANGE HISTORY

CHANGE HISTORY		
REV	DATA	DESCRIPTION
D	2020/07/03	Update radiation pattern, add different cable length and 6-7.125GHz band
E	2020/08/31	Optimized Part 4.2 Peak Gain & Efficiency

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<b>AS-2069940100</b>	Hai Liu 2020/08/31	Cheng Kang 2020/08/31	Andy Zhang 2020/08/31