



# APPLICATION SPECIFICATION

Document Title: RHCP LDS GPS Antenna Application Specification

Revision No. (版本)	Revision History (变更内容)	Responsibility (责任人)	Date (日期)
A	Initial Release	Benson	2016/03/14
B	Update Antenna Performance	Benson	2016/07/08
C	Update Footprint on PCB	Rao Ziliang	2016/12/01

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DOCUMENT NUMBER: <b>AS-146216-001</b>	CREATED / REVISED BY: <b>Benson Liu 2016/12/01</b>	CHECKED BY: <b>Ryan Liu 2016/12/01</b>	APPROVED BY: <b>Welson Tan 2016/12/01</b>



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## RHCP LDS GPS ANTENNA

### 1.0 SCOPE

This specification describes the antenna application and recommended PCB layout for the Molex RHCP LDS GPS Antenna. The information in this document is for reference and benchmark purposes only. The user is responsible for validating antenna RF performance based on users own PCB and matching circuits. The antenna RF performance can meet various bands including GPS, Glonass and Beidou with the help of different matching networks.

All measurements are done of the antenna mounted on the recommended PCB with VNA Agilent 5071C and OTA chamber.

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

#### A. DEFINITIONS OF TERMS

The antenna design is based on carrier size 11.8mm x 11.5mm x 6mm (Length\*Width\* Height). There are one feeding pad, one grounding pad, three fixing pads and antenna radiator. See figure 1.

##### 1. FEEDING PAD

SMT mounted to feeding pad on PCB. The signal from the transmission line must feed into the feeding pad on the PCB.

##### 2. GROUNDING PAD

SMT mounted to grounding pad on PCB.

##### 3. FIXING PAD

SMT mounted to dummy pads on PCB. Anchoring the antenna to the PCB

##### 4. ANTENNA RADIATOR

To act as a transducer that converts unguided electromagnetic wave to guided electromagnetic wave and vice versa.

##### 5. PICK AND PLACE FEATURE

To enable the antenna to be picked up by SMT machine pick up nozzle.

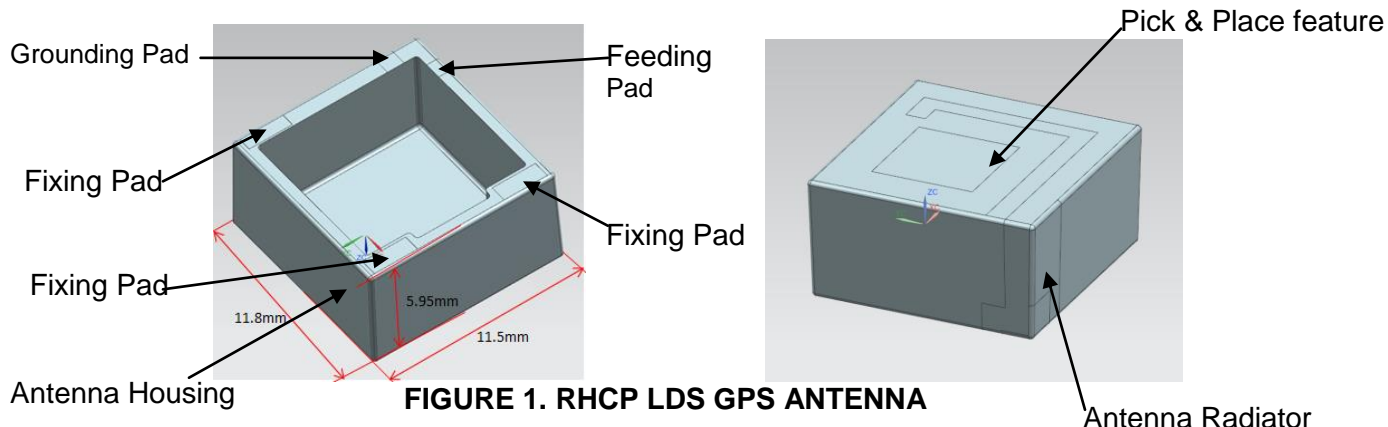


FIGURE 1. RHCP LDS GPS ANTENNA

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## B. REFERENCE IMPLEMENTATION

### I. REFERENCE PCB DESCRIPTION

The size of reference PCB design is 100mm\* 100mm \*1mm, which is used for this antenna performance verification. There are one feeding pad and three fixing pads. Furthermore, there is a "L" type matching network reserved close to feeding pad. See figure 2 and 2.1.

#### 1. FEEDING PAD

The signal from transmission line must be fed into the feeding pad.

#### 2. GROUNDING PAD

The antenna must be SMT mounted to grounding pad on PCB.

#### 3. MATCHING CIRCUIT

It is necessary to reserve PCB space for a "L" type matching circuit in this design. In order to adjust the return loss due to loading by the device housing and surroundings, the matching circuits need to be changed accordingly.

### II. REFERENCE PCB LAYOUT

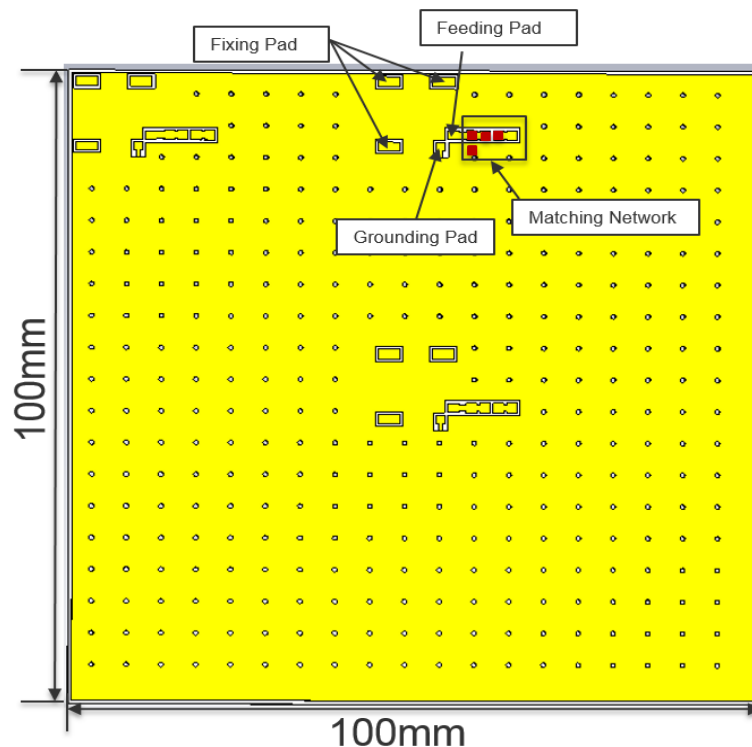


FIGURE 2: REFERENCE PCB LAYOUT

(Note: PCB Ground Size of 100 mm x 100 mm x 1 mm)

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## III. ANTENNA PERFORMANCE AT RECOMMENDED LOCATION

The recommended antenna location is at the upper center of the PCB as shown in Figure 2.1.

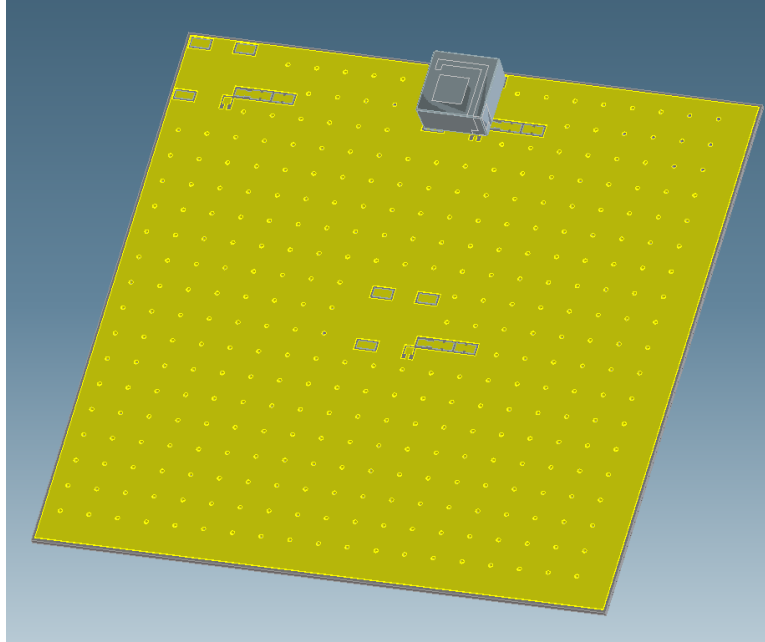


FIGURE 2.1 RECOMMENDED ANTENNA LOCATION

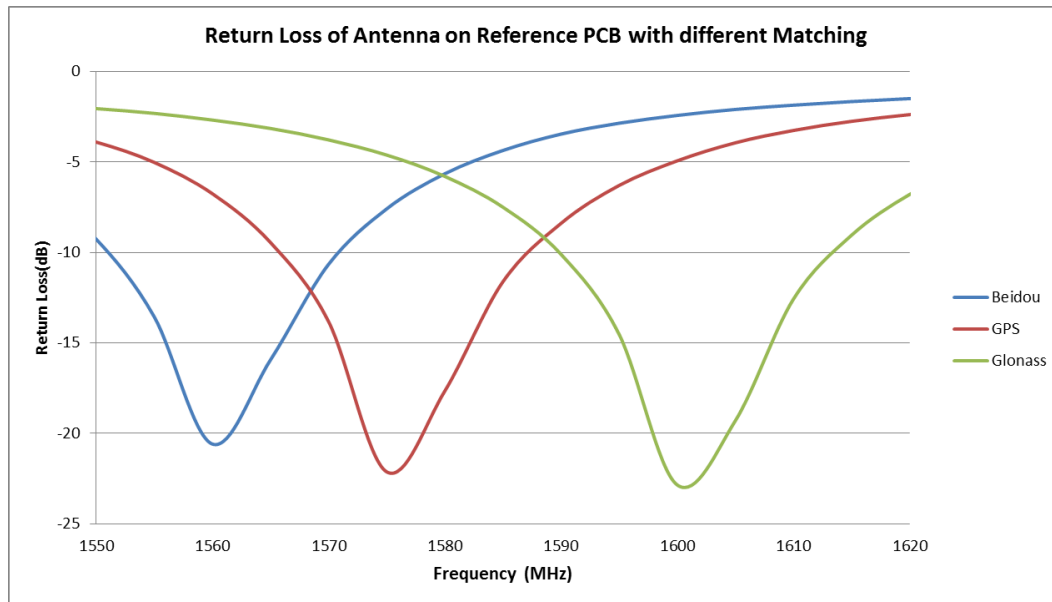
DESCRIPTION	Test Condition	Requirements		
Frequency Range	Measure antenna on recommended PCB through VNA E5071C	1561MHz +/-5MHz	1575MHz +/-5MHz	1602MHz +/-5MHz
Return Loss	Measure antenna on recommended PCB through VNA E5071C	< -10 dB		
Peak Gain	Measure antenna on recommended PCB through OTA chamber	0.7dBi	0.7dBi	1.5dBi
Avg. Total Efficiency	Measure antenna on recommended PCB through OTA chamber	>55%	>57%	>60%
Polarization	Measure antenna on recommended PCB through OTA chamber	RHCP		
Axial Ratio	Measure antenna on recommended PCB through OTA chamber	<3dB		
Input Impedance	Measure antenna on recommended PCB through VNA E5071C	50Ohms		

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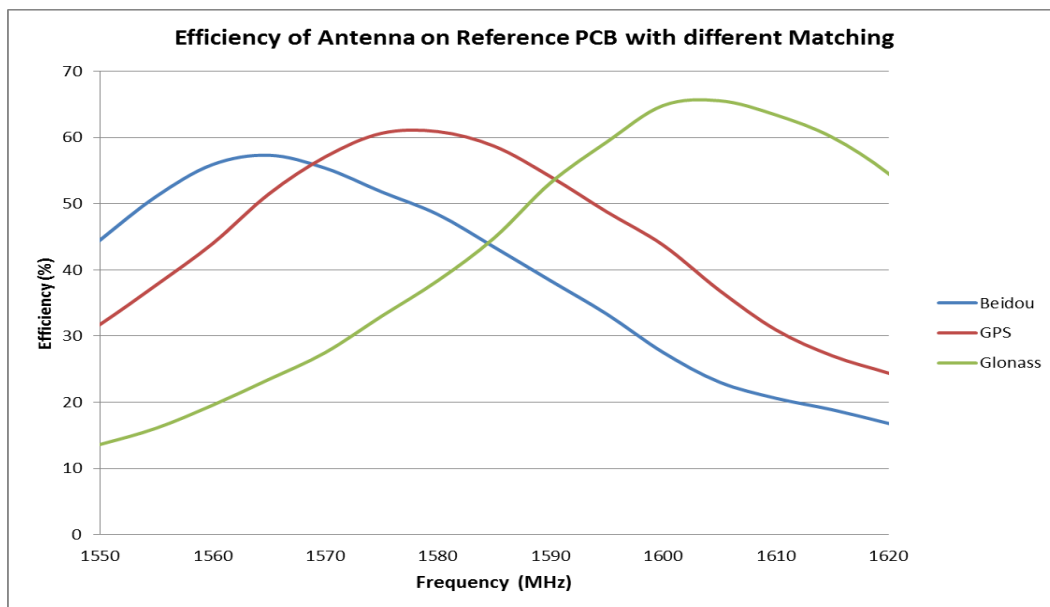


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In order to support various bands including GPS, Glonass and Beidou, three kinds of matching circuits have been applied for the three bands respectively. Figure 2.2- Figure 2.5 comparatively present the return loss, efficiency, peak Gain and axial ratio at different bands with the help of the three matching circuits.



**FIGURE 2.2 RETURN LOSS OF ANTENNA ON REFERENCE PCB AT REFERENCE LOCATION WITH THREE DIFFERENT MATCHING CIRCUITS**

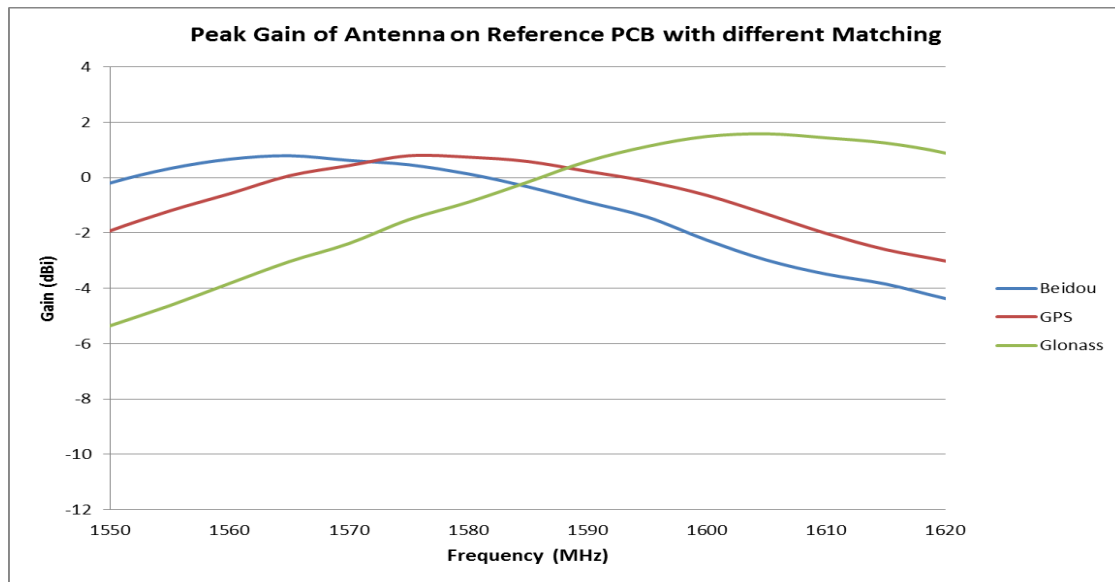


**FIGURE 2.3 EFFICIENCY OF ANTENNA ON REFERENCE PCB AT REFERENCE LOCATION WITH THREE DIFFERENT MATCHING CIRCUITS**

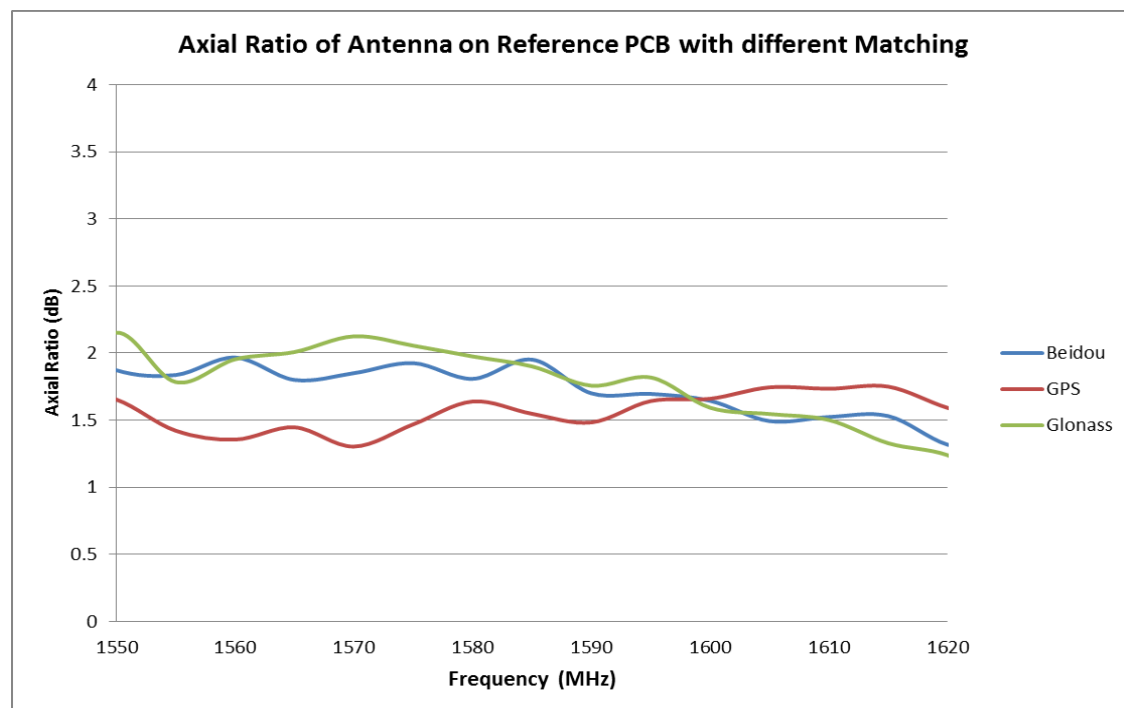
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**FIGURE 2.4 PEAK GAIN OF ANTENNA ON REFERENCE PCB AT REFERENCE LOCATION WITH THREE DIFFERENT MATCHING CIRCUITS**



**FIGURE 2.5 AXIAL RATIO OF ANTENNA ON REFERENCE PCB AT REFERENCE LOCATION WITH THREE DIFFERENT MATCHING CIRCUITS**

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## 3.0 REFERENCE DOCUMENTS

- Sales Drawing: SD-146216-001
- Product Specification: PS-146216-001
- Packaging Information – Refer to the Molex related packaging drawings.

## 4.0 RF PERFORMANCE AS A FUNCTION OF IMPLEMENTATION

### 4.0.1 ANTENNA RF PERFORMANCE AS A FUNCTION OF LOCATIONS ON REFERENCE PCB

Three locations have been evaluated RF performance and these locations are shown in figure 4.1. Figure 4.1.1, figure 4.1.2, figure 4.1.3 and figure 4.1.4 comparatively present the return loss, efficiency, peak Gain and axial ratio at GPS band at three locations.

The efficiency at location 2 is the best while the axial ratio at location 1 is the best. However, the axial ratio at location 2 is over 10dB while the efficiency at location 1 is acceptable. So location 1 (upper center location) is the recommended location for this antenna.

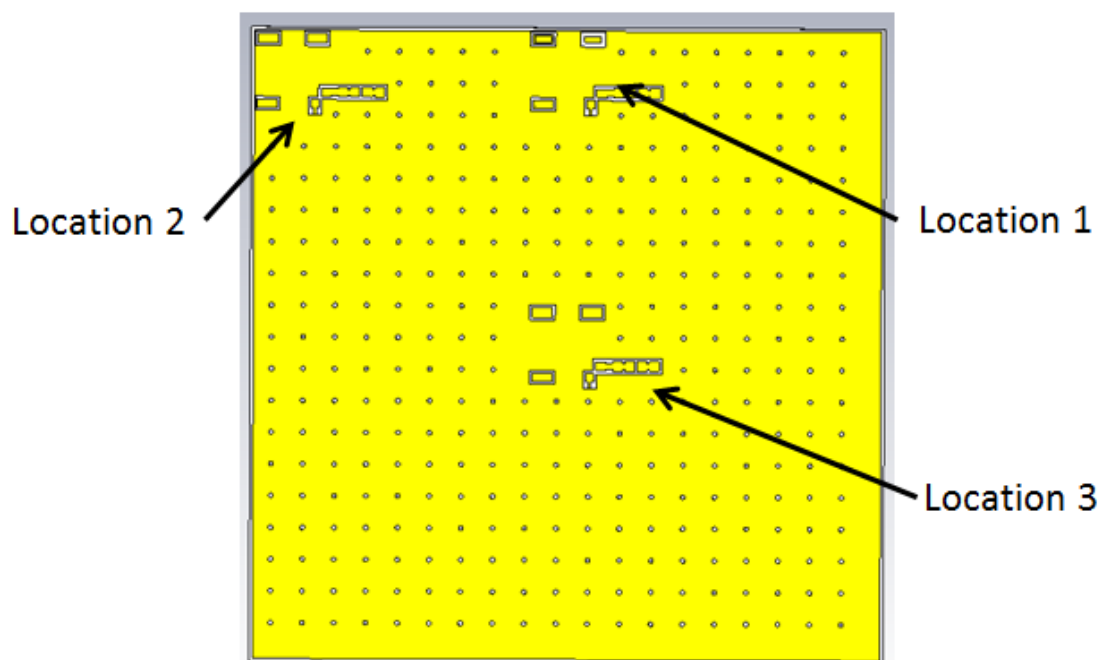
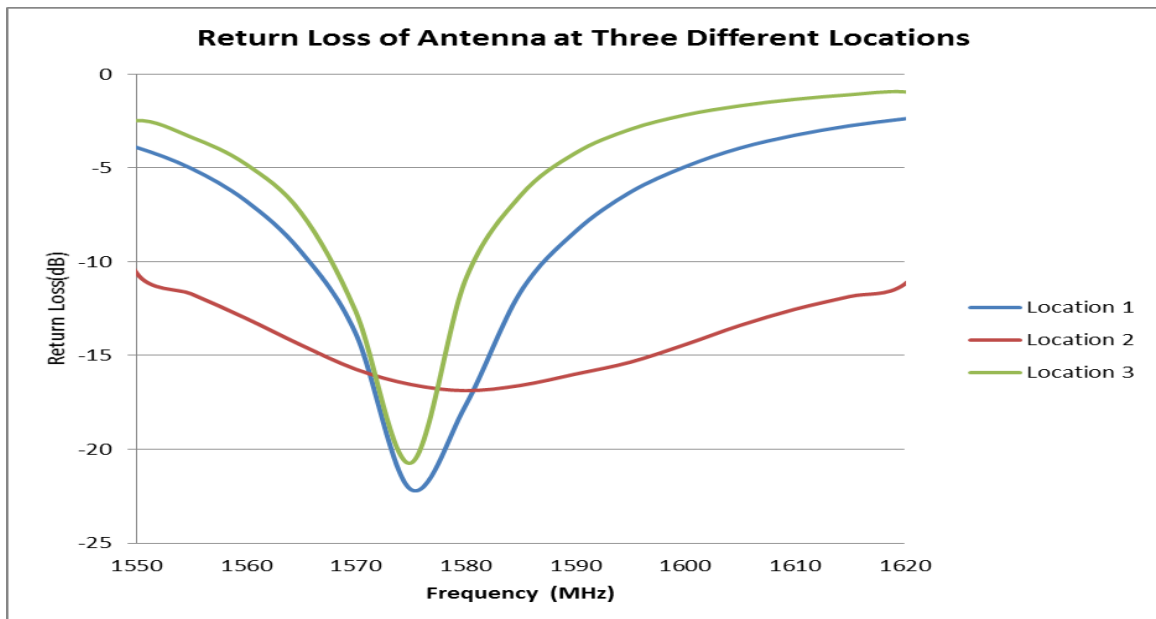


FIGURE 4.1 THREE LOCATIONS ON REFERENCE PCB

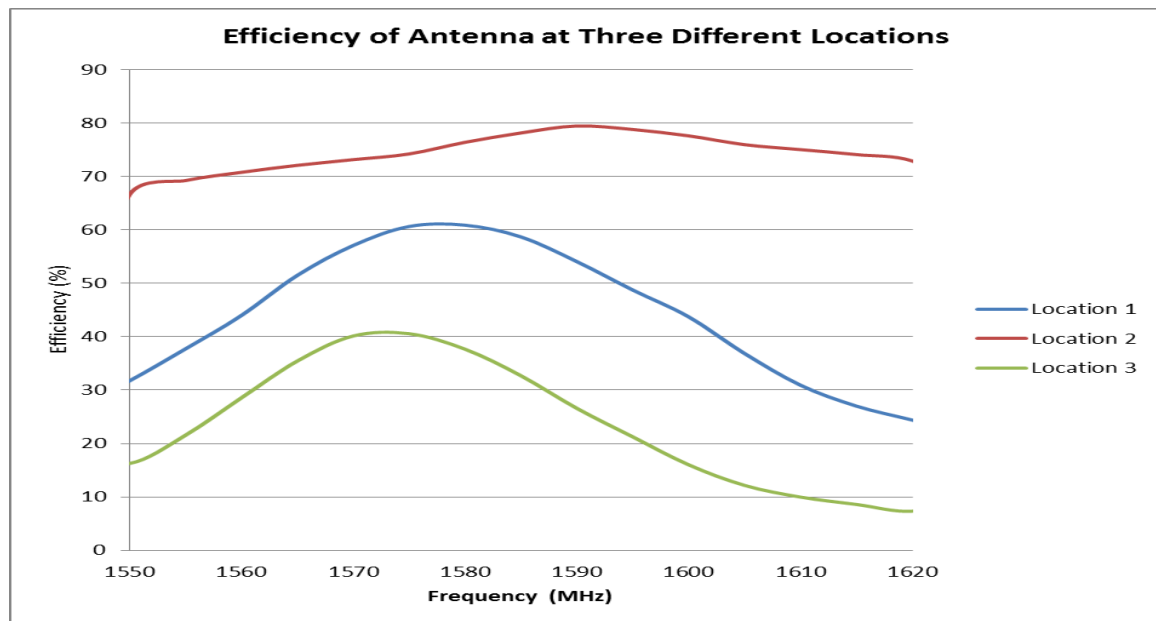
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**Figure 4.1.1 RETURN LOSS OF ANTENNA AT GPS BAND AT THREE LOCATIONS**



**Figure 4.1.2 EFFICIENCY OF ANTENNA AT GPS BAND AT THREE LOCATIONS**

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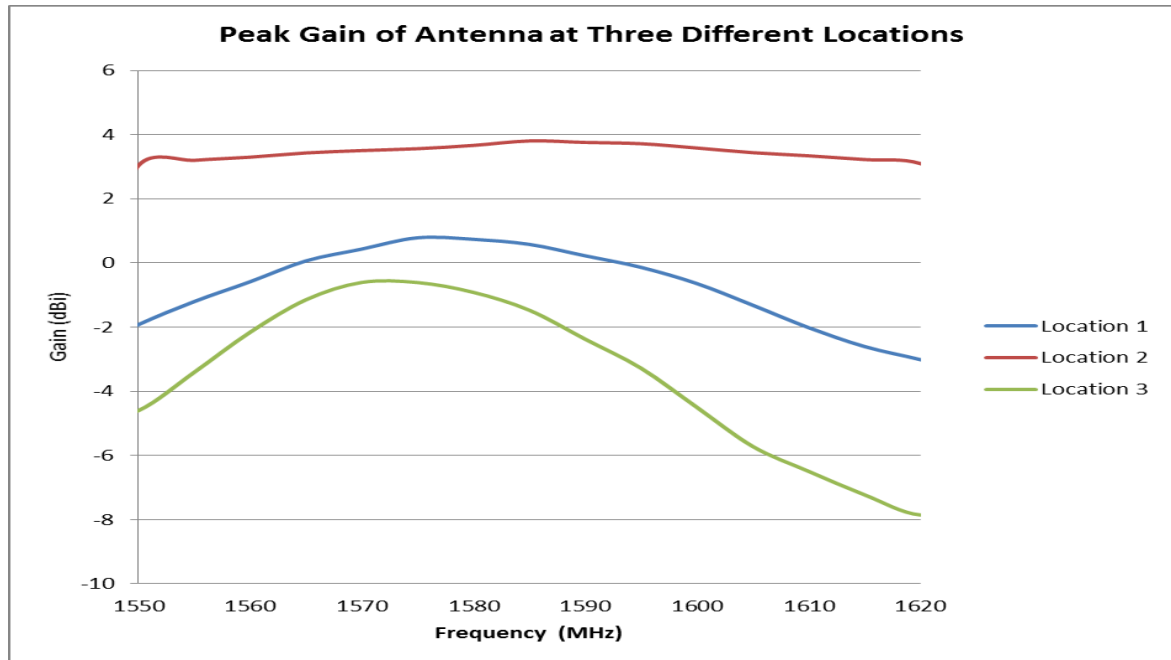


Figure 4.1.3 PEAK GAIN OF ANTENNA AT GPS BAND AT THREE LOCATIONS

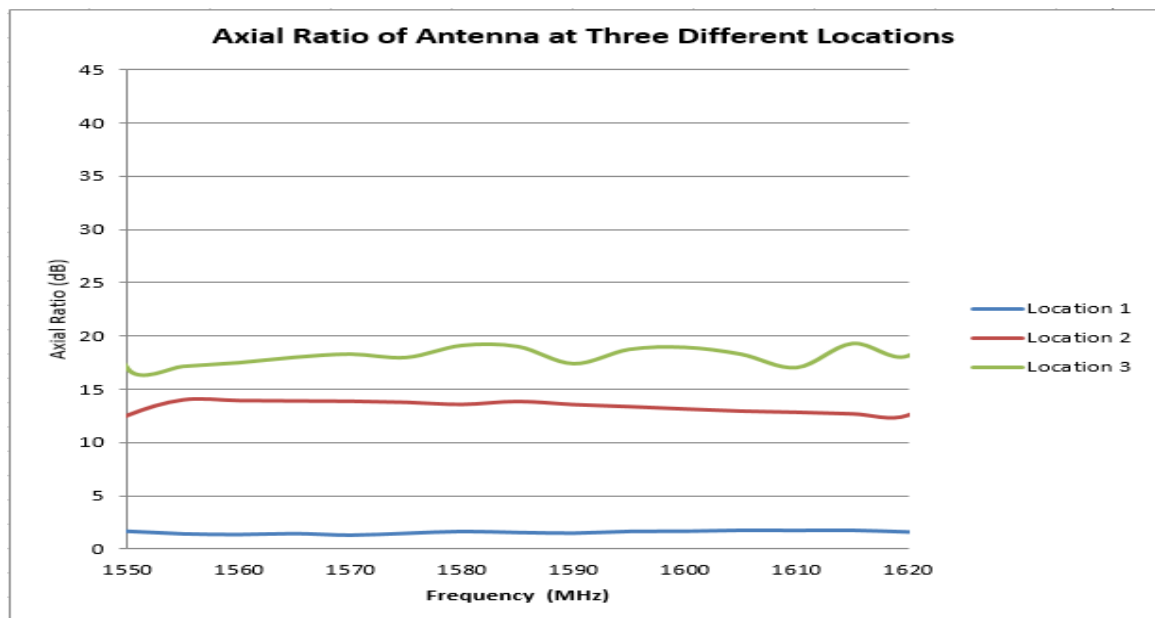


Figure 4.1.4 AXIAL RATIO OF ANTENNA AT GPS BAND AT THREE LOCATIONS

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## 4.0.2 ANTENNA RF PERFORMANCE INFLUENCED BY NEARBY SHIELDING CAN

A shielding can with size of 30mm\*30mm\*2mm was used for this study.

An evaluation was done with 3 different distances from the antenna which located at the recommended location to the shielding can. The 3 distances are as following: 1mm, 3mm and 5mm.

From the study, we recommend that a shielding can should be placed 5mm away from the antenna. When the distance is less than 5mm, the antenna performance will be significantly degraded. Refer to figure 4.2.1-4.2.4

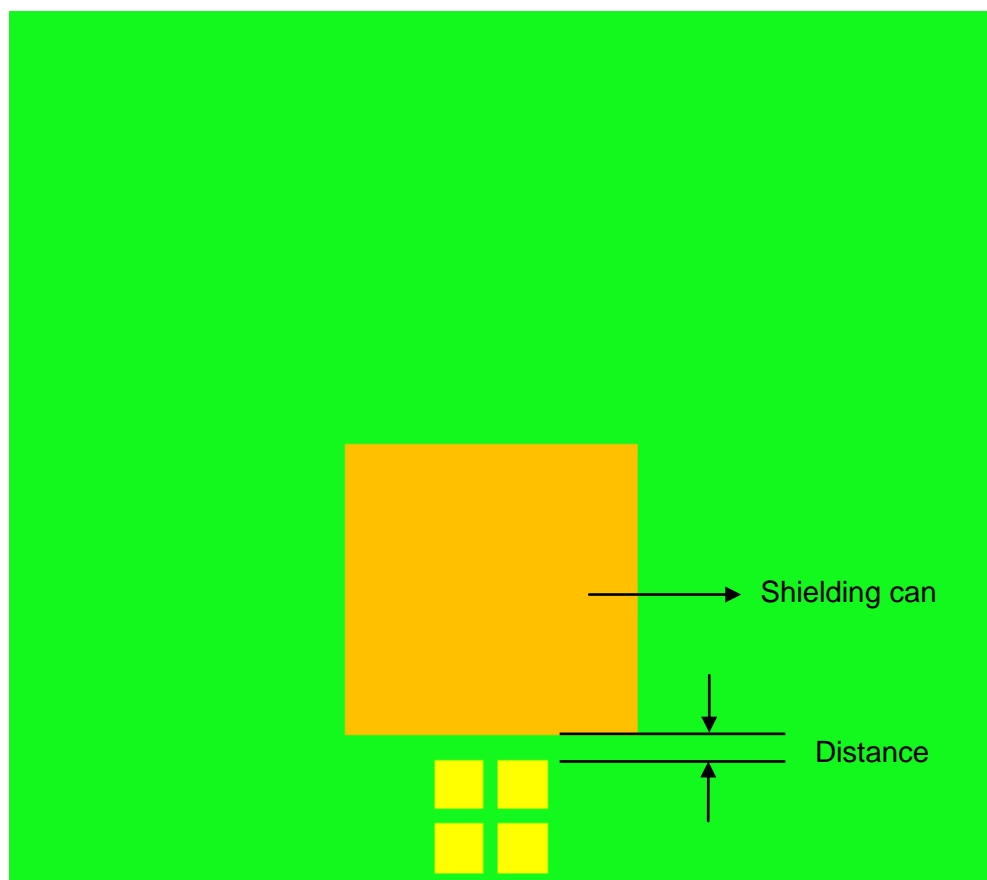


Figure 4.2 SHIELDING CAN FIXED ON REFERENCE PCB

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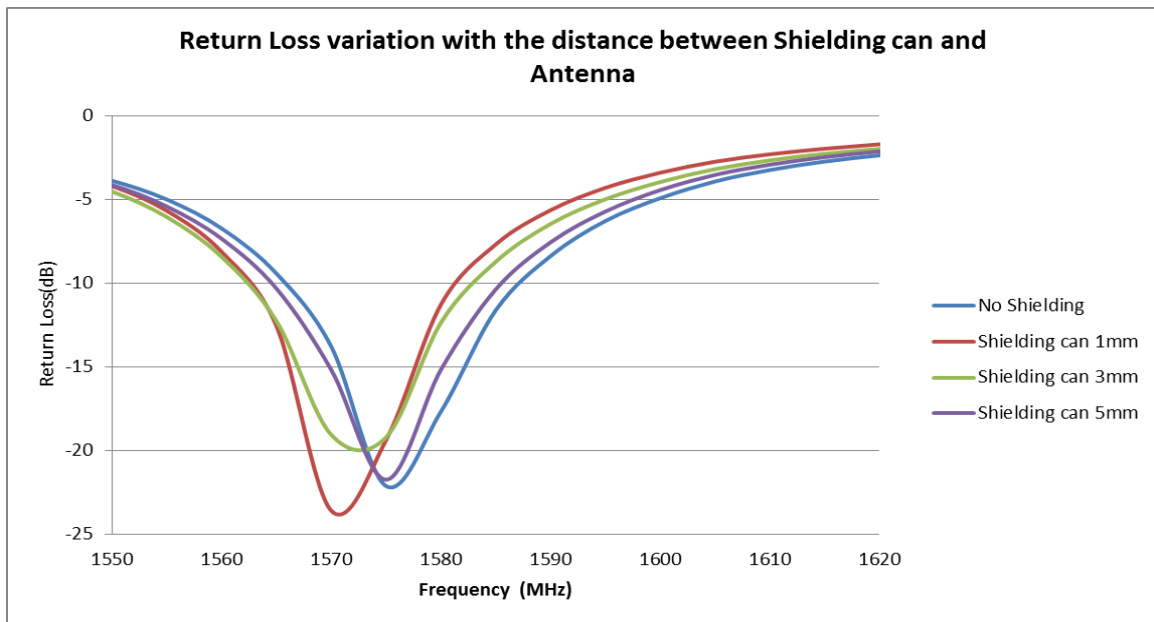


FIGURE 4.2.1 RETURN LOSS COMPARISON AT GPS BAND OF SHIELDING CAN DISTANCE FROM ANTENNA

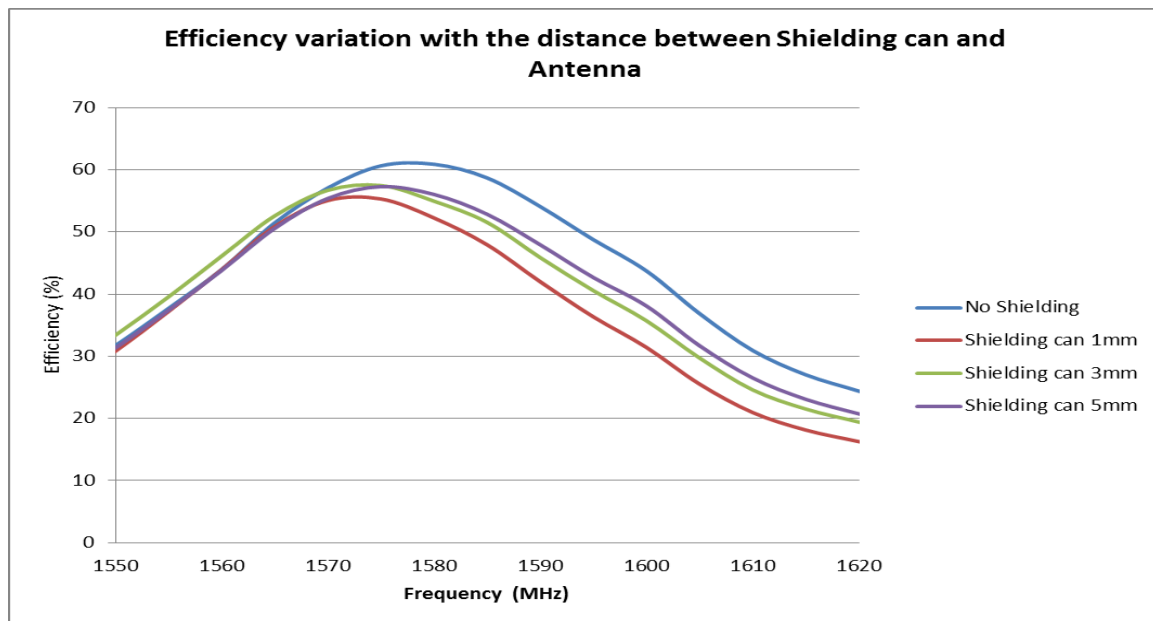


FIGURE 4.2.2 EFFICIENCY COMPARISON AT GPS BAND OF SHIELDING CAN DISTANCE FROM ANTENNA

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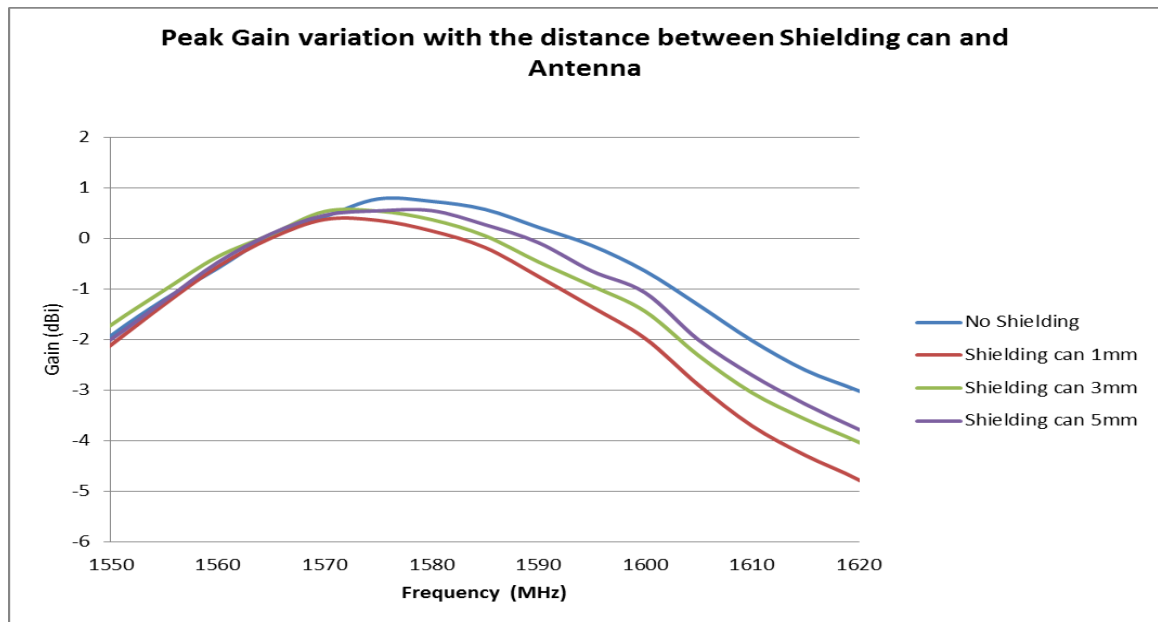


FIGURE 4.2.3 PEAK GAIN COMPARISON AT GPS BAND OF SHIELDING CAN DISTANCE FROM ANTENNA

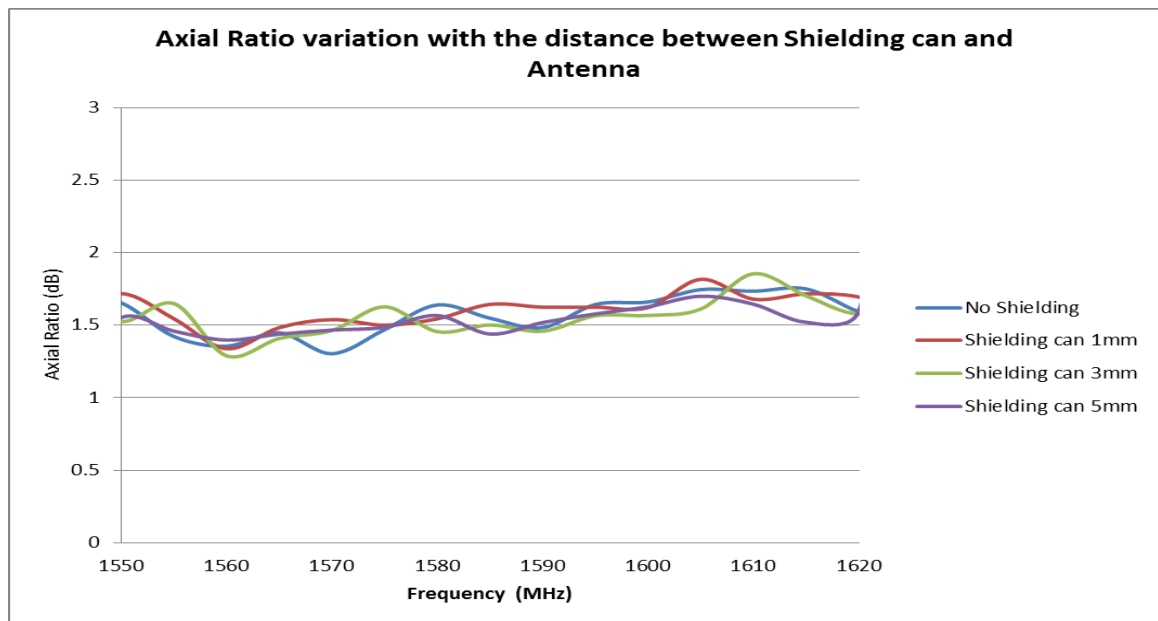


FIGURE 4.2.4 AXIAL RATIO COMPARISON AT GPS BAND OF SHIELDING CAN DISTANCE FROM ANTENNA

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## 4.0.3 RF PERFORMANCE AS AN EFFECT OF NEARBY BATTERY

A battery with size of 30mm\*60mm\*3mm was used for this study.

An evaluation was done with 3 different distances from the antenna which located at the recommended location. The 3 distances are as follow: 1mm, 3mm and 5mm.

From the study, we recommend a battery should be placed at least 5mm away from the antenna. When the distance is less than 5mm, the antenna performance will be significantly degraded. Refer to figure 4.3.1-4.3.4.

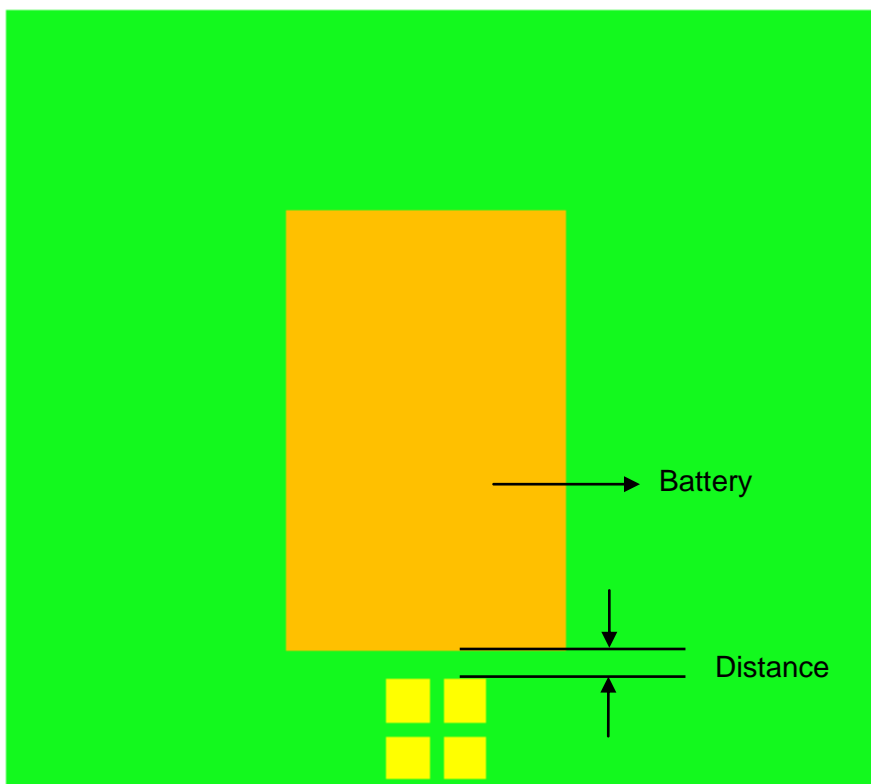


FIGURE 4.3 BATTERY FIXED ON REFERENCE PCB

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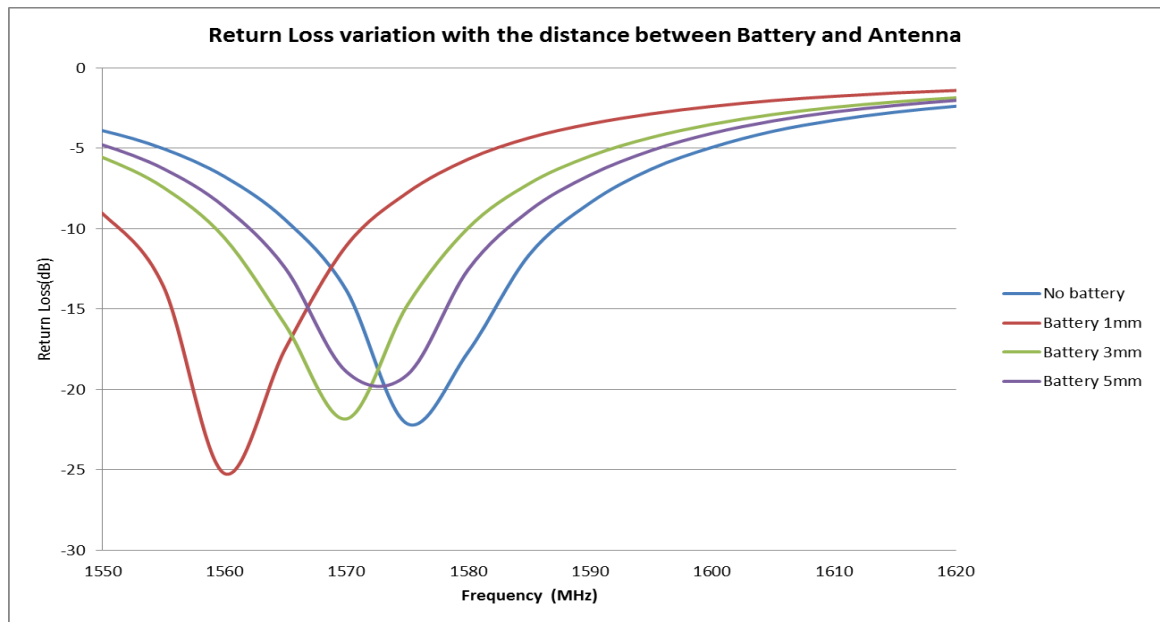


FIGURE 4.3.1 RETURN LOSS COMPARISON AT GPS BAND OF BATTERY DISTANCE FROM ANTENNA

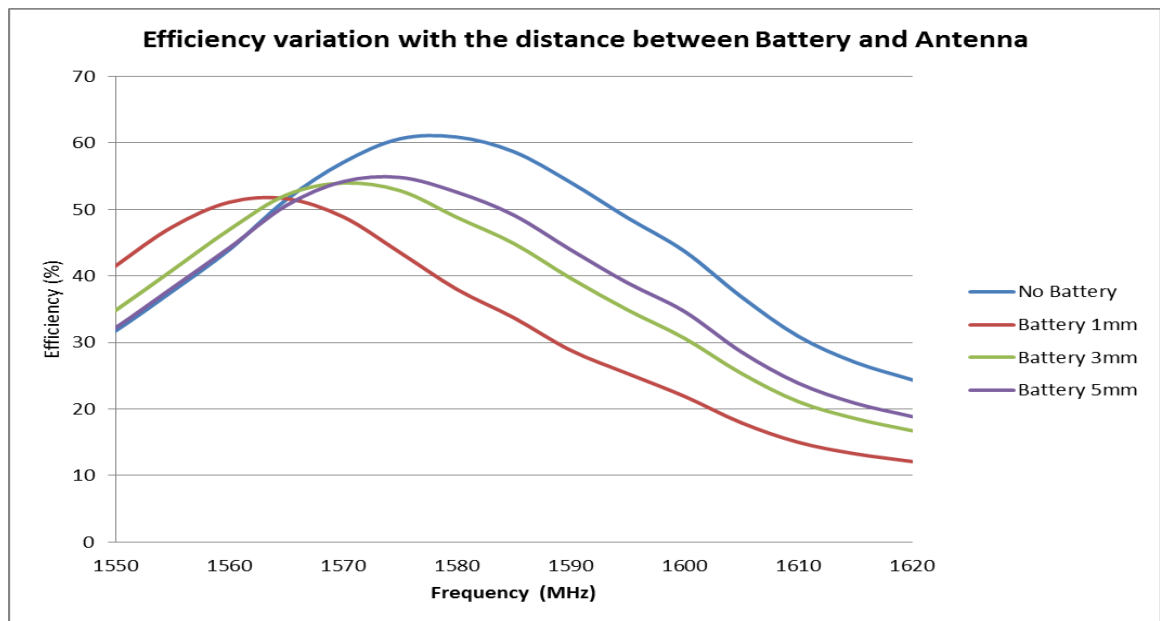


FIGURE 4.3.2 EFFICIENCY COMPARISON AT GPS BAND OF BATTERY DISTANCE FROM ANTENNA

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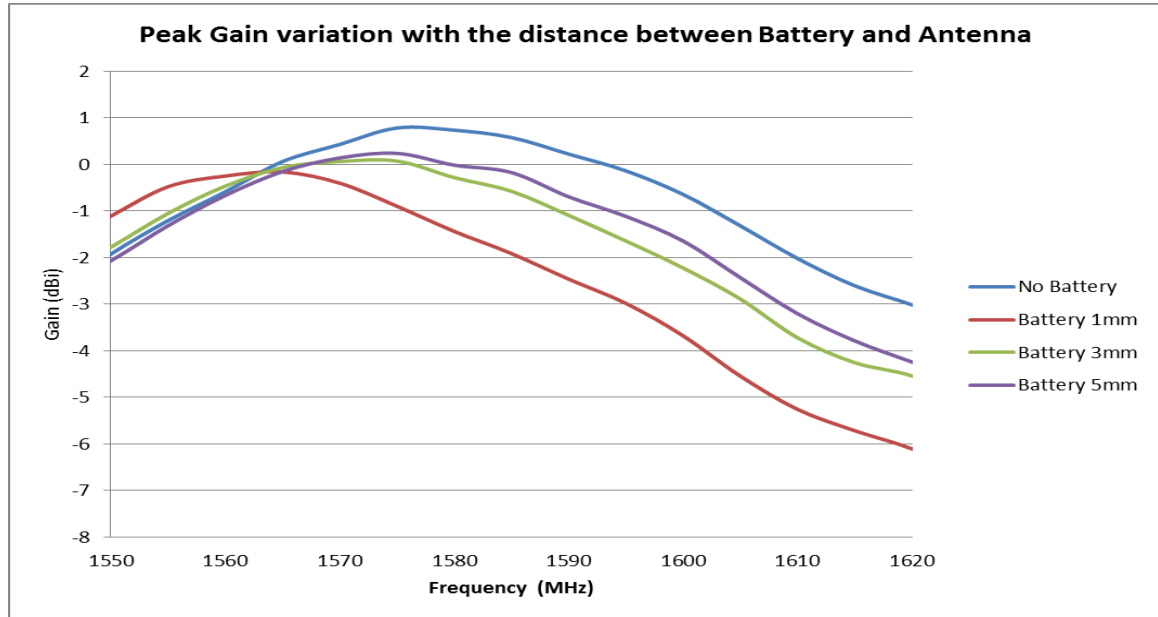


FIGURE 4.3.3 PEAK GAIN COMPARISON AT GPS BAND OF BATTERY DISTANCE FROM ANTENNA

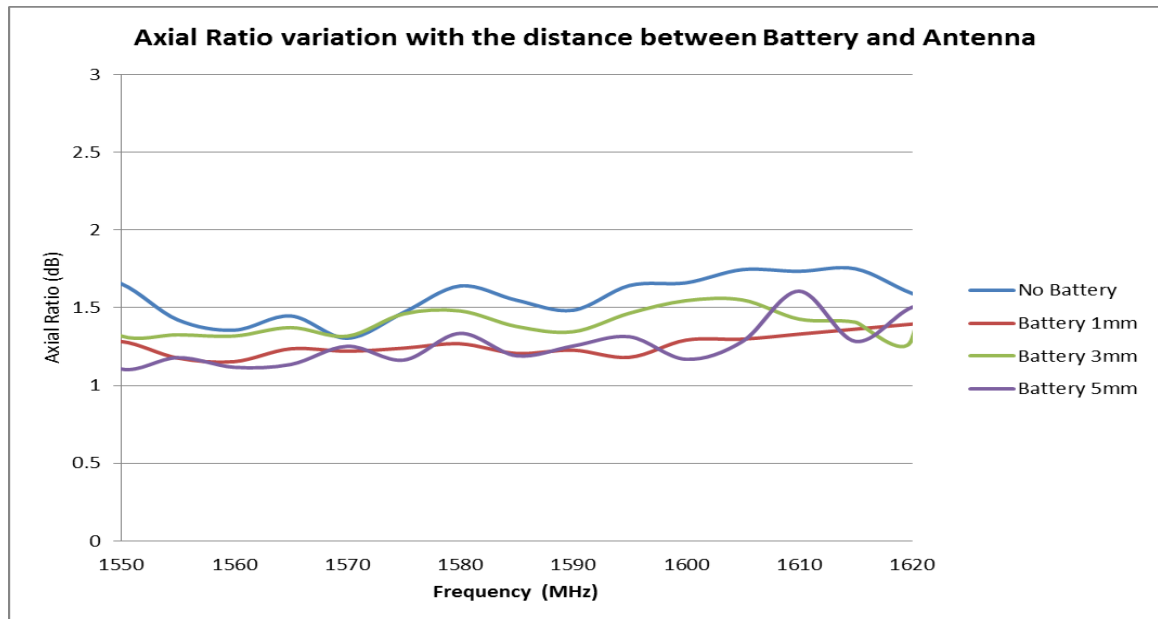
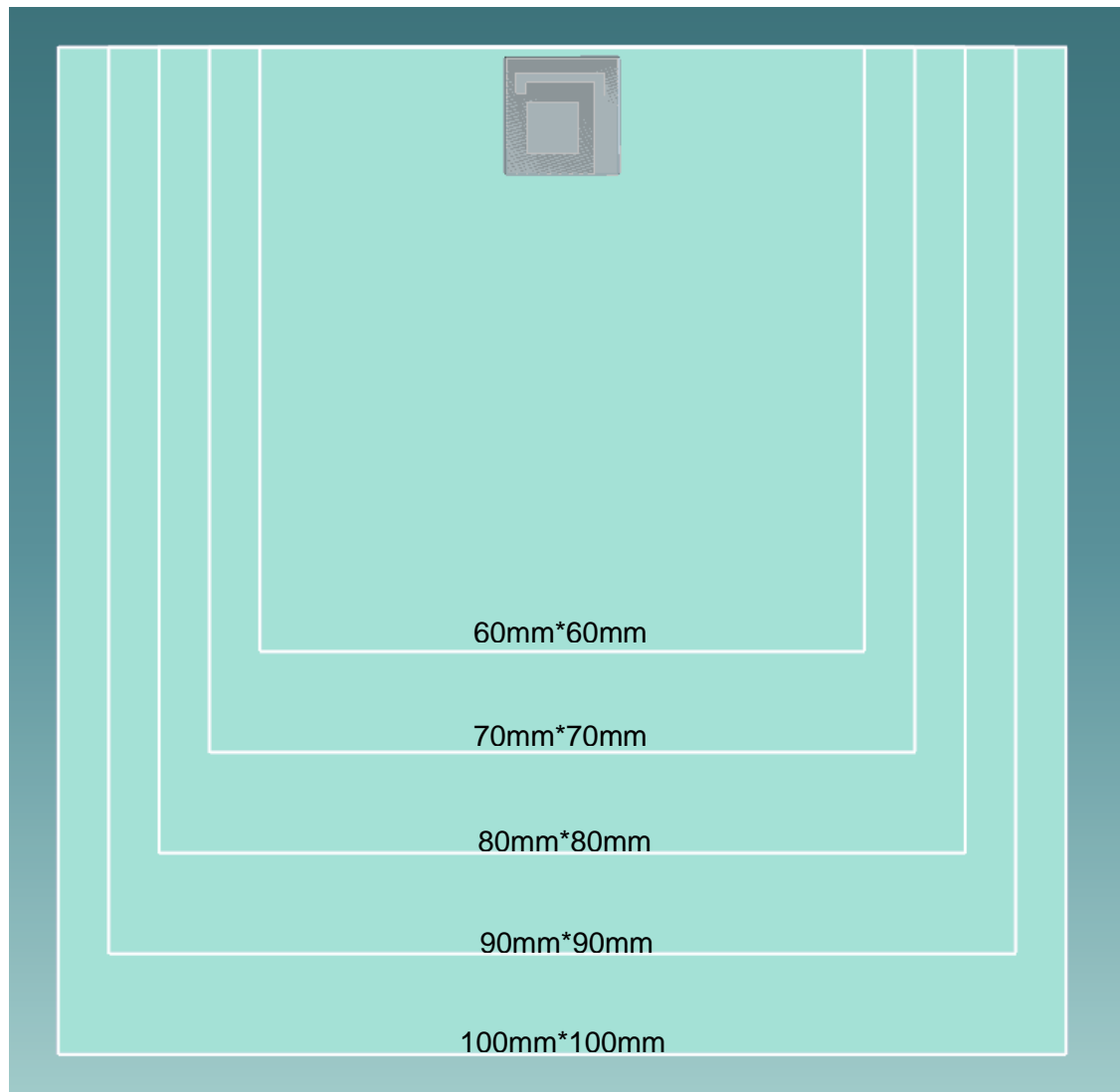


FIGURE 4.3.4 AXIAL RATIO COMPARISON AT GPS BAND OF BATTERY DISTANCE FROM ANTENNA

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## 4.0.4 RF PERFORMANCE AS AN EFFECT OF PCB GROUND SIZE

Five kinds of PCB ground size have been evaluated and these configurations are shown in figure 4.4. Figure 4.4.1-4.4.4 comparatively show the return loss, the efficiency, the peak gain and axial ratio of this antenna with five kinds of PCB. 90mm\*90mm is the recommended minimum PCB ground size for this antenna. When the ground size is less than 90mm\*90mm, the axial ratio will be significantly increased.



**FIGURE 4.4 DIFFERENT GROUND PCB SIZE**

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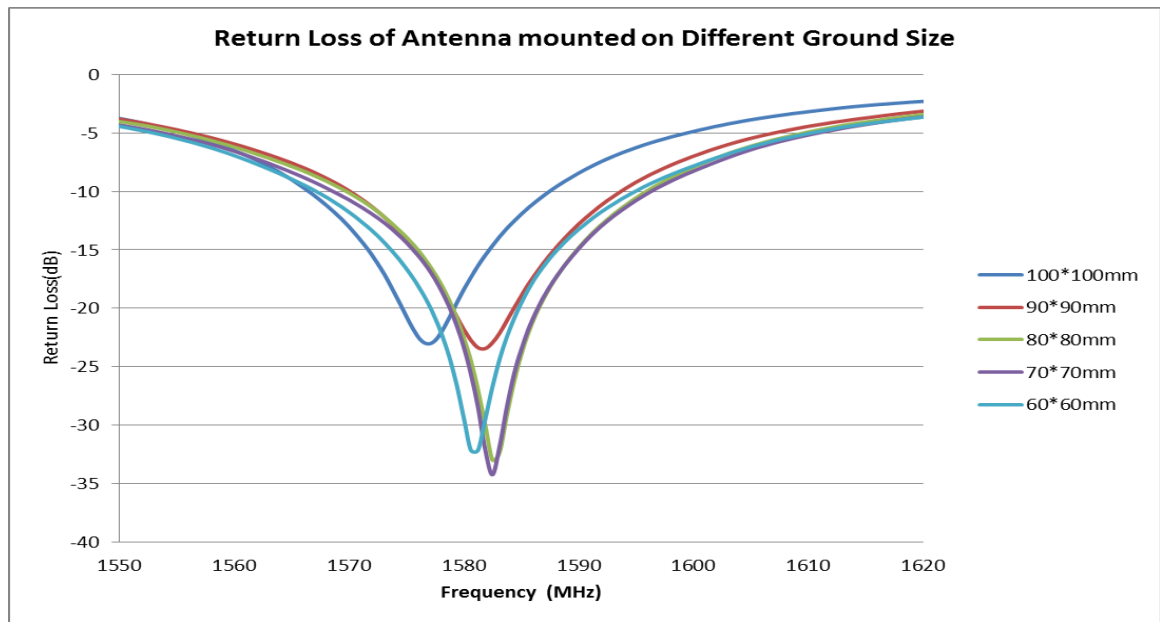


FIGURE 4.4.1 RETURN LOSS COMPARISON AT GPS BAND OF AN ANTENNA MOUNTED ON DIFFERENT GROUND SIZE

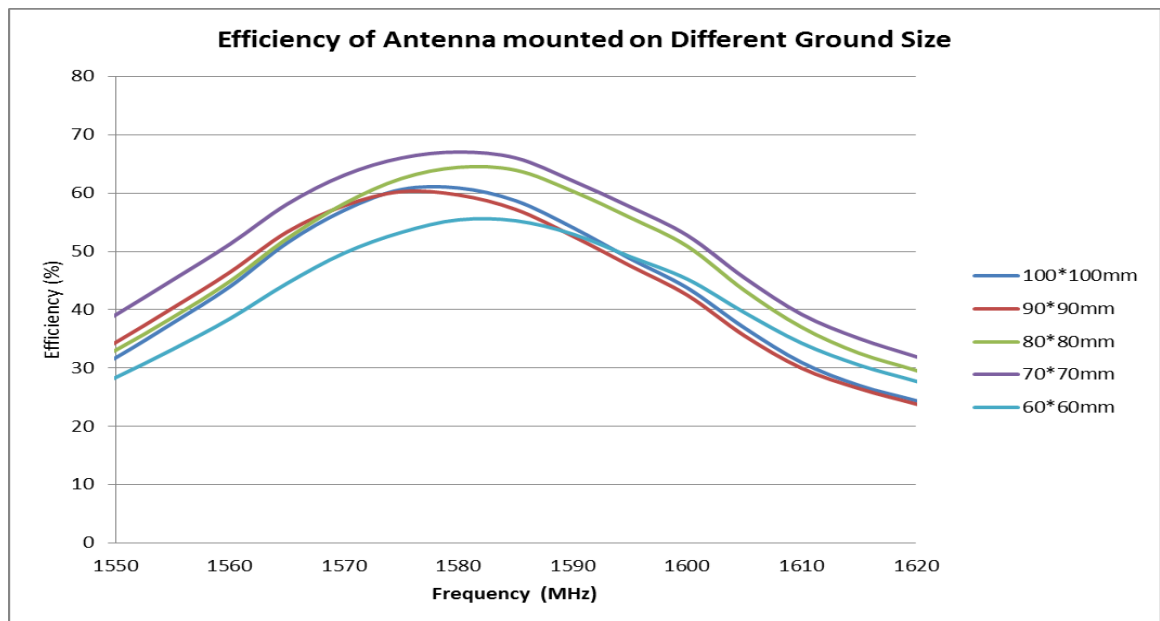


FIGURE 4.4.2 EFFICIENCY COMPARISON AT GPS BAND OF AN ANTENNA MOUNTED ON DIFFERENT GROUND SIZE

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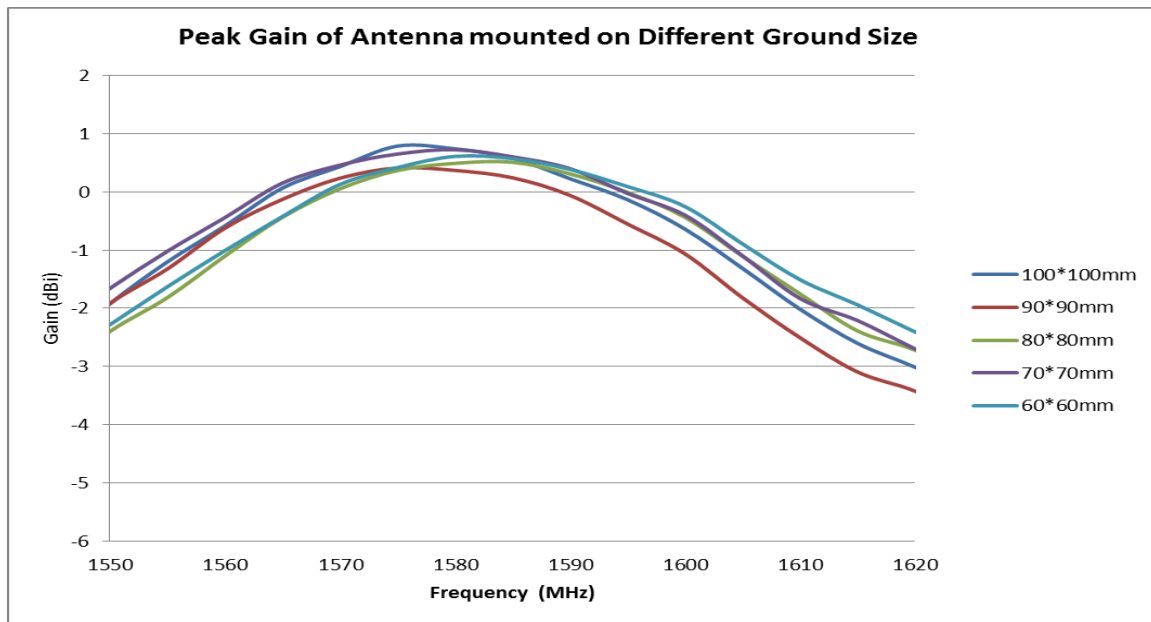


FIGURE 4.13 PEAK GAIN COMPARISON AT GPS BAND OF AN ANTENNA MOUNTED ON DIFFERENT GROUND SIZE

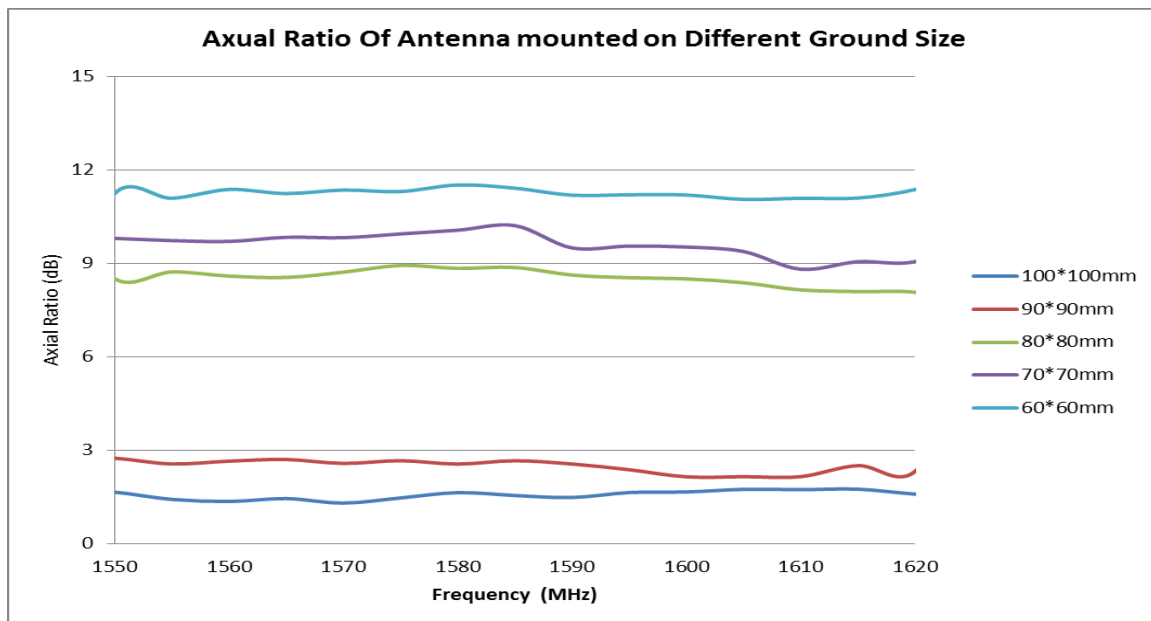


FIGURE 4.14 AXIAL RATIO COMPARISON AT GPS BAND OF AN ANTENNA MOUNTED ON DIFFERENT GROUND SIZE

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## 5.0 MATCHING NETWORK DESRICPTION

The “L” type matching circuit is recommended to be applied for this antenna at the recommended position on reference PCB. The sequence of parallel element and series element depends on the resistance of antenna in smith chart shows in Figure 5.1. Figure 5.2 shows the matching network for this antenna at GPS band at the recommended position on reference PCB. The matching network is a parallel 0.5pF capacitor following with a series 5.6nH inductor for GPS Band (The matching network is a parallel 12nH inductor following with a series 1.2pF capacitor for Beidou Band while it is a parallel 3.9nH inductor following with a series 2.7pF capacitor for Glonass Band).

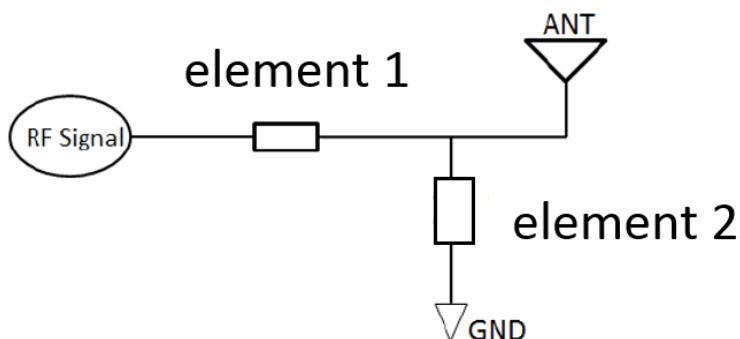


FIGURE 5.1 CONFIGURE 1 FOR GPS BAND

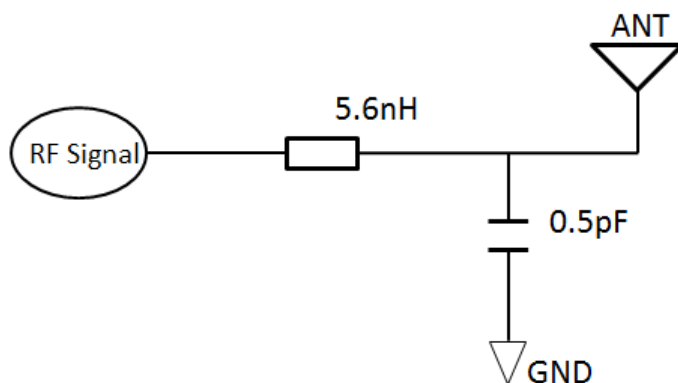


FIGURE 5.2 RECOMMEND MATCHING NETWORK FOR ANTENNA AT GPS BAND

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The following figure 5.3 and figure 5.4 are the return loss and smith chart comparison with and without the matching network for the antenna at GPS band on reference PCB ground size and at reference location.

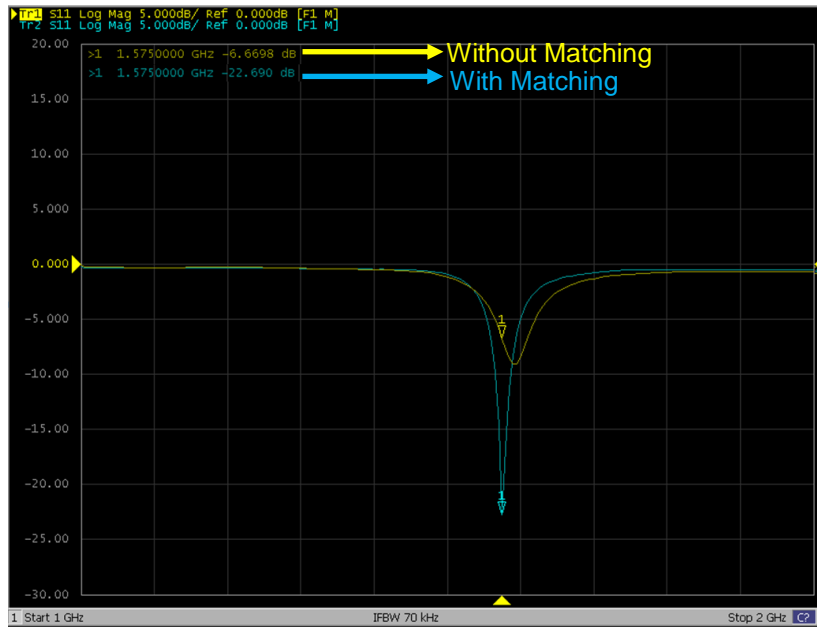


FIGURE 5.3 RETURN LOSS OF ANTENNA WITH AND WITHOUT MATCHING ON REFERENCE PCB GROUND SIZE AT REFERENCE LOCATION

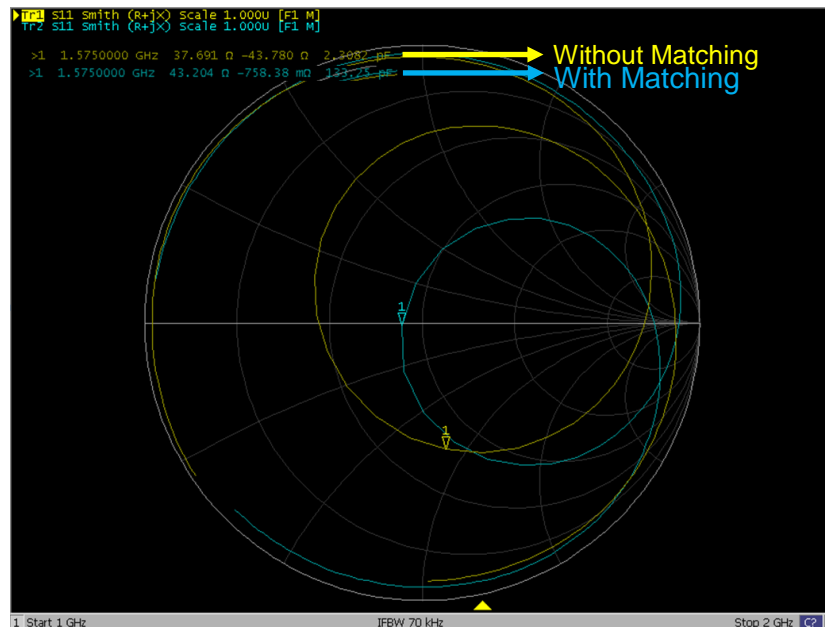


FIGURE 5.4 SMITH CHART OF ANTENNA WITH AND WITHOUT MATCHING ON REFERENCE PCB GROUND SIZE AT REFERENCE LOCATION

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AS-146216-001	Benson Liu 2016/12/01	Ryan Liu 2016/12/01	Welson Tan 2016/12/01



# APPLICATION SPECIFICATION

## 6.0 RADIATION PATTERN

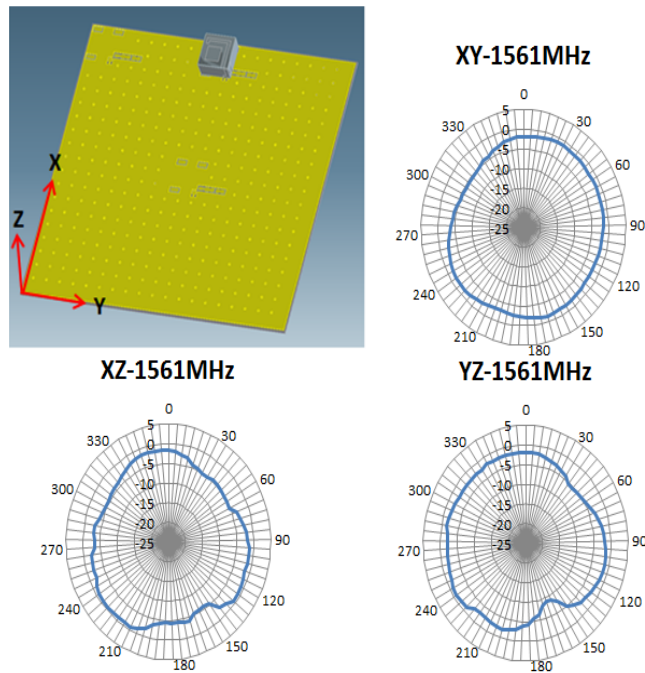


FIGURE 6.1 RADIATION PATTERN OF ANTENNA AT 1561 MHZ AT RECOMMENDED LOCATION

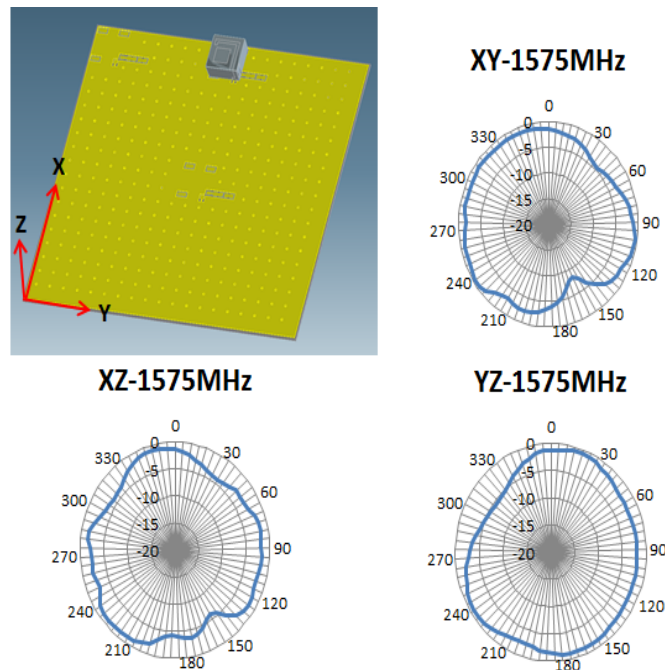


FIGURE 6.2 RADIATION PATTERN OF ANTENNA AT 1575 MHZ AT RECOMMENDED LOCATION

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# APPLICATION SPECIFICATION

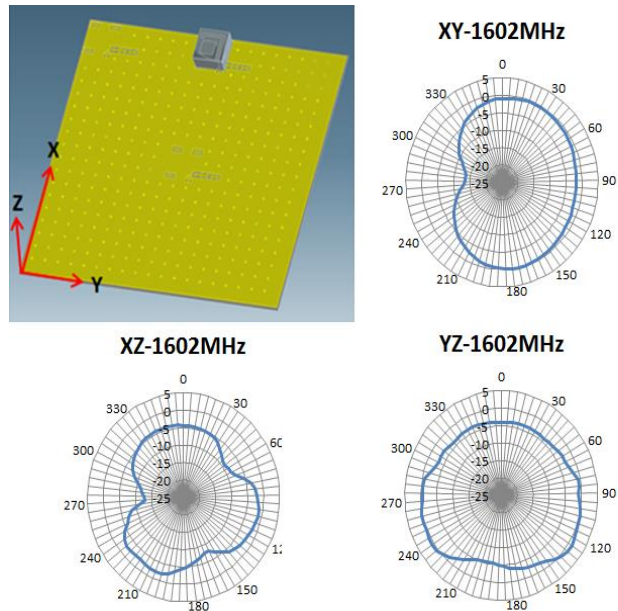


FIGURE 6.2 RADIATION PATTERN OF ANTENNA AT 1602 MHZ AT RECOMMENDED LOCATION

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# APPLICATION SPECIFICATION

## 7.0 ASSEMBLY INSTRUCTIONS

### A. RECOMMENDED SMT REFLOW PROFILE

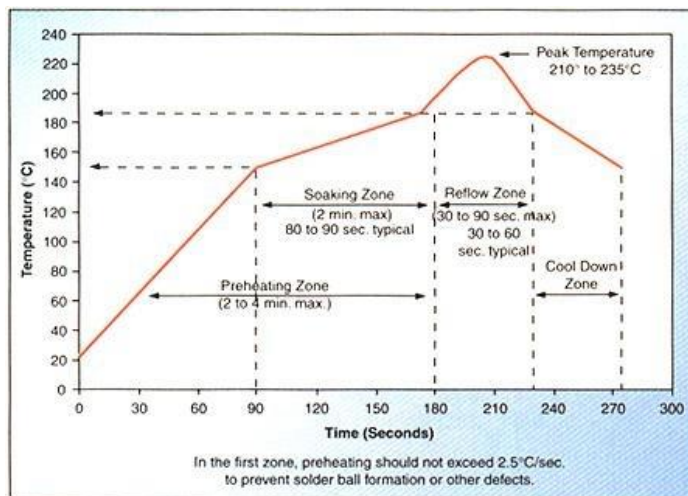


FIGURE 7.1 RECOMMENDED SMT REFLOW PROFILE

### B. MECHANICAL INTERFACE

#### I. GENERAL DESCRIPTION

The overall antenna size is 11.8mm x 11.5mm x 5.95mm

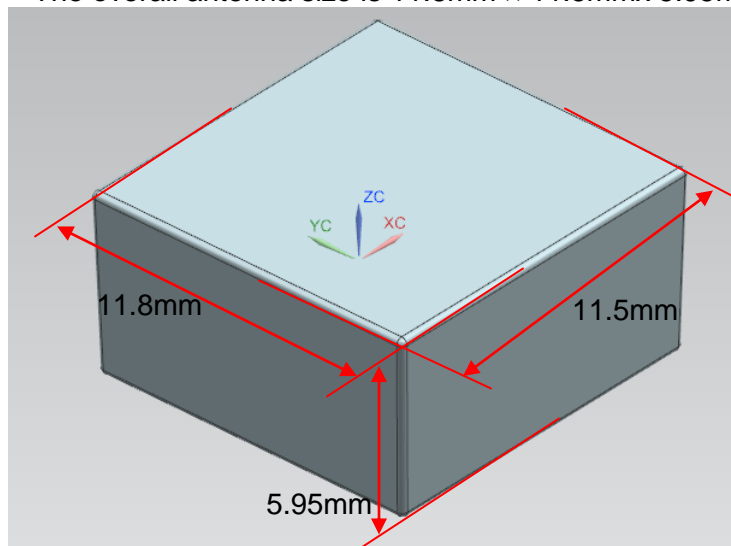
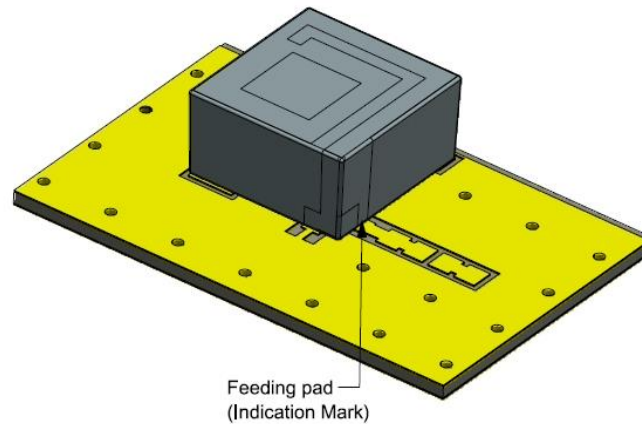


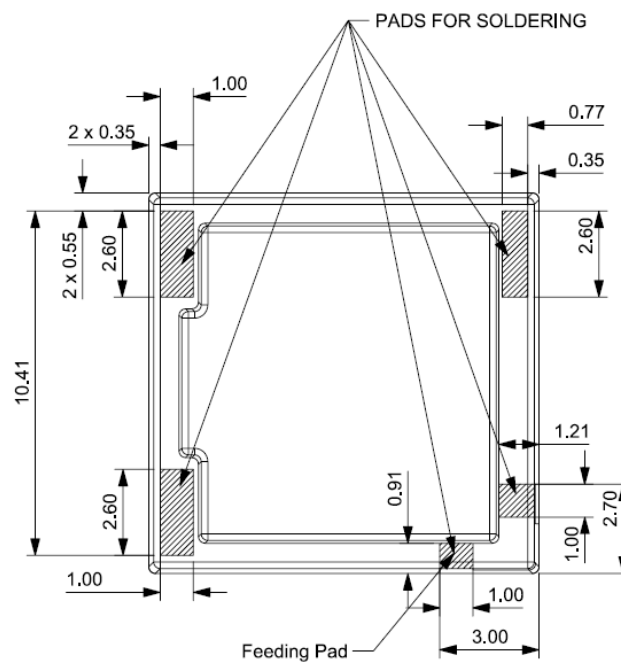
FIGURE 7.2 OVERALL ANTENNA SIZE

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## II. STRUCTURE FUNCTIONAL DESCRIPTION



### FIGURE 7.3 ANTENNA ASSEMBL



### FIGURE 7.4 PADS OF PRODUCT FOR SOLDERING

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<u>DOCUMENT NUMBER:</u>  <div style="font-weight: bold;">AS-146216-001</div>		<u>CREATED / REVISED BY:</u> Benson Liu 2016/12/01	<u>CHECKED BY:</u> Ryan Liu 2016/12/01	<u>APPROVED BY:</u> Welson Tan 2016/12/01	





# APPLICATION SPECIFICATION

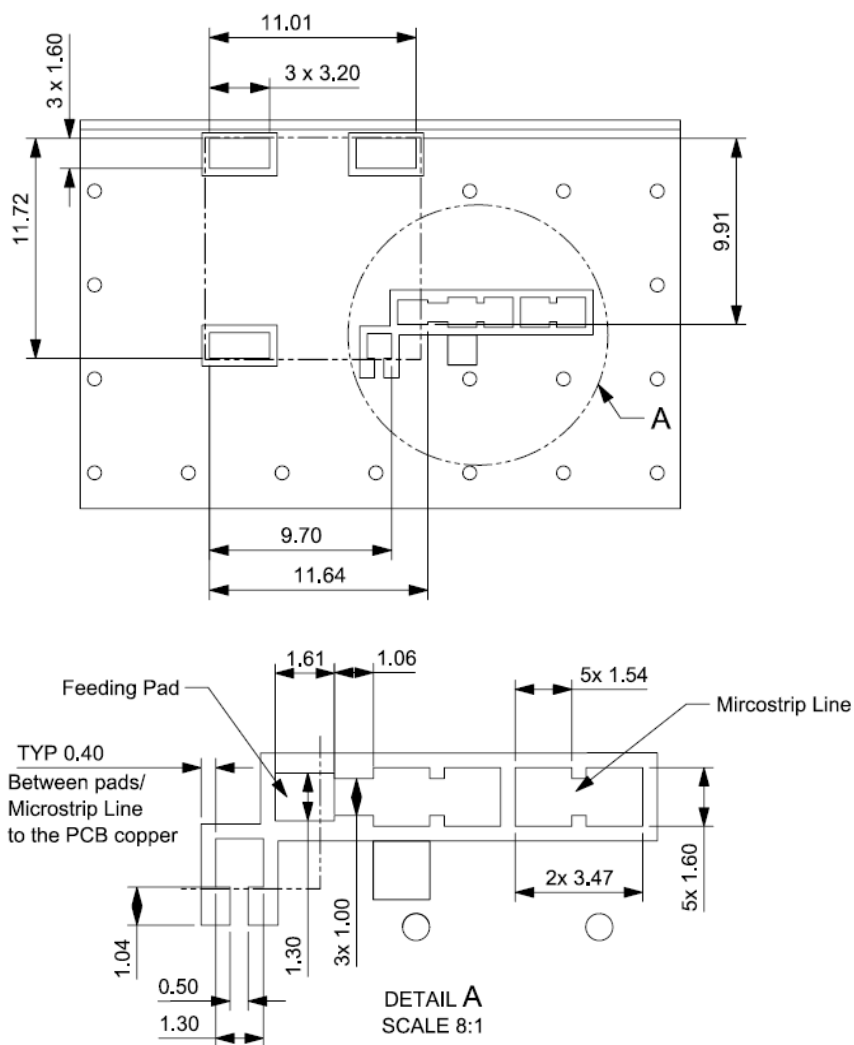


FIGURE 7.5 RECOMMENDED FOOTPRINT ON PCB FOR SOLDERING

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