

## **WB001 HARDWARE BUILD INSTRUCTION**

**Version 1.2**

**This document is subject to change without  
notice**

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## 1 Scope

This document details the performance, construction details and design trade-offs for DecaWave's WB001 tag antenna, also called the HOE Antenna. The document and its associated gerber/DXF files are intended to provide all the information required to integrate this antenna into a DW1000 based tag product.

## 2 General

The WB001 tag antenna is designed to be integrated onto a DW1000 based tag design. It is designed specifically to work with DecaWave's DW1000 UWB transceiver providing a low or zero cost, high efficiency compact solution with good efficiency, fidelity and low group delay variation with antenna orientation. When implemented correctly it should meet the following basic goals:

**Operational Frequency Range:** 3.5 GHz to 7 GHz

**Maximum Gain:** 4dBi at 4GHz  
3.7dBi at 6.5 GHz

**Radiation Pattern:** Omni-directional

## 3 Build Details

The WB001 antenna is designed to be printed on 0.8 mm FR4 PCB substrate.

The following files are provided to assist with the integrating this antenna into your PCB layout:

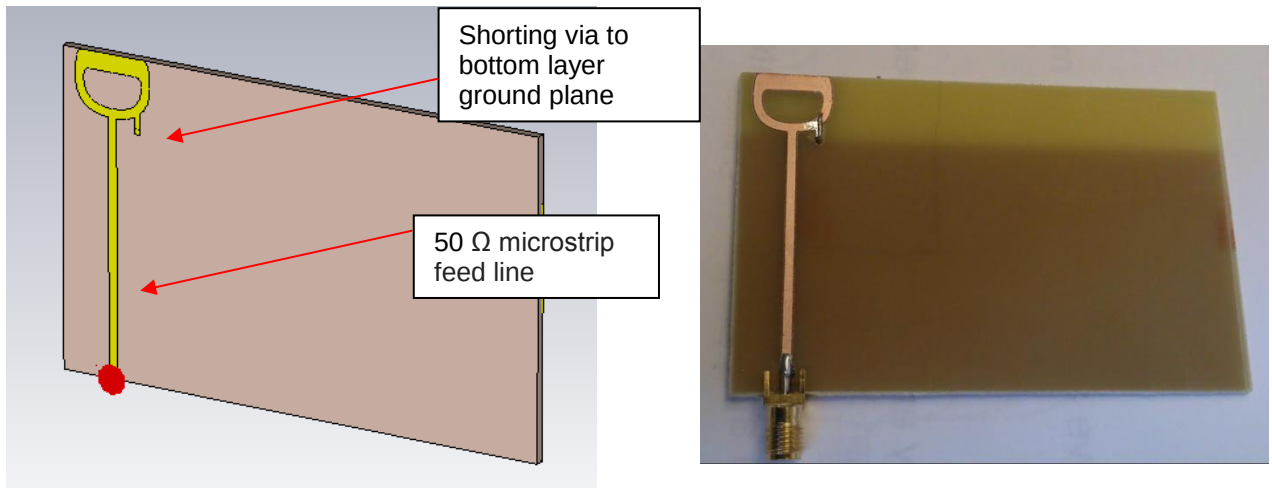
**Table 1 Deliverables**

| File Name                        | File Type | Description         |
|----------------------------------|-----------|---------------------|
| TAG_Decawave_WB001_top_layer.grb | Gerber    | Top layer copper    |
| TAG_Decawave_WB001_btm_layer.grb | Gerber    | Bottom layer copper |
| TAG_Decawave_WB001_top_layer.dxf | DXF       | Top layer copper    |
| TAG_Decawave_WB001_btm_layer.dxf | DXF       | Bottom layer copper |

Either gerber or DXF files can be used.

A shorting via is to be inserted where the circle is located in the layout files. The 50  $\Omega$  feeding strip can be trimmed up to the edge of the ground plane. It should be noted that the ground plane forms part of the antenna. The more ground plane the better the performance. Section 5 shows the trade-off between performance and ground plane size and spacing.

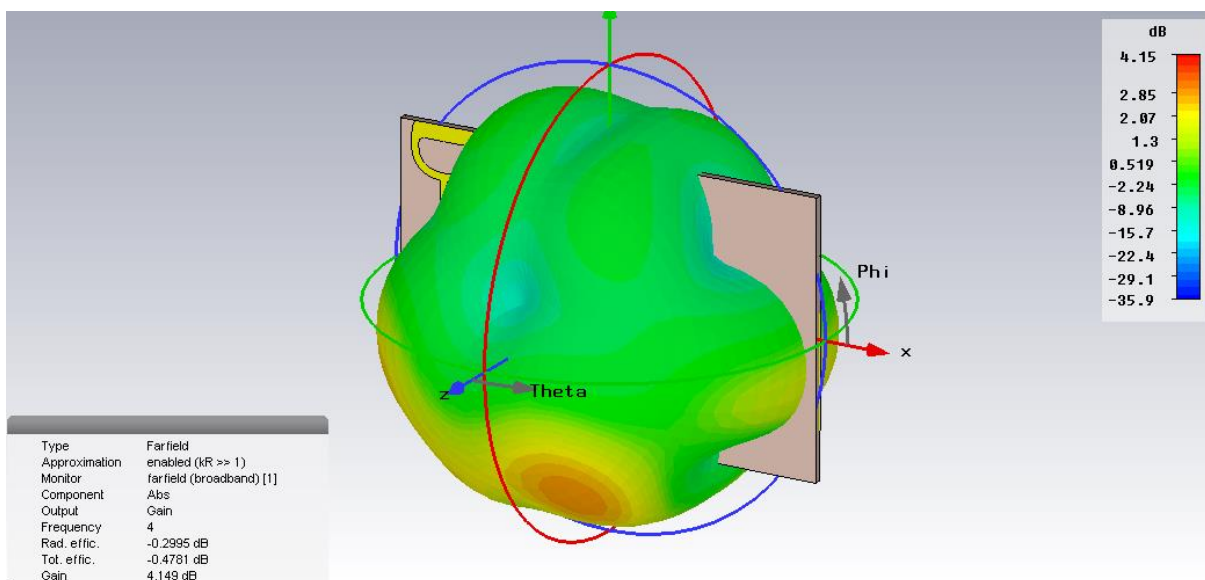
It is recommended that the PCB manufacturer uses impedance control to ensure that the 50  $\Omega$  feed line and hence the rest of the antenna design is within a  $\pm 5\%$  tolerance.

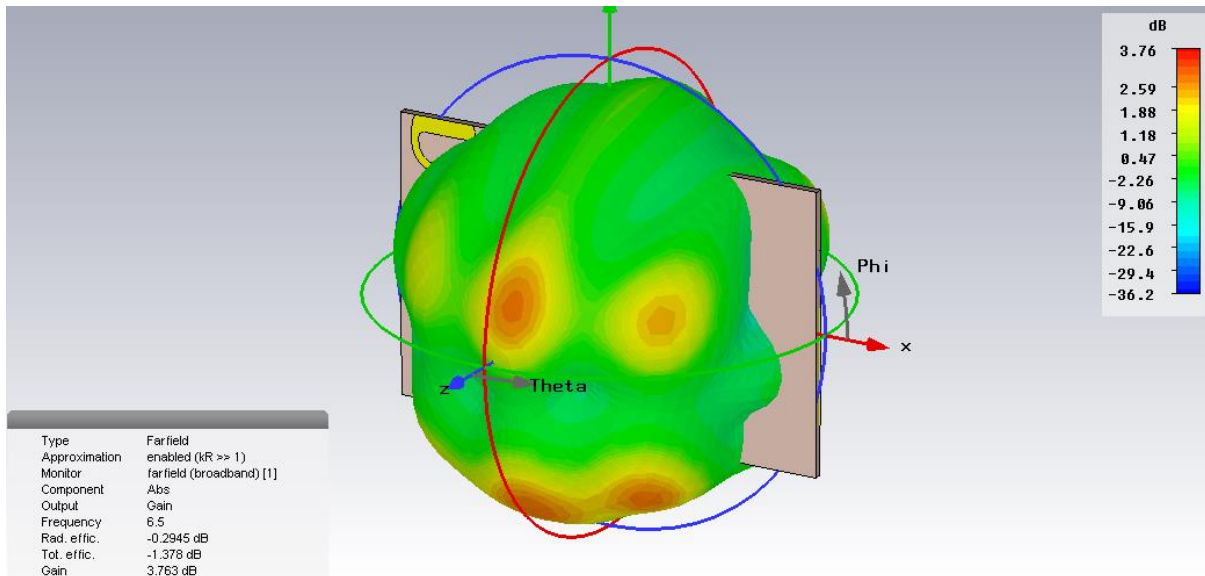
**Figure 1 WB001 Tag antenna**

## 4 Simulation Results

The following results show the expected performance of WB001 when using a full ground plane as shown in the layout files in section 3. The performance obtained will be slightly reduced when the ground plane area is reduced, see section 5 for details.

### 4.1 Radiation patterns

**Figure 2 Radiation Pattern at 4GHz in free-space**



**Figure 3 Radiation Pattern at 6.5GHz in free-space**

## 4.2 Impedance Matching

The following plot shows simulated WB001 return loss in proximity to a metal plate. The purpose is this is to show how the return loss and hence general performance degrades when objects (metal plate, body etc) are placed close to the antenna. These results show that generally the WB001 antenna has a good immunity to objects in close proximity but as a rule the antenna should be as far away from tag housings etc as possible.

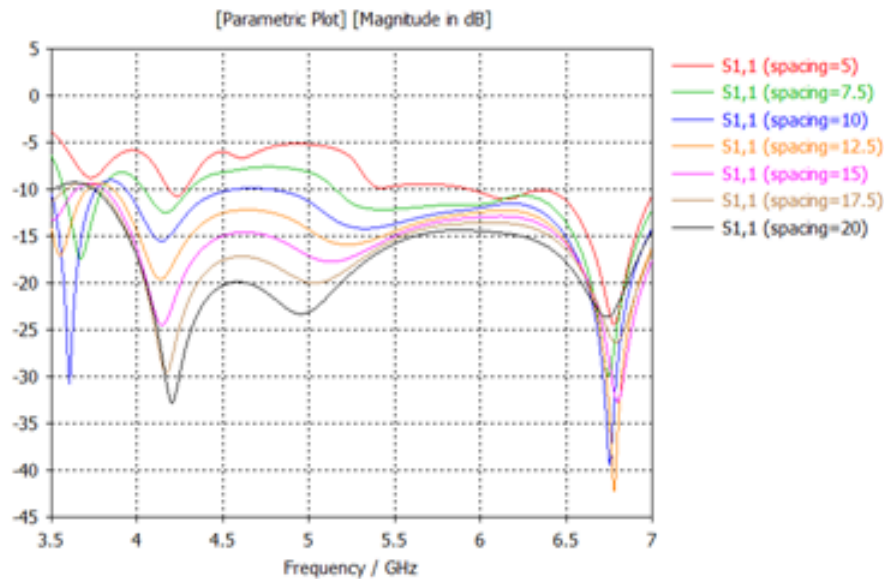


Figure 4 Impedance matching for different distances from a metal plate (Proximity test)

### 4.3 Efficiency

The following plot shows simulated WB001 efficiency in proximity to a metal plate

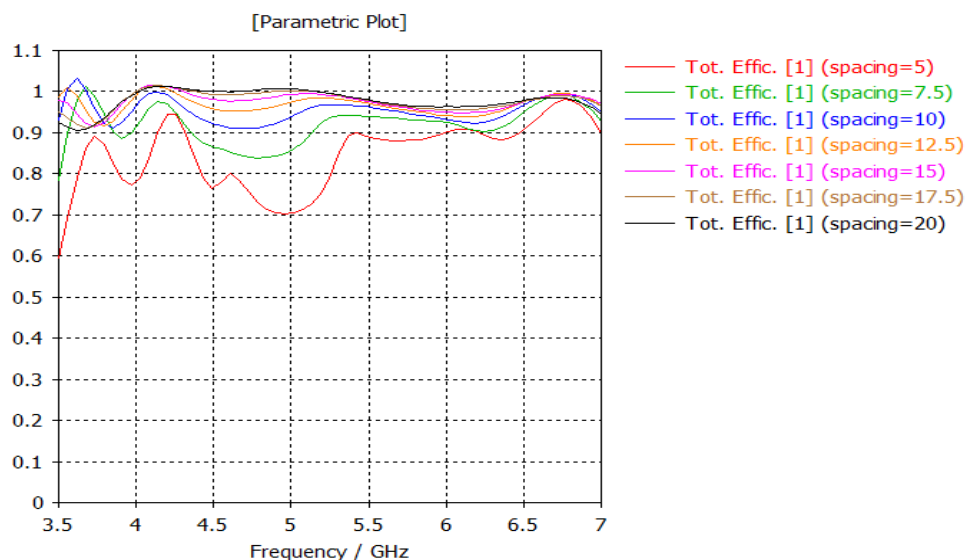


Figure 5 Efficiency for different distances from a metallic plate (Proximity test)

## 4.4 Maximum Gain

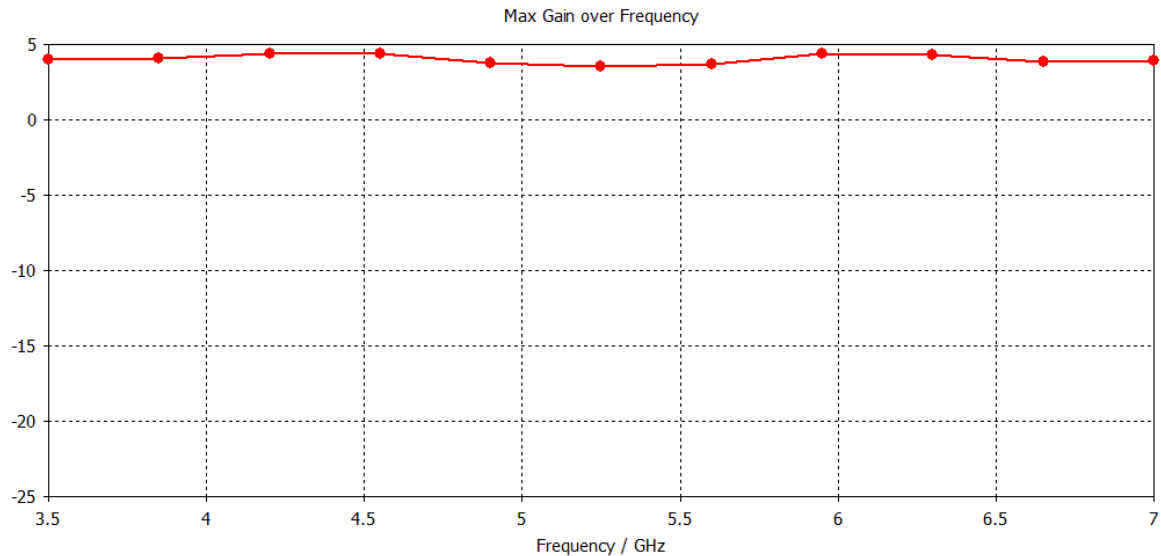


Figure 6 Maximum Gain across frequency

## 4.5 Group Delay Variation

Group delay variation is an important parameter to consider for antennas to be used in location solutions using IR-UWB such as DW1000. Here we mean how the group delay of the antenna changes as the antenna is rotated. 1ns of variation would represent 30cm variation in the reported distance, so we aim for a group delay variation with antenna rotation of <100ps.

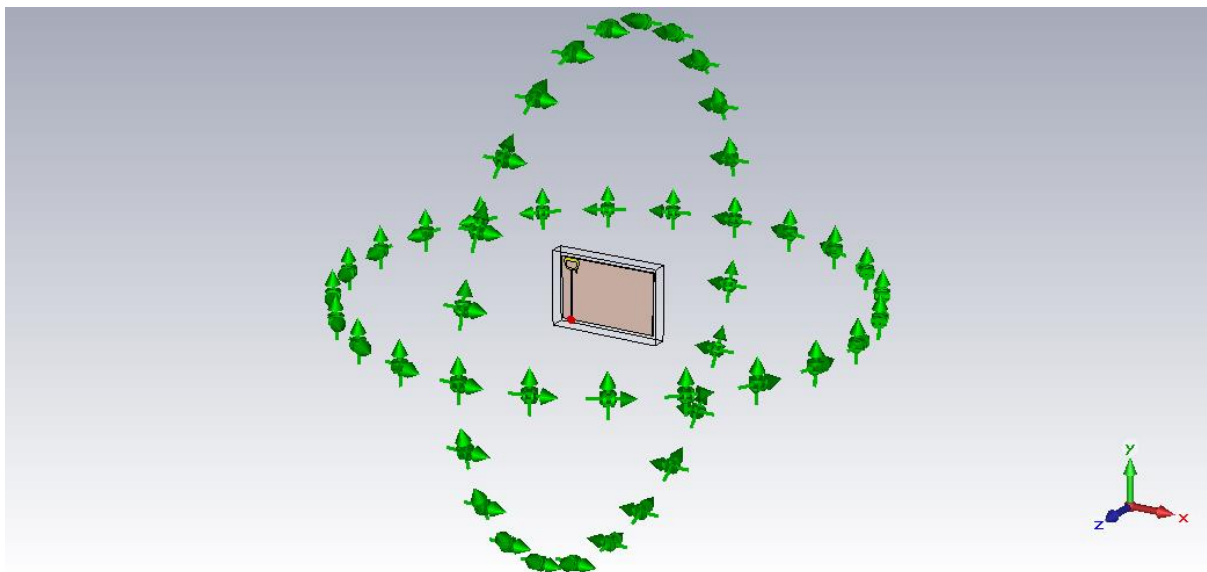
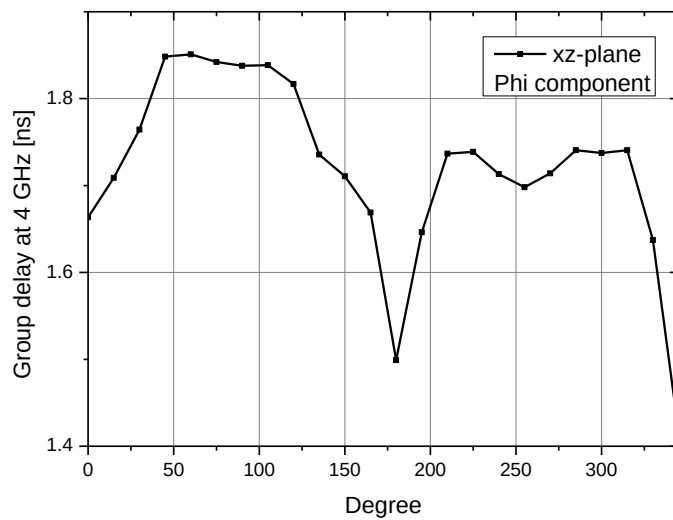
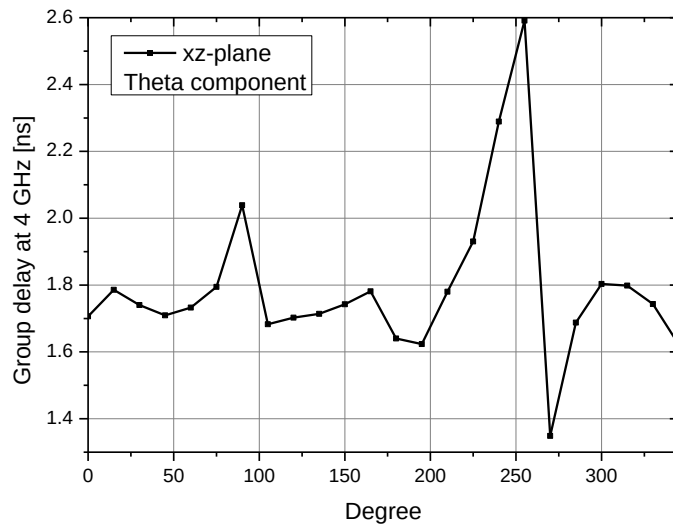


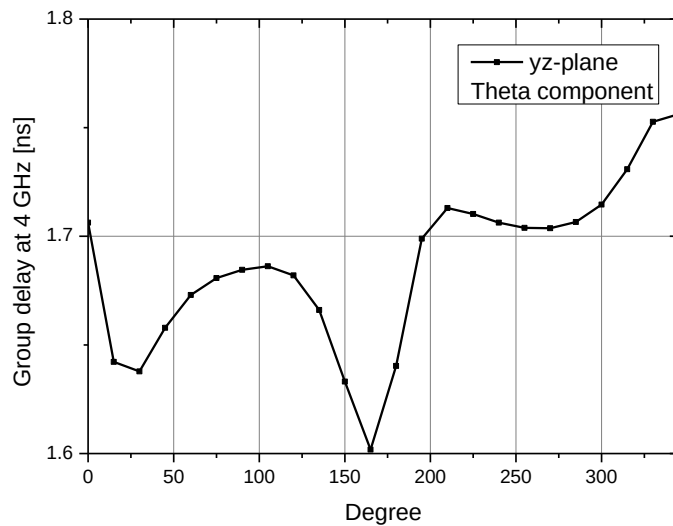
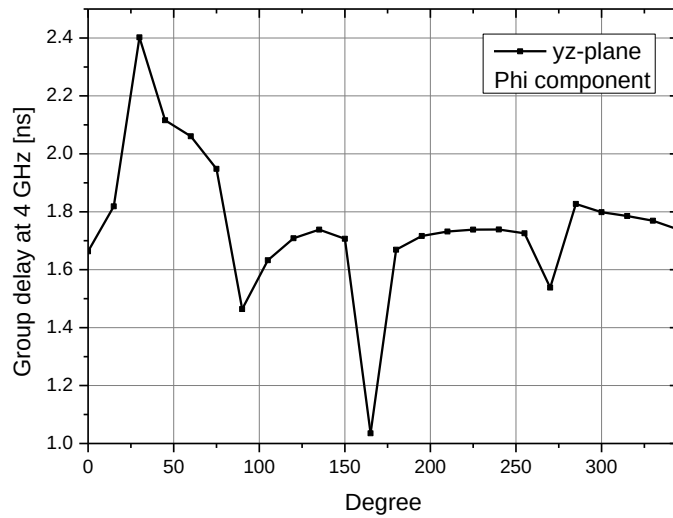
Figure 7 Probe placement in simulation

Ideal probes placed on the xz- and yz-plane at the distance of  $5\lambda$  from the centre of the antenna

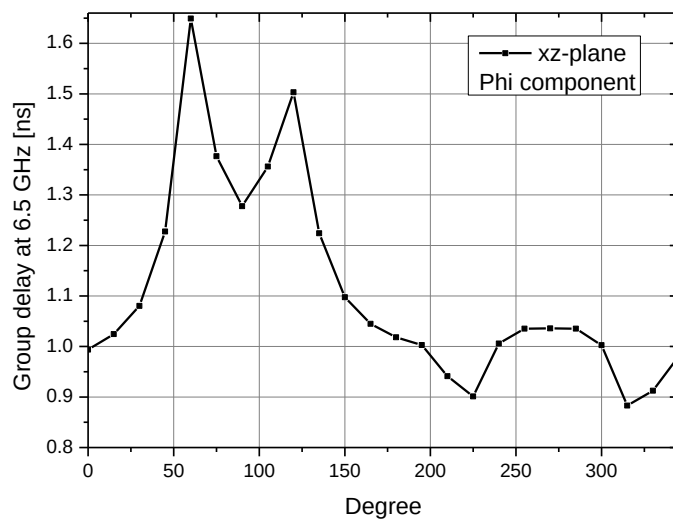
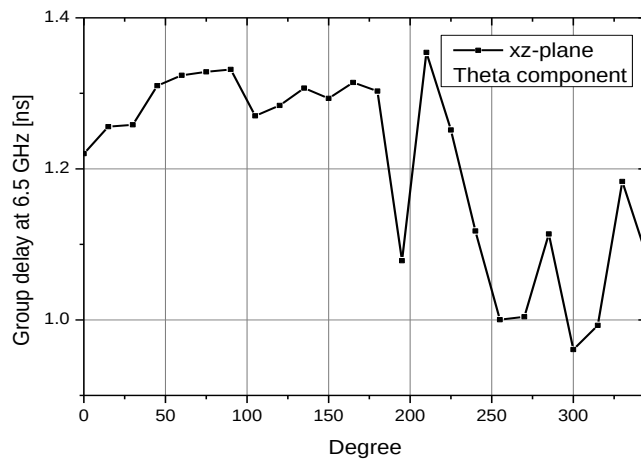


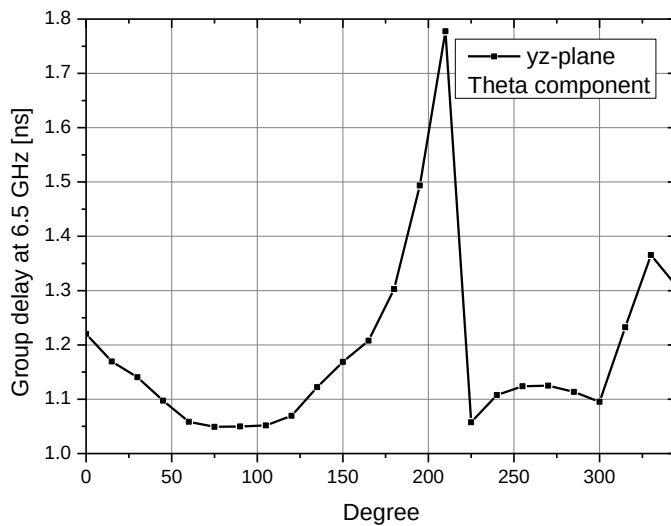
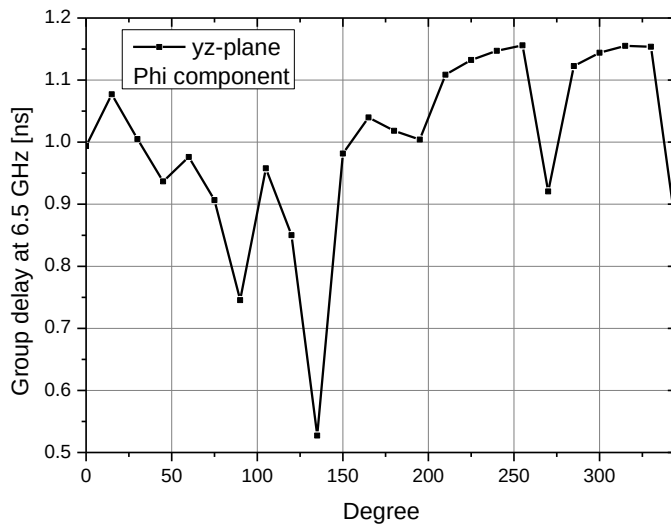
#### 4.5.1 Group Delay Variation at 4GHz





#### 4.5.2 Group Delay Variation 6.5 GHz

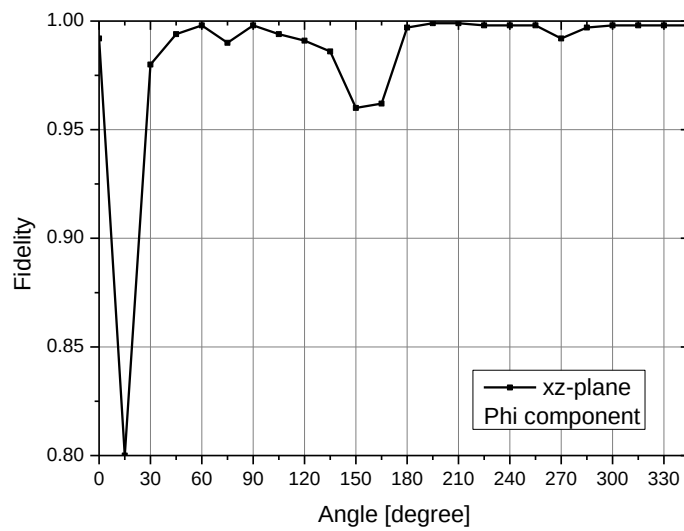
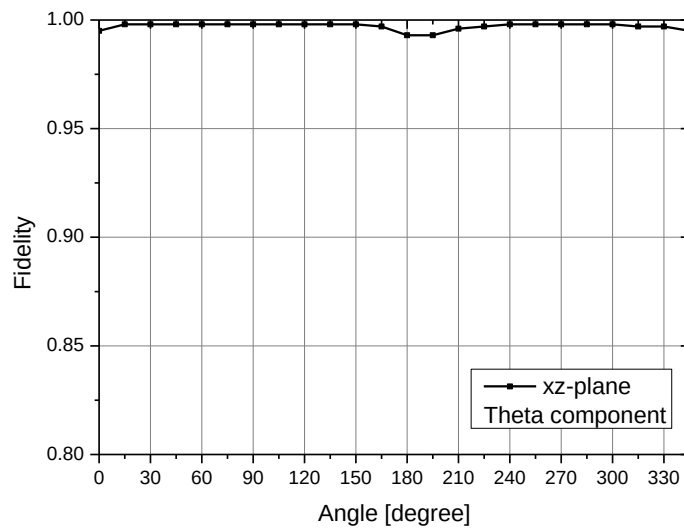


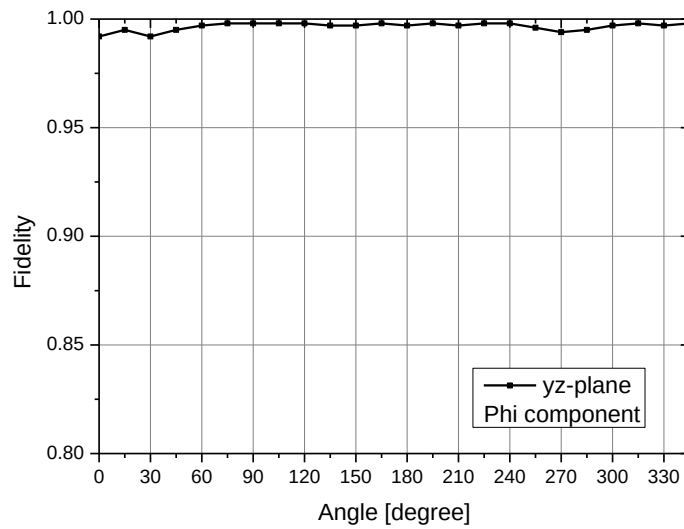
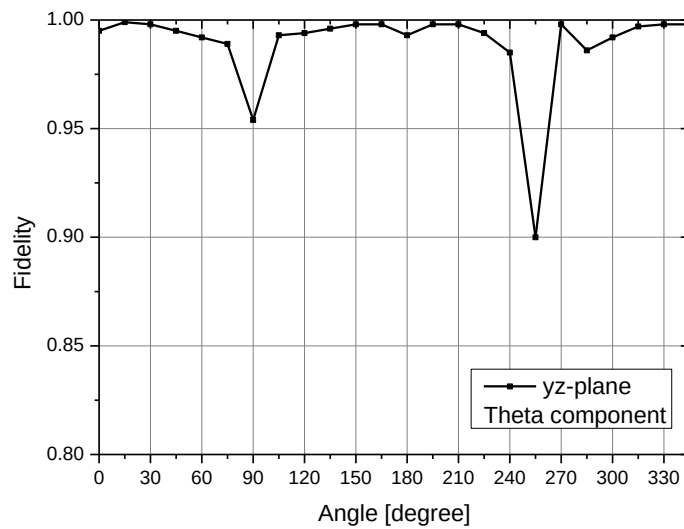


## 4.6 Fidelity Factor

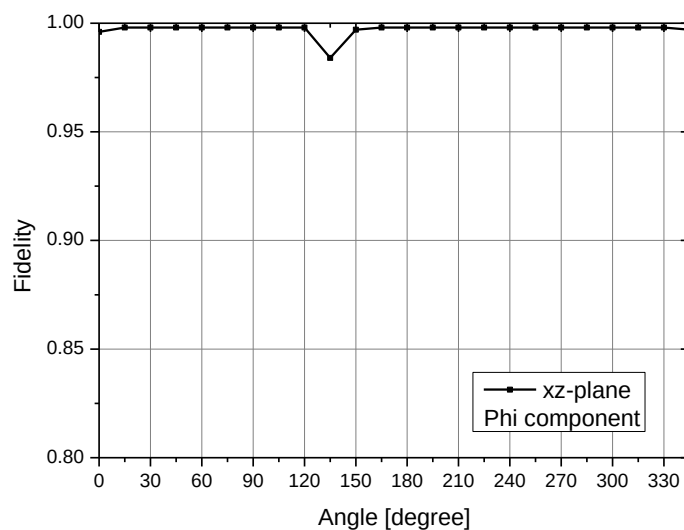
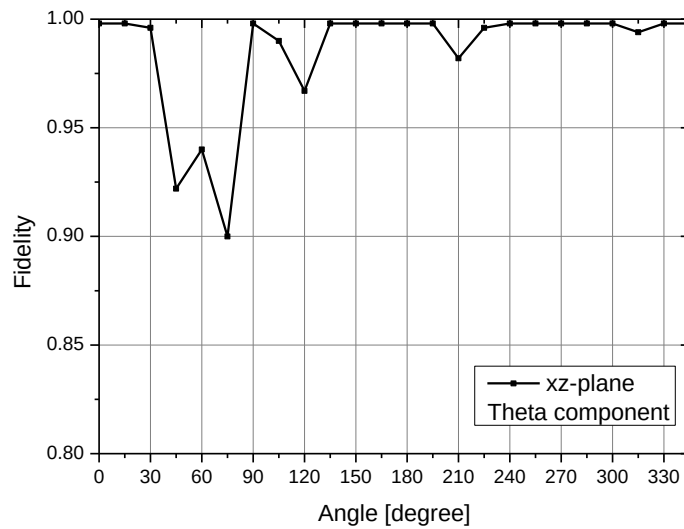
The following plots show simulated results of the fidelity factor for WB001. They show how well the antenna will perform in the time domain given it is to be used in an IR-UWB system. A figure of 1 is ideal with 0.9 being the target.

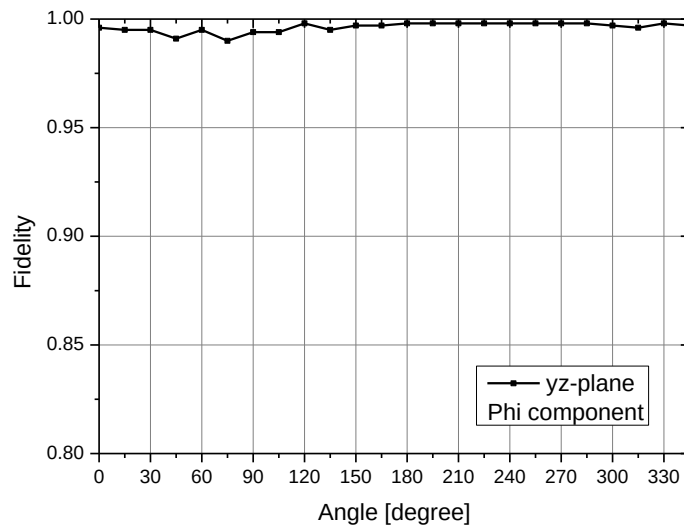
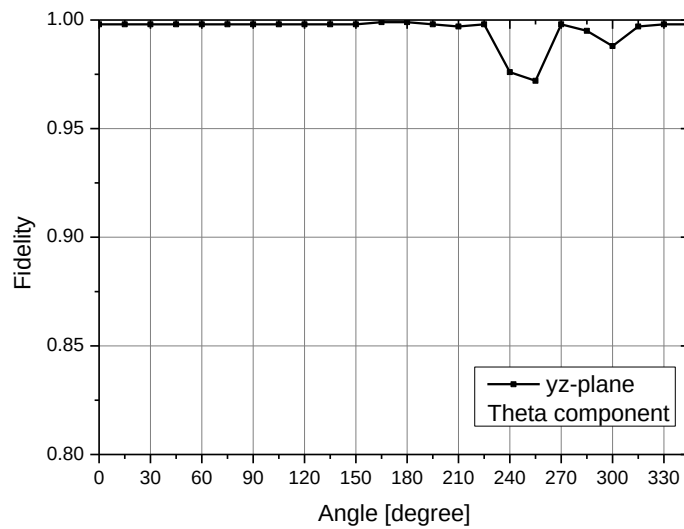
### 4.6.1 Fidelity factor 4 GHz





#### 4.6.2 Fidelity factor 6.5 GHz





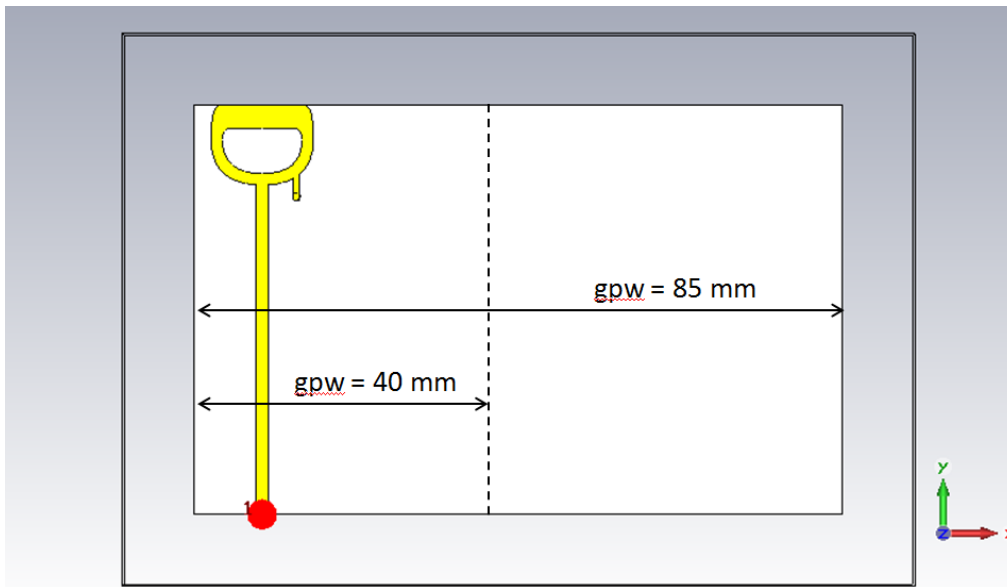


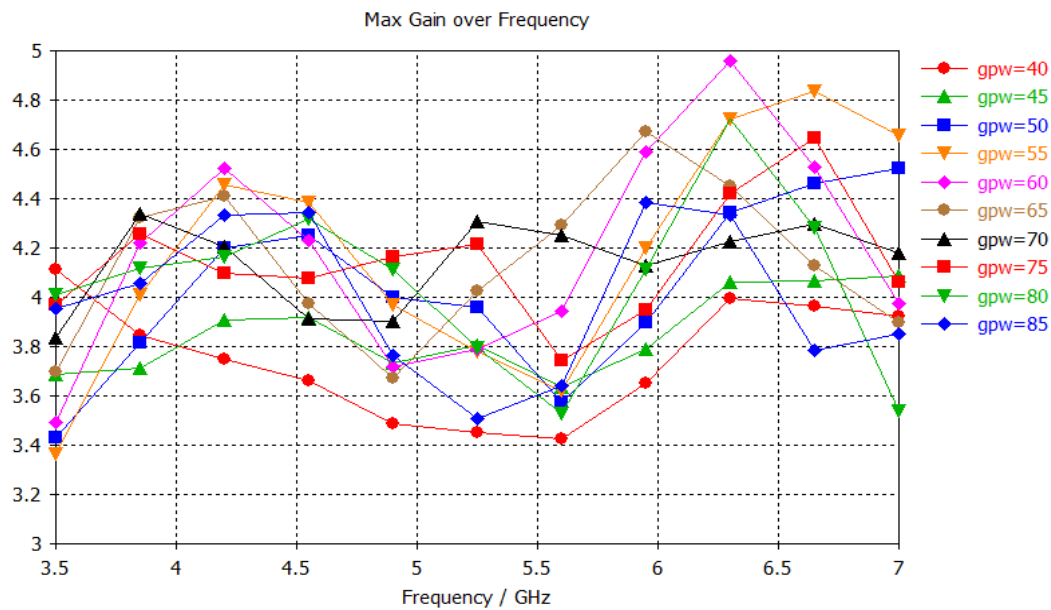
## 5 Performance using less ground plane

In most DW1000 based tag designs, tags are designed to be as small as possible. As the ground-plane for WB001 forms part of the antenna the larger the ground-plane the better the performance. This section details how small the tag can be with regard to how much ground plane is required. Tag PCB layout should use as much copper ground fill as possible to increase ground plane area.

### 5.1 Reducing the Ground Plane Width

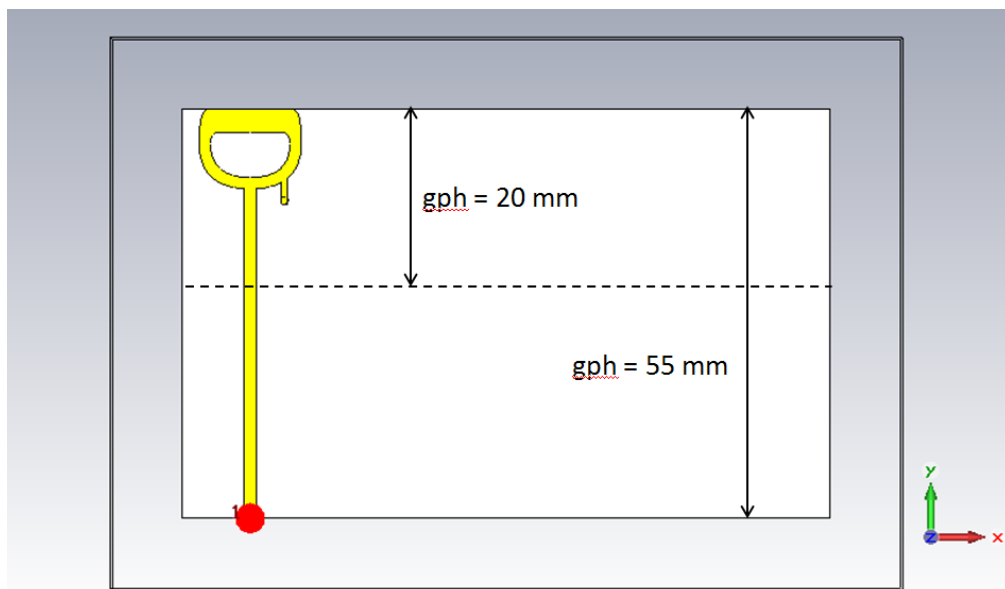
In the following plots, the ground plane width given in the supplied gerber/dxf files is reduced and the effects on antenna gain are plotted.

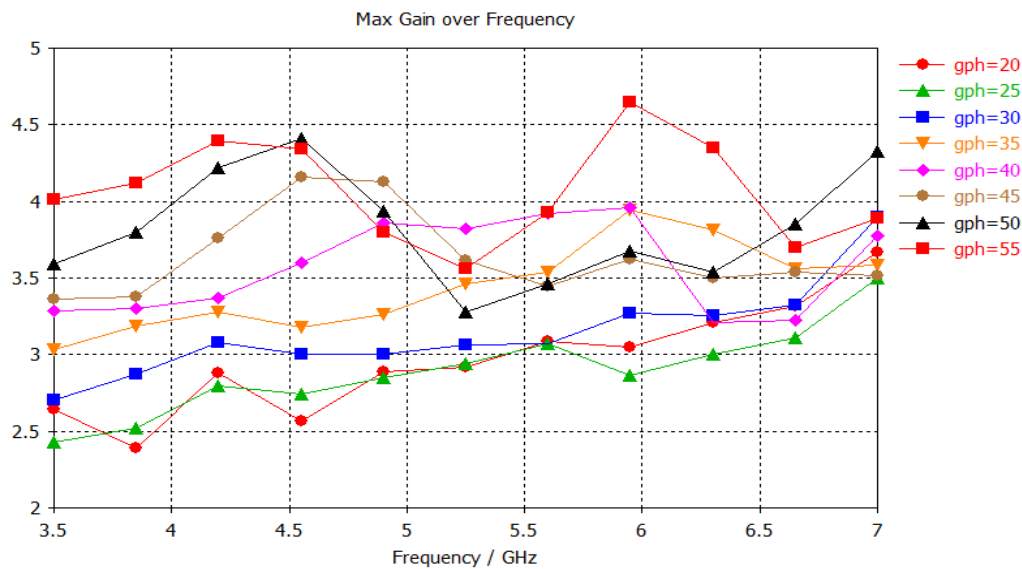




## 5.2 Reducing the Ground Plane Height

In the following plots the ground plane height given in the supplied gerber/dxf files is reduced and the effects on antenna gain is plotted.

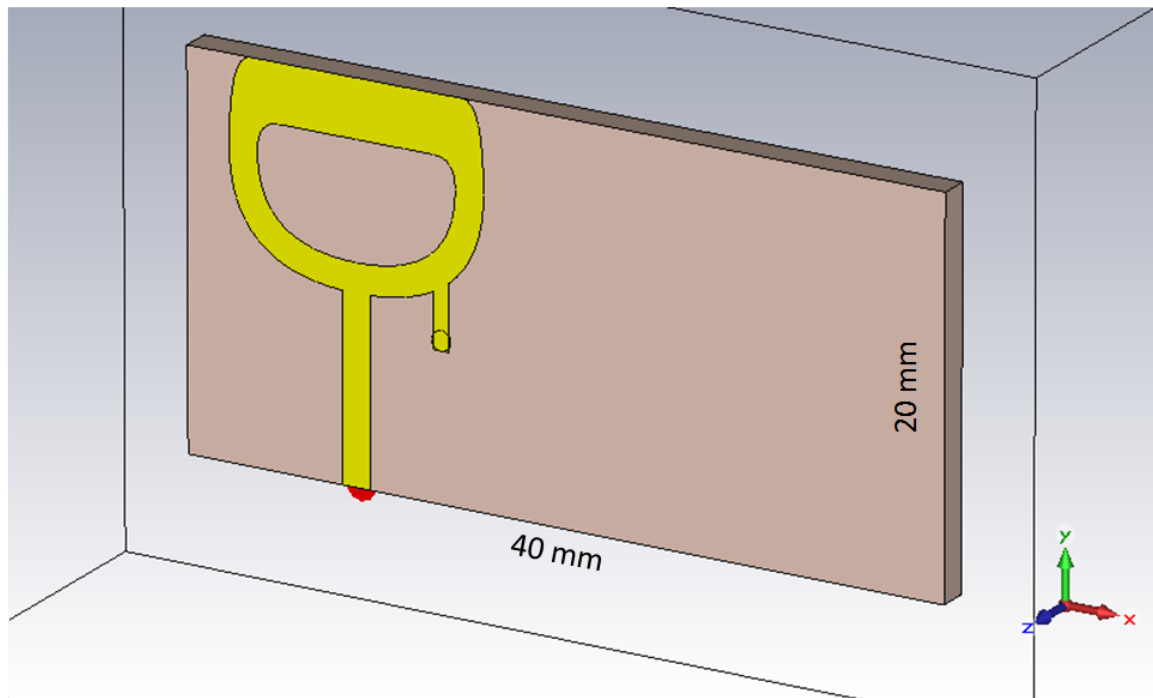




### 5.3 Smallest Recommended Design

As stated already, for the best performance the ground plane should be large, however this is not practical in most tag designs. This section shows the recommended smallest ground plane size and the effects this reduced size has on antenna performance.

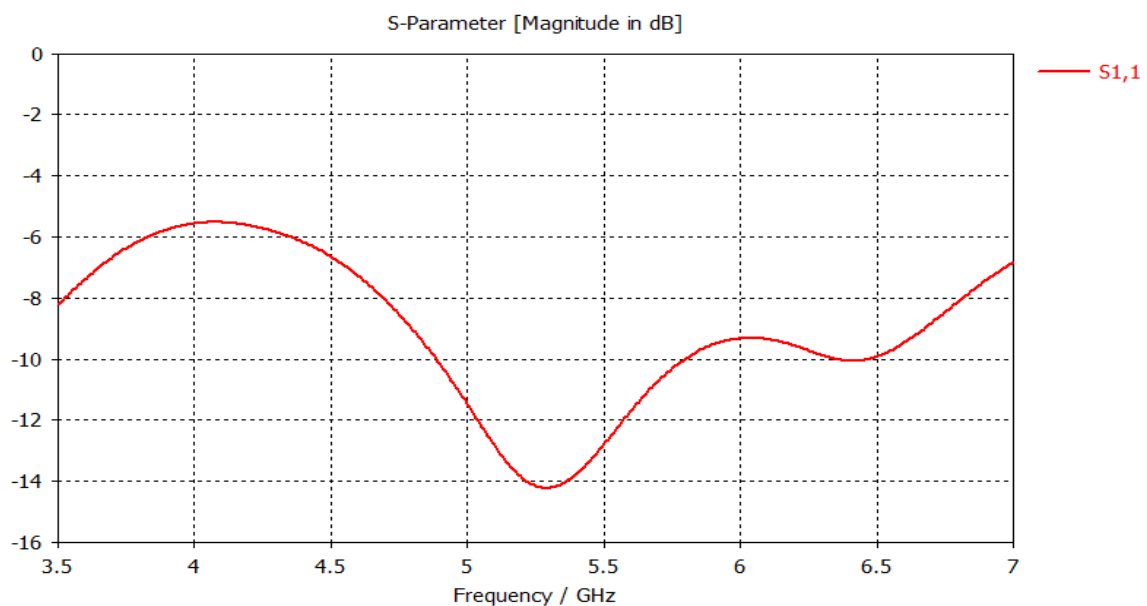
#### 5.3.1 Smallest antenna design 40mm x 20mm



**Figure 8 Smallest design size (40mm x 20mm)**

In Figure 8, the smallest recommended tag size is shown in a 40mm x-plane, 20mm y-plane orientation with the layout rest of the layout as per the gerber/dxf files supplied.

#### 5.3.1.1 Performance with 40mm x 20mm antenna



**Figure 9 Return Loss with 40mm x 20mm antenna**

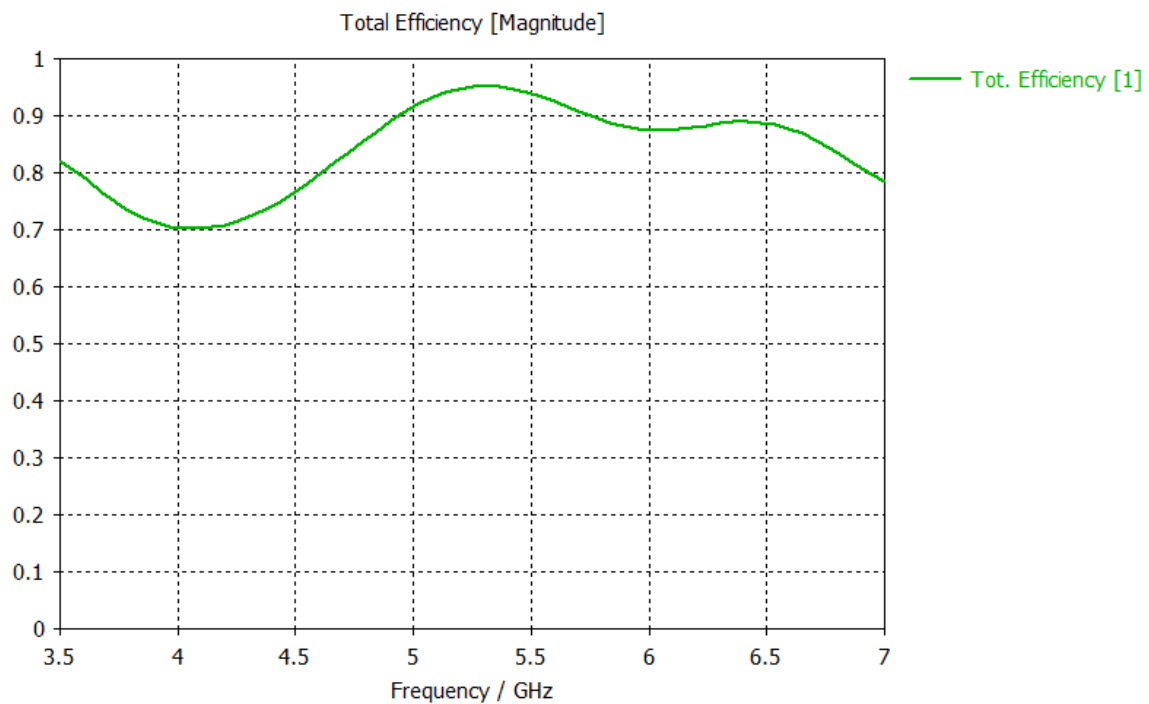


Figure 10 Efficiency with 40mm x 20mm antenna

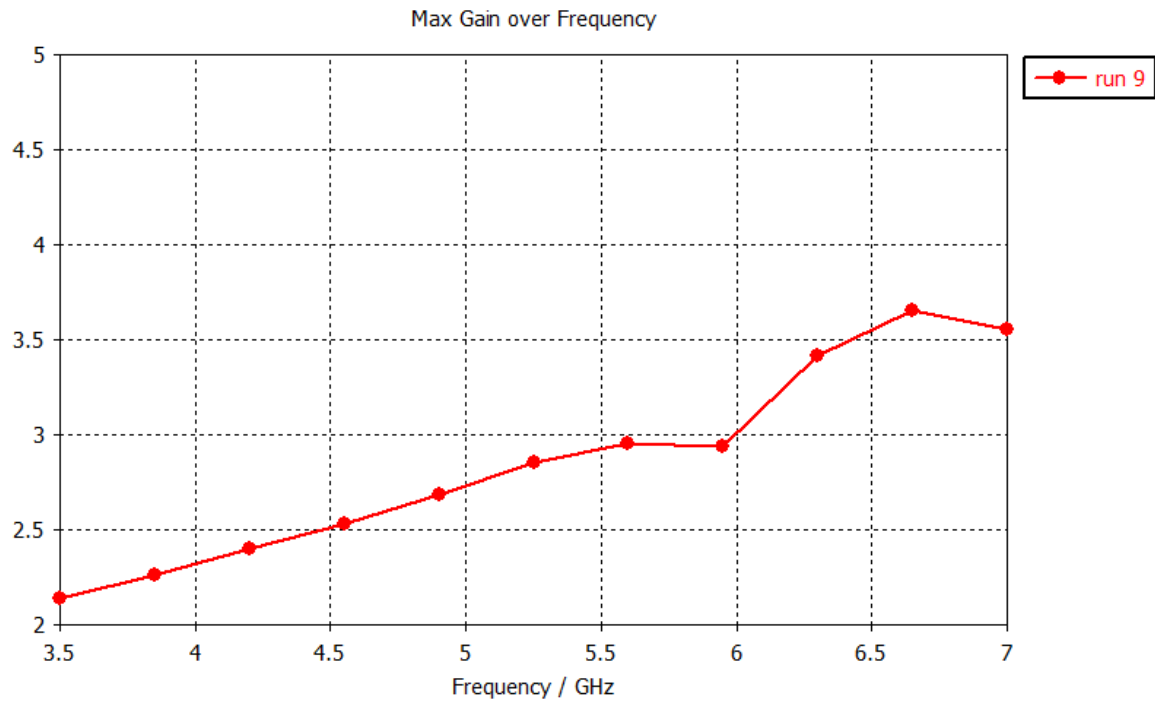
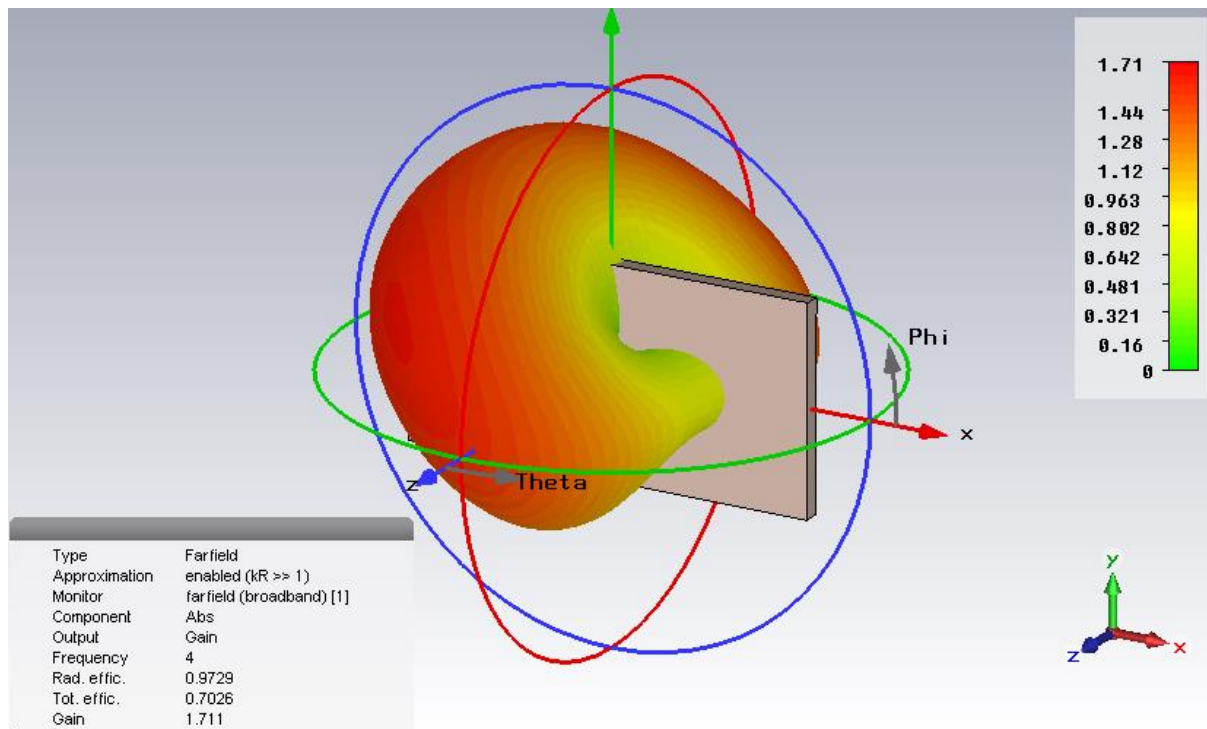
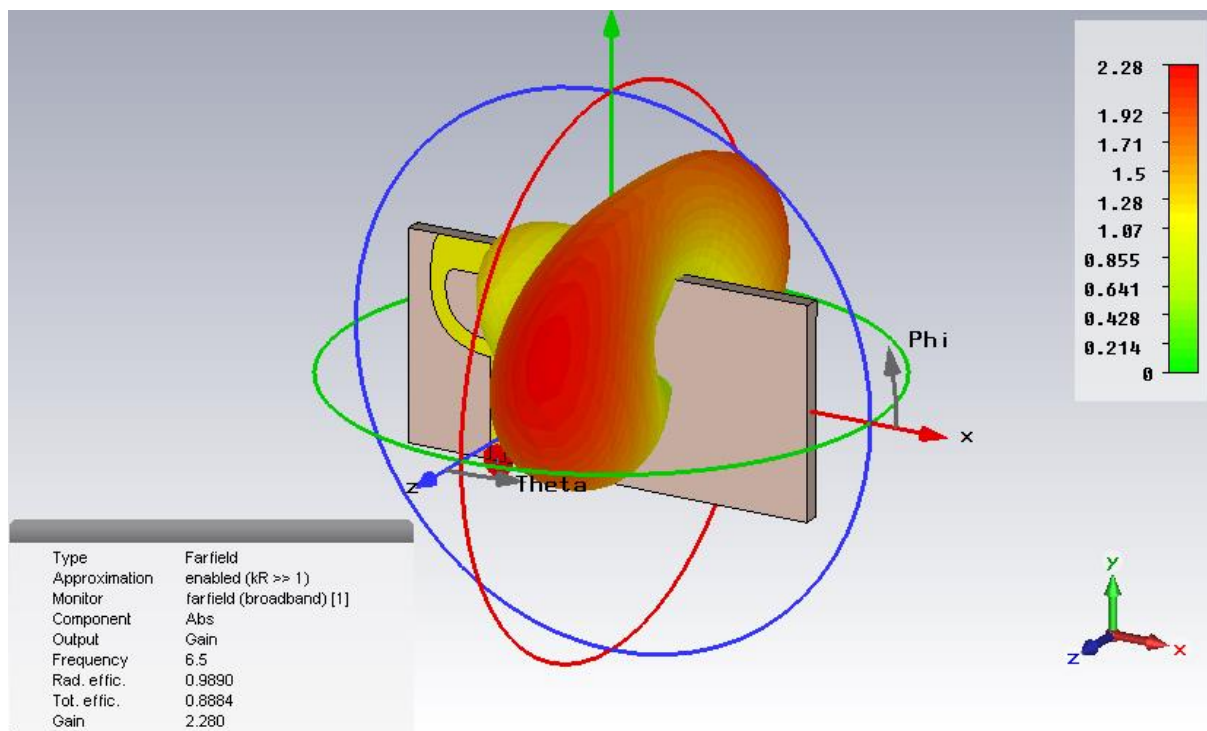
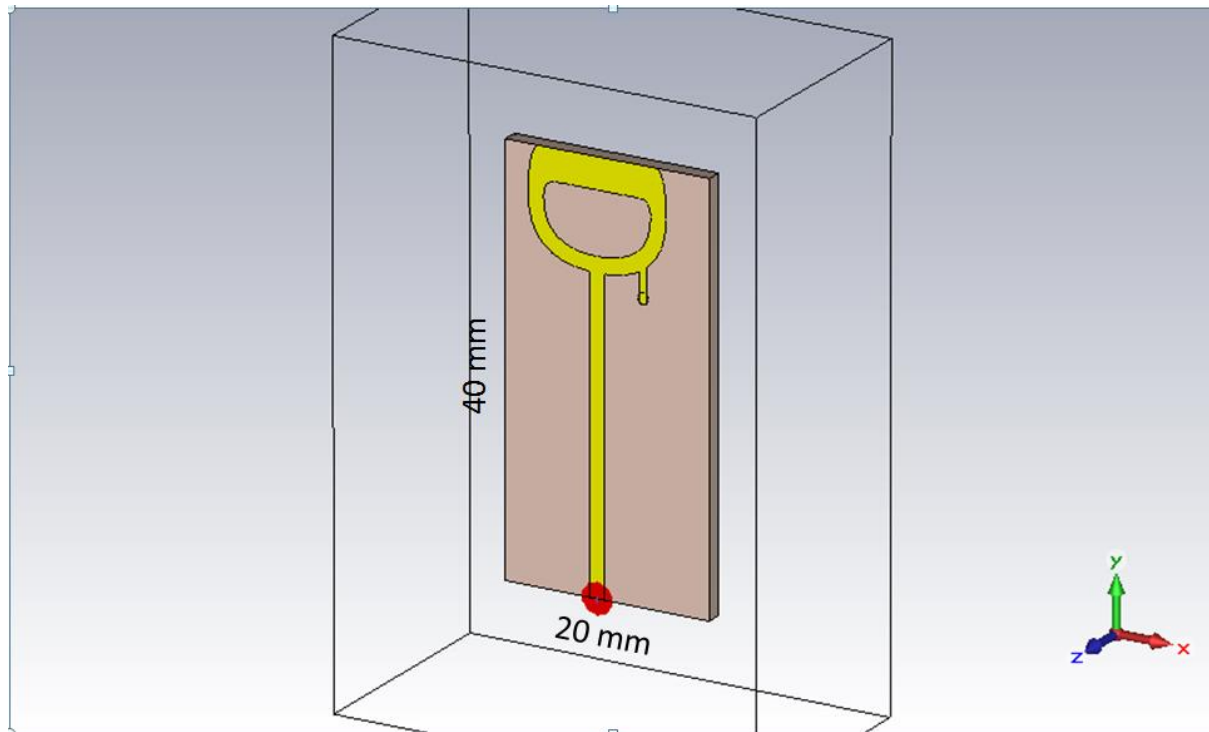


Figure 11 Gain with 40mm x 20mm antenna

**Figure 12 Radiation Pattern at 4GHz with 40mm x20mm antenna****Figure 13 Radiation pattern at 6.5GHz with 40mm x 20mm antenna**

### 5.3.2 Smallest antenna design 20mm x 40mm



**Figure 14 Smallest design size 20mm x 40mm**

In Figure 14, the smallest recommended tag size is shown in a 20mm x-plane, 40mm y-plane orientation with the layout rest of the layout as per the gerber/dxf files supplied.

### 5.3.2.1 Performance with 20mm x 40mm antenna

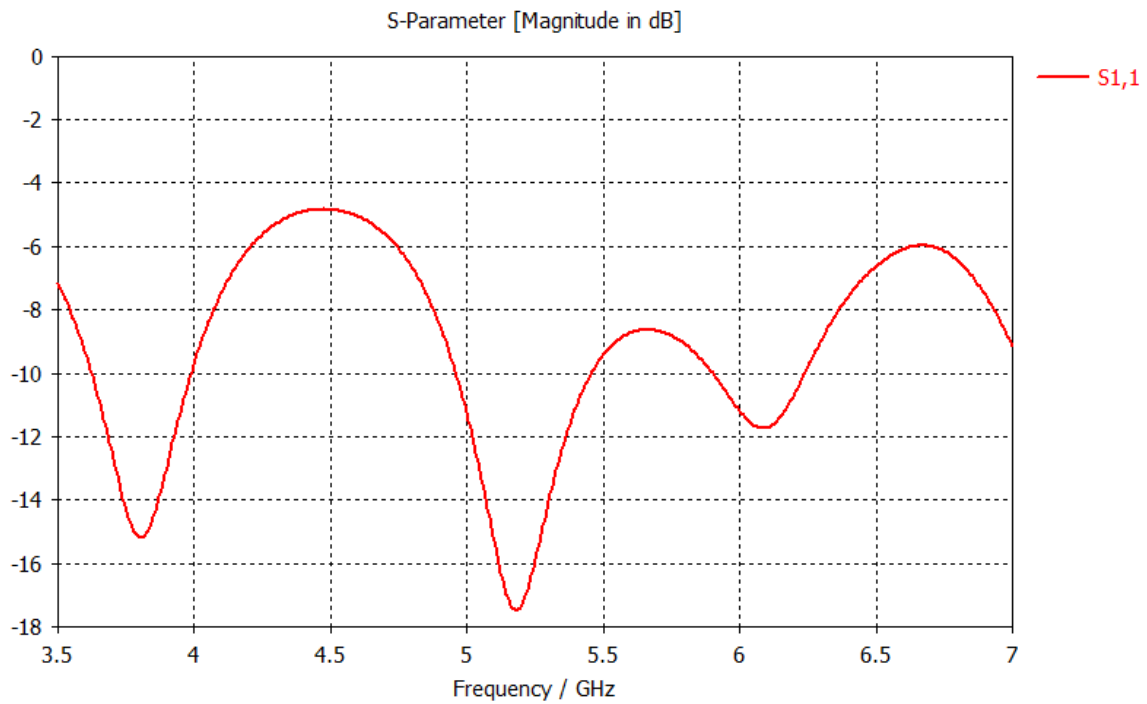


Figure 15 Return Loss with 20mm x 40mm antenna

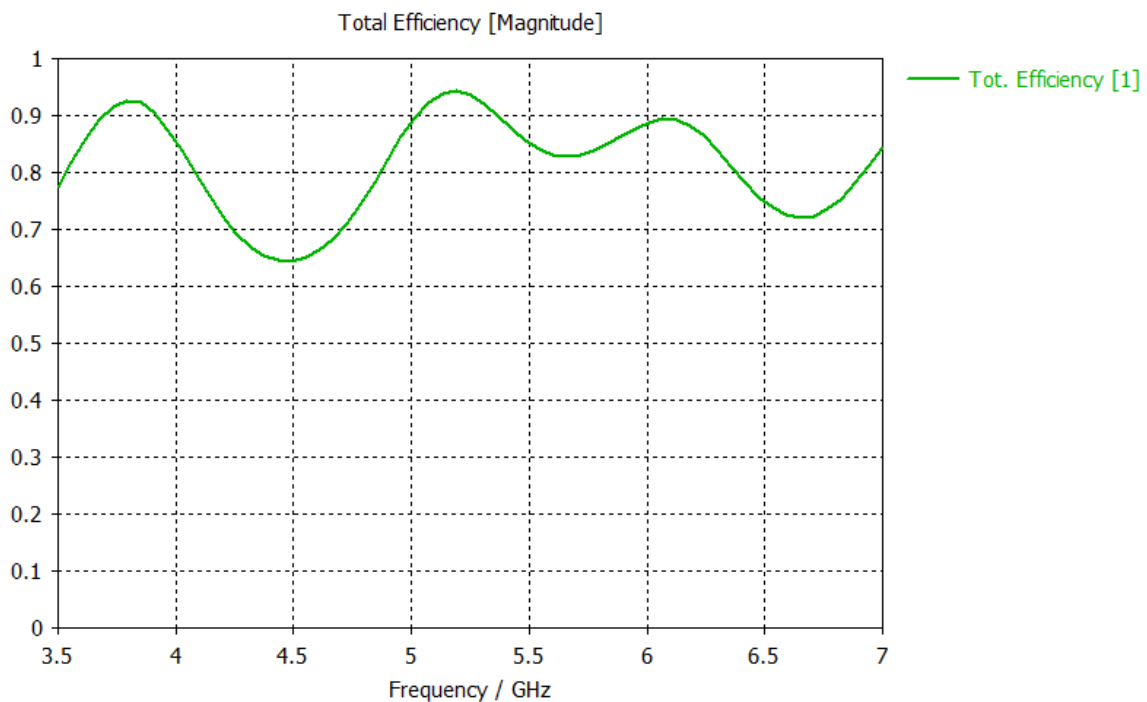


Figure 16 Efficiency with 20mm x 40mm



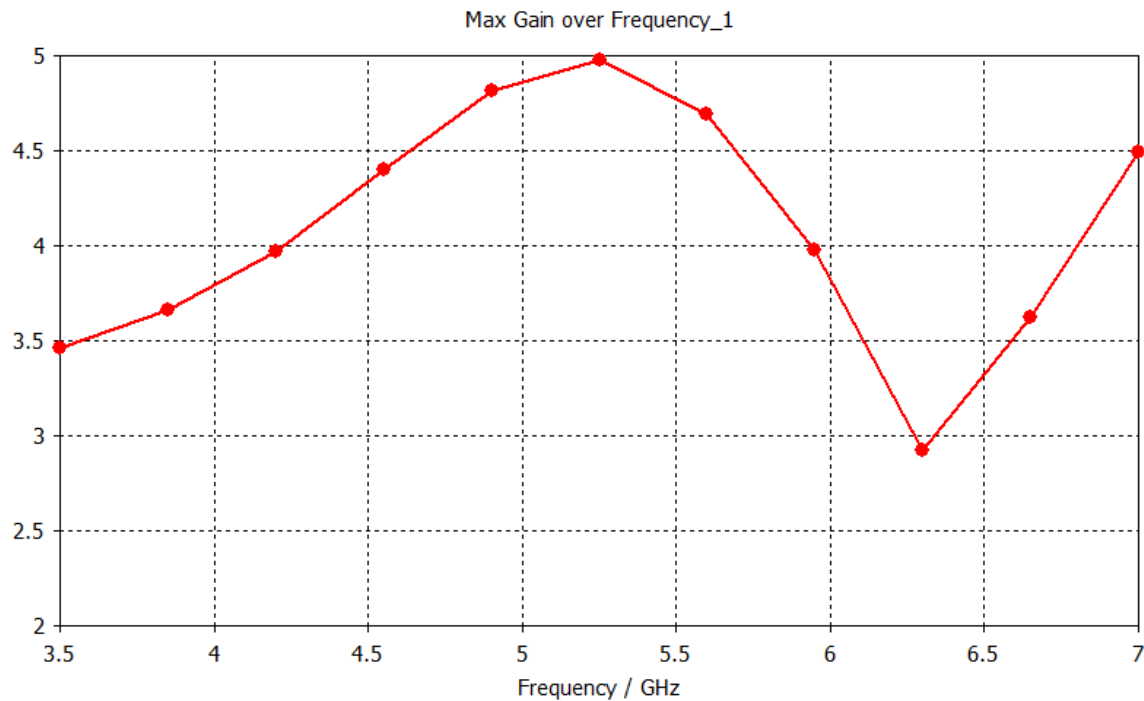


Figure 17 Gain with 20mm x 40mm antenna

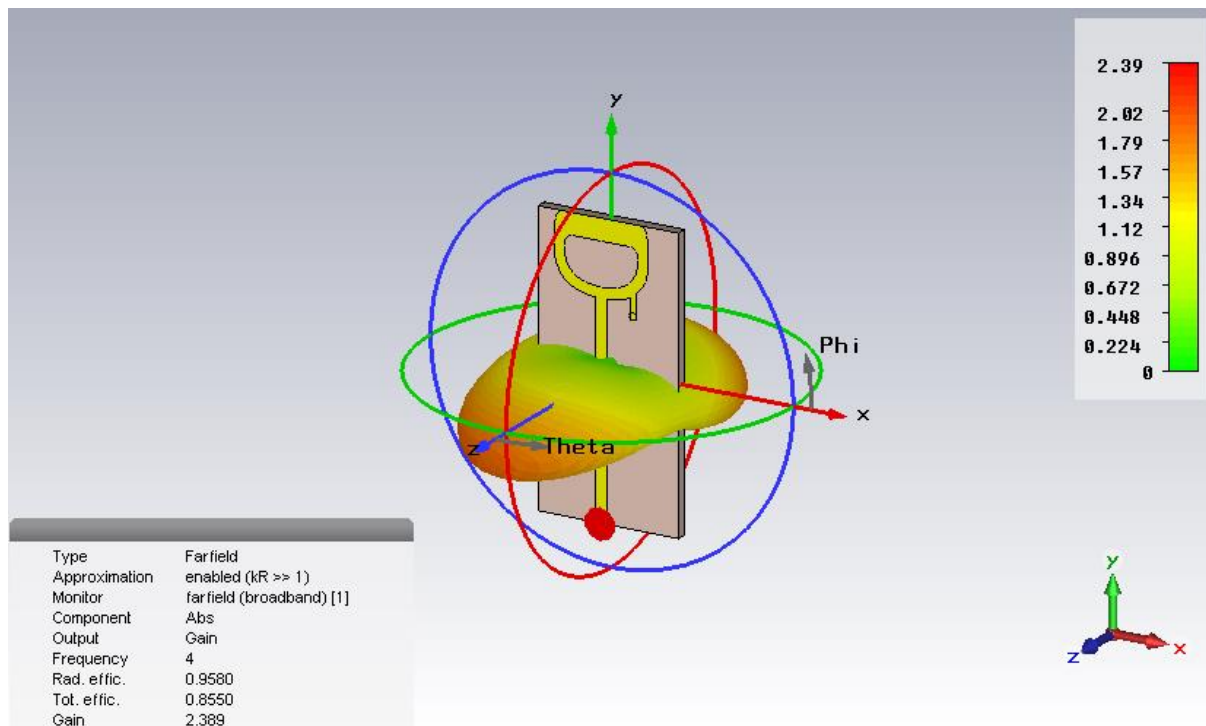


Figure 18 Radiation Pattern at 4GHz with 20mm x 40mm antenna

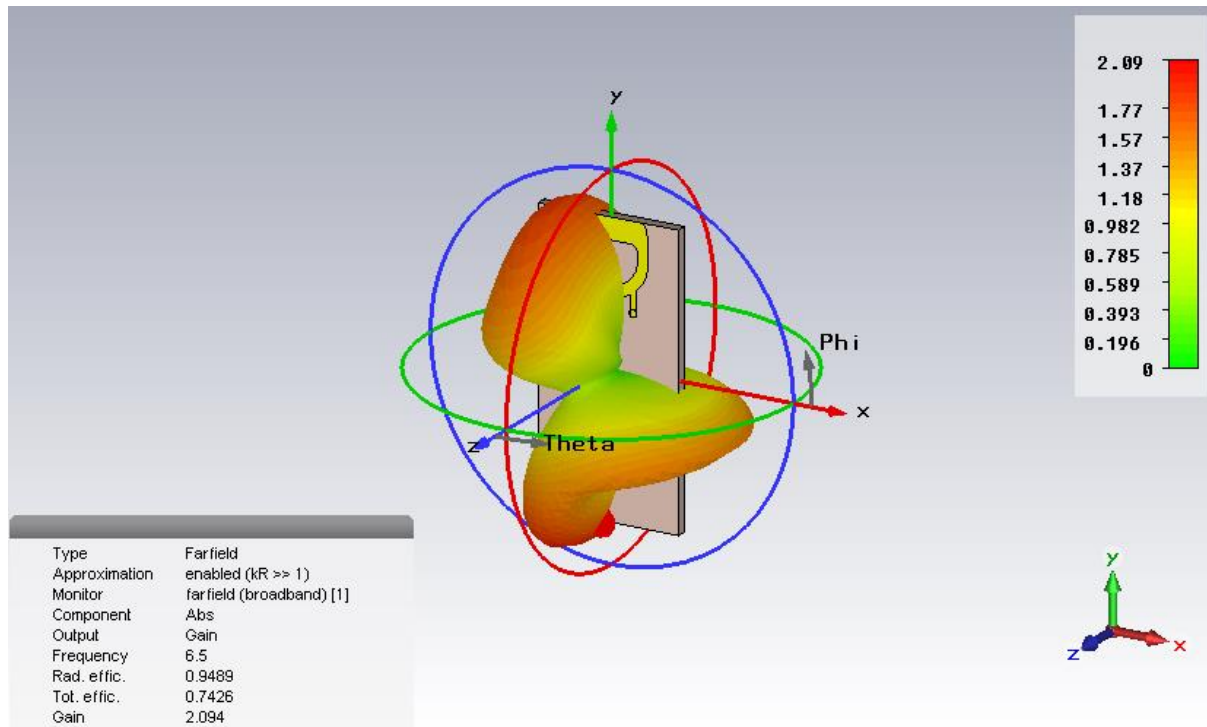


Figure 19 Radiation pattern at 6.5GHz with 20mm x 40mm

## 6 References

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## 7 Document History

| Revision | Date                            | Description                   |
|----------|---------------------------------|-------------------------------|
| 1.0      | 30 <sup>th</sup> September 2016 | Initial release.              |
| 1.1      | 31 <sup>st</sup> July 2018      | Scheduled update Updated Logo |
| 1.2      | 31 <sup>st</sup> October 2018   | Scheduled update              |

## 8 Major Changes

### V1.0

| Page | Change Description       |
|------|--------------------------|
| All  | Initial external release |

### v1.1

| Page | Change Description            |
|------|-------------------------------|
| All  | New logo and new template.    |
| 2    | Reference made to HOW antenna |

### v1.2

| Page | Change Description         |
|------|----------------------------|
| 3    | Change thickness to 0.8 mm |

## 9 Further Information

Decawave develops semiconductors solutions, software, modules, reference designs - that enable real-time, ultra-accurate, ultra-reliable local area micro-location services. Decawave's technology enables an entirely new class of easy to implement, highly secure, intelligent location functionality and services for IoT and smart consumer products and applications.

For further information on this or any other Decawave product, please refer to our website [www.decawave.com](http://www.decawave.com).