AN11662

High-performance PCB antennas for ZigBee networks

Rev. 1.0 — 22 May 2015 Application note

Document information

Info	Content
Keywords	Meander antenna, Inverted-F antenna, Dipole antenna, JN516x, ZigBee
Abstract	This application note describes three designs of printed antenna for use with the NXP JN516x series of wireless microcontrollers used in IEEE802.15.4-based systems, such as ZigBee networks.

Revision history

Rev	Date	Description
1.0	20150522	Initial version

Contact information

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Table 1. Reference board summary

Reference design	Short description	Embeds
OM15006	SSB W and TW with antenna	JN5168 and TEA1721

1. Introduction

The NXP JN516x wireless microcontrollers are designed for use in the nodes of low-power wireless networks based on the IEEE802.15.4 protocol standard. These networks may employ higher level networking protocols built on top of IEEE802.15.4, such as ZigBee PRO or ZigBee-RF4CE. The antenna for use with a JN516x device must be selected by the developer and this application node describes three designs for a suitable high-performance PCB antenna:

- Meander antenna - see Section 2
- Inverted-F antenna (IFA) - see Section 3
- Dipole antenna - see Section 4

2. Meander antenna

The meander antenna simulations have been done with ADS from Cadence and EMPro from Agilent.

2.1 Two-layer printed antenna

2.1.1 PCB characteristics

Substrate FR4.

Substrate thickness = 1.0 mm.

Er = 4.6, Er TanD = 0.01.

Copper thickness = 17 µm.

2.1.2 Antenna layout

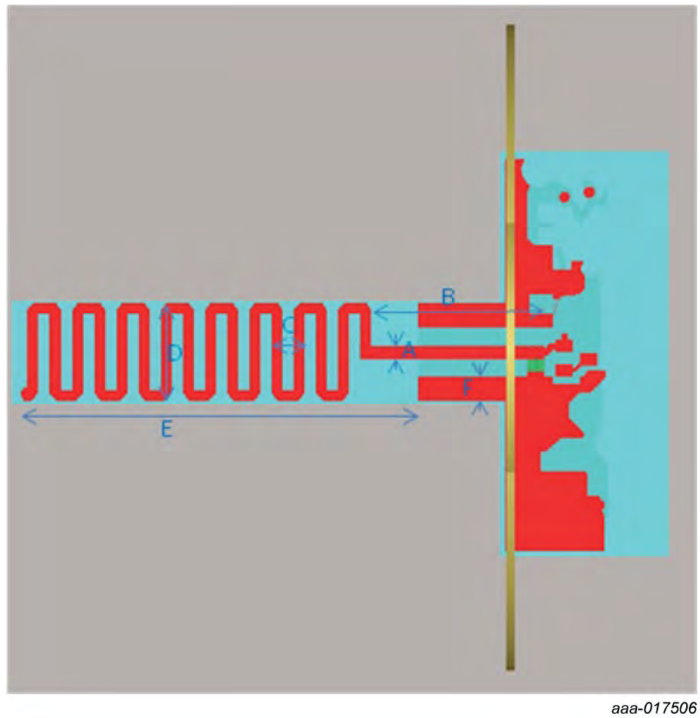


Fig 1. Meander antenna layout diagram

Table 2. Meander antenna layout dimensions

Reference (in diagram)	Distance (mm)
A	0.5
B	7.7
C	1.6
D	4.5
E	17.7
F	1.1

2.1.3 Counter poise

The counter poise is made of metallic tin plate with a thickness of 0.3 mm.

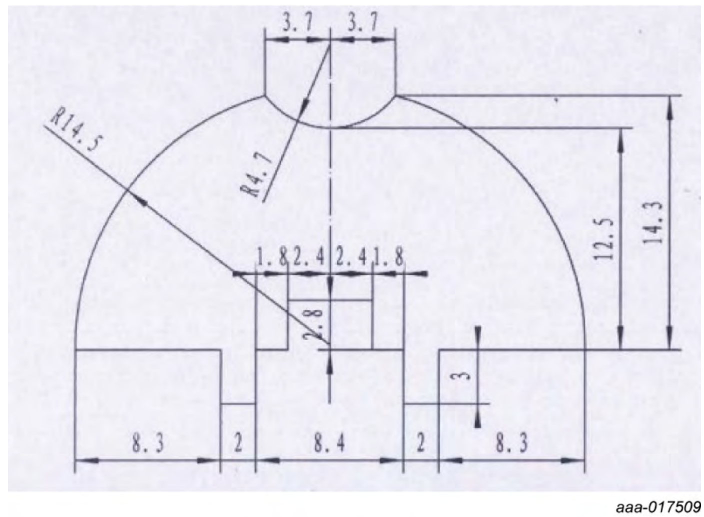


Fig 2. Counter poise dimensions

2.1.4 Assembled view

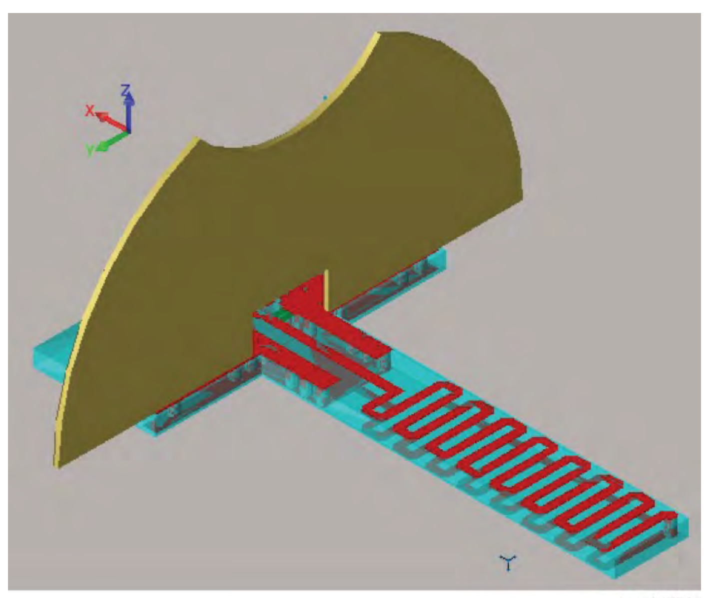


Fig 3. 3D view of meander antenna with its counter poise

2.2 Simulation results

2.2.1 S parameters

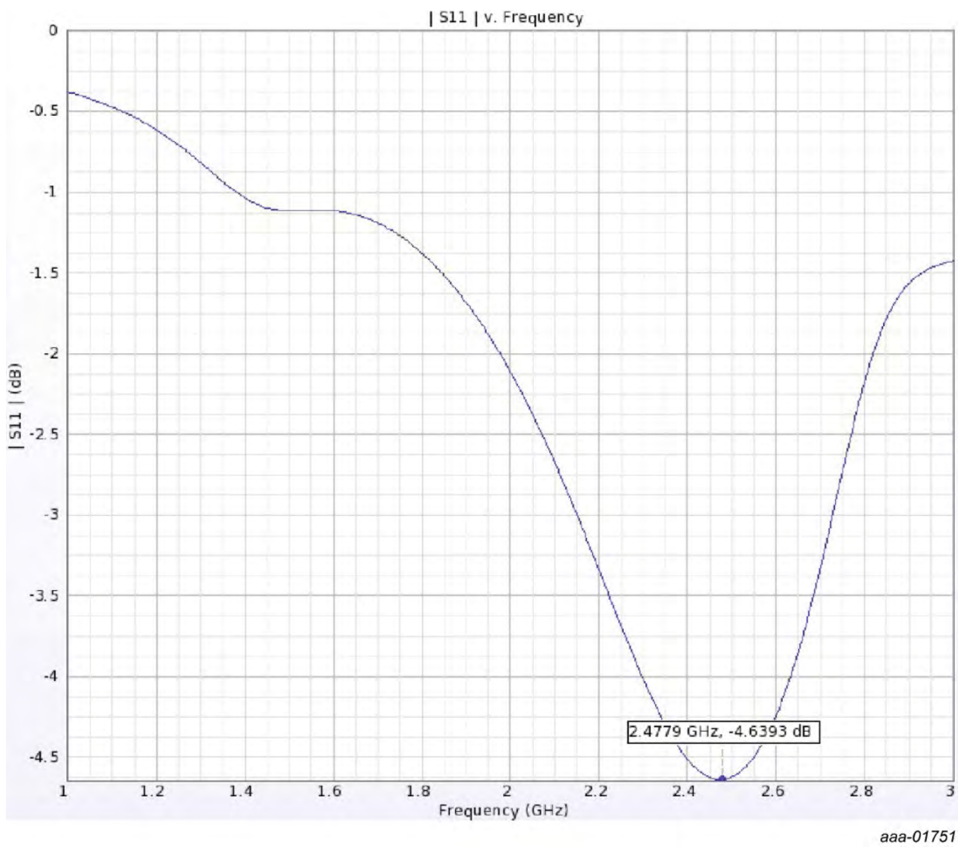


Fig 4. S11 parameter

2.2.2 S11 results

S11[2.350 GHz] = –4.31 dB.

S11[2.400 GHz] = –4.51 dB.

S11[2.510 GHz] = –4.6 dB.

2.2.3 S11 Smith chart

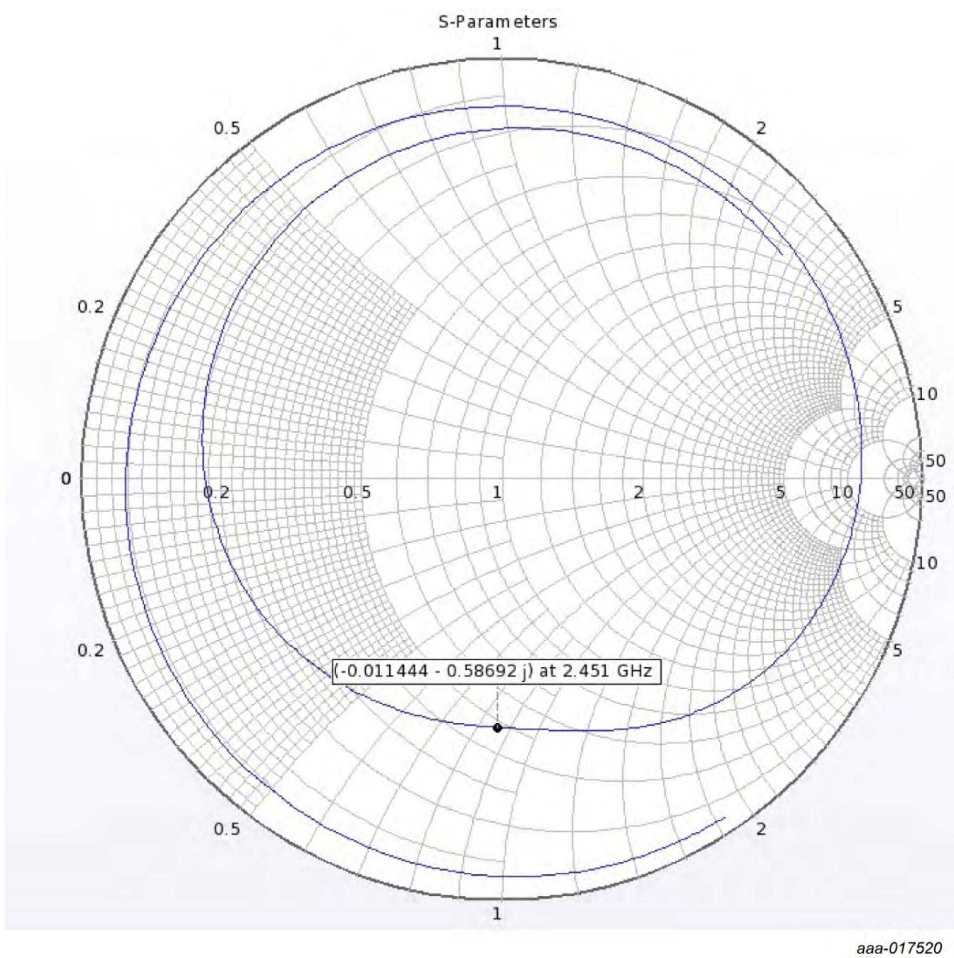


Fig 5. S11 Smith chart

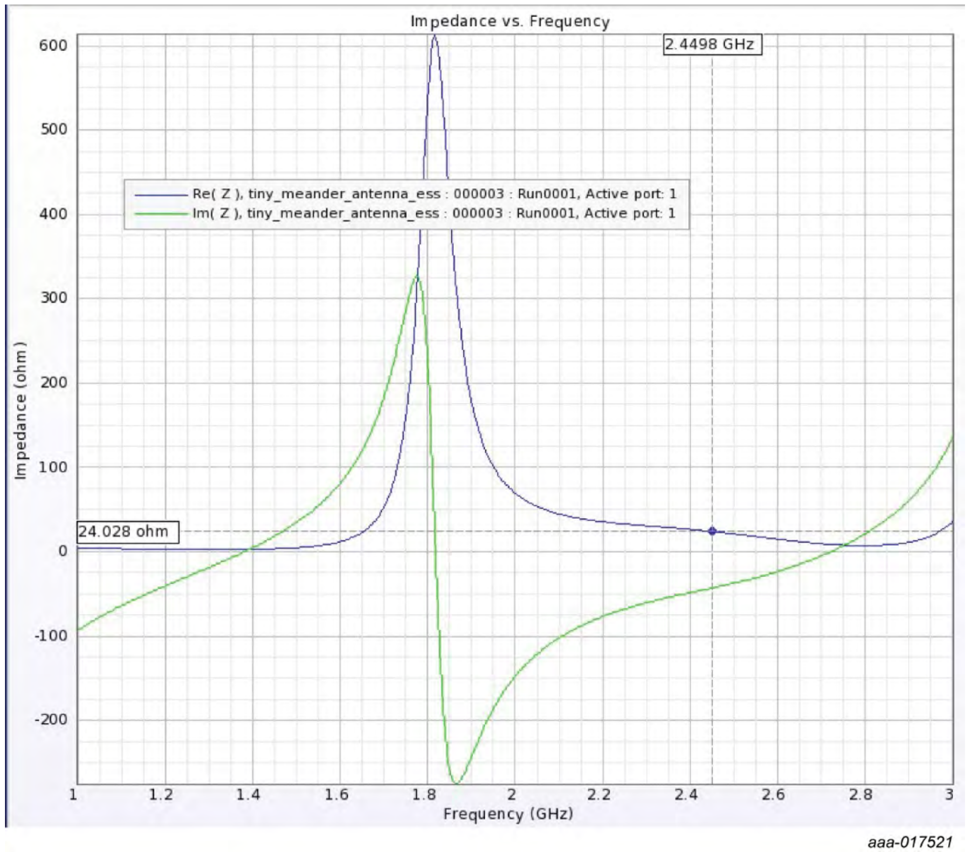


Fig 6. **S11 Smith chart**

2.2.4 3D radiation

The maximum gain is in the theta direction.

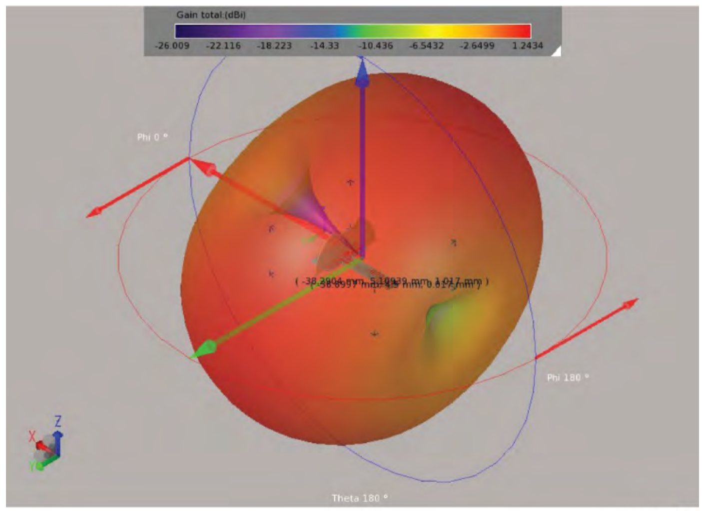
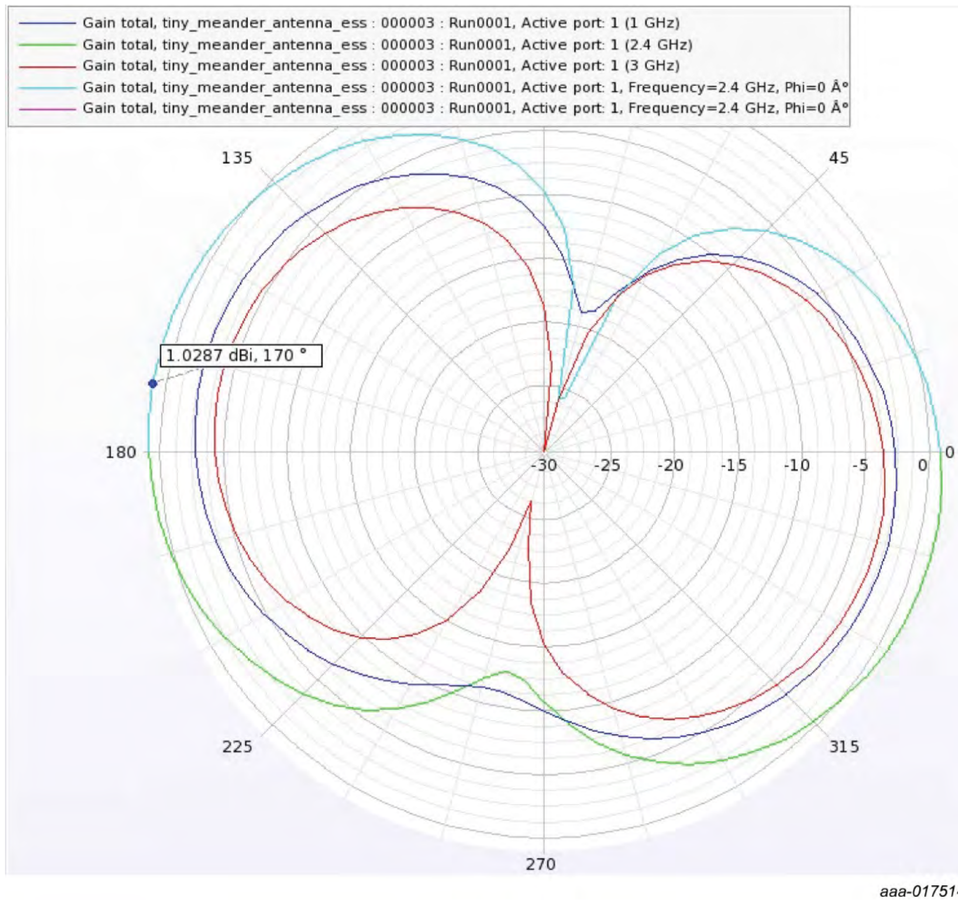


Fig 7. Total gain for all directions



(1) Maximum gain 1.2 dBi at 13°

Fig 8. Gain in theta direction

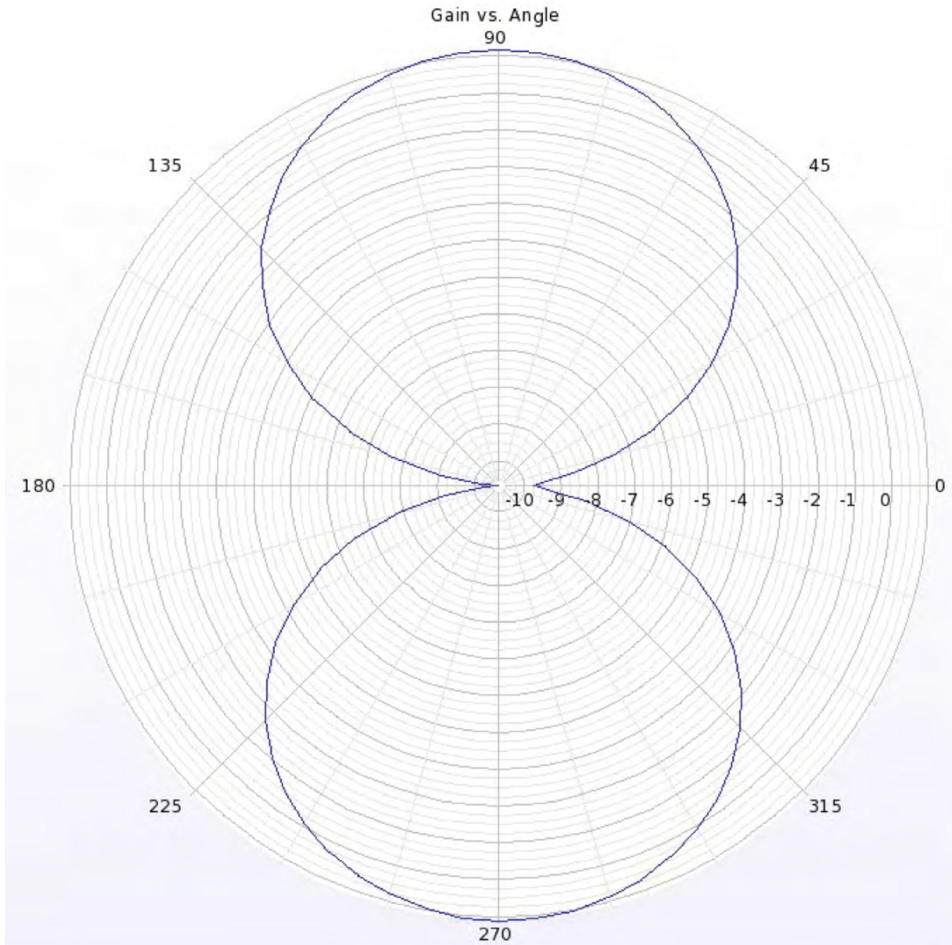


Fig 9. Gain in phi direction

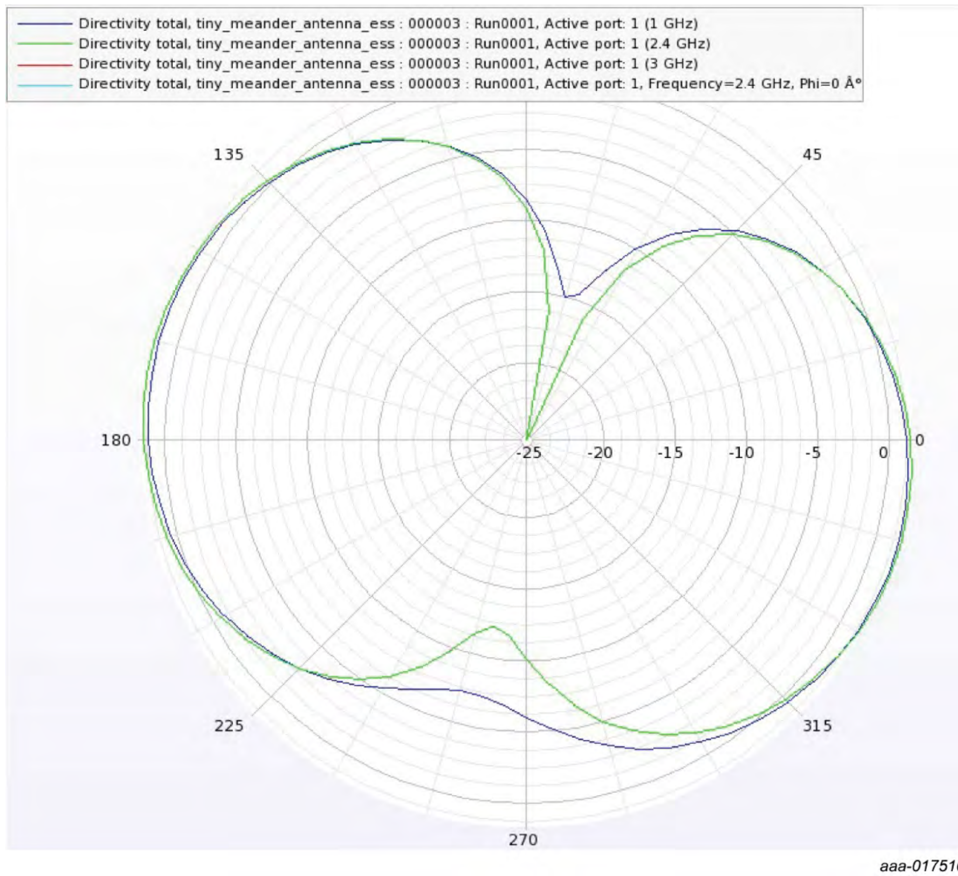


Fig 10. Directivity versus Theta

2.2.5 Radiation efficiency

Table 3. Radiation efficiency at 1 GHz, 2.4 GHz and 3 GHz

Frequency	Efficiency
1 GHz	40.6%
2.4 GHz	87.1%
3 GHz	28.2%

3. Inverted-F antenna (IFA)

The Inverted-F antenna simulations have been done with ADS from Cadence.

3.1 One-layer printed antenna

3.1.1 PCB characteristics

Substrate FR4.

Substrate thickness = 1.6 mm.

Er = 4.6, Er TanD = 0.01.

Copper thickness = 35 µm.

3.1.2 Antenna layout

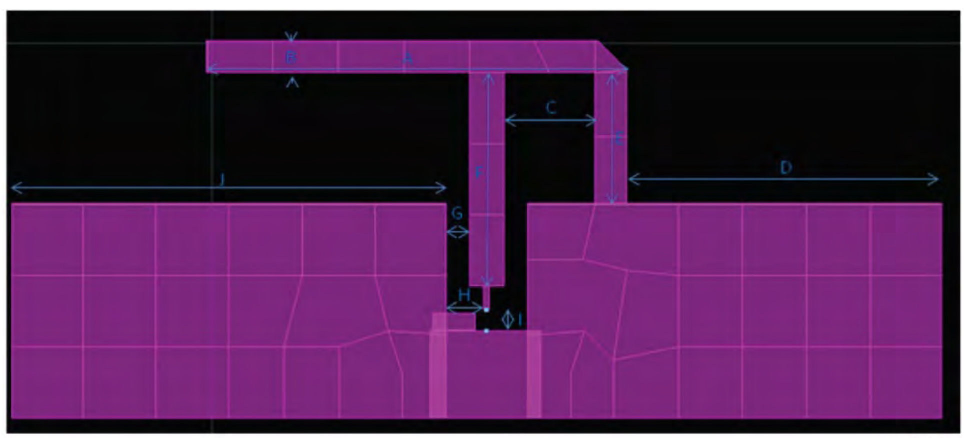


Fig 11. Inverted-F antenna layout diagram

Table 4. Inverted-F antenna layout dimensions

Reference (in diagram)	Distance (mm)
A	1.5
B	20.3
C	4.4
D	15.2
E	6.3
F	10.3
G	1.145
H	1.85
I	1.05
J	21

3.2 Simulation results

3.2.1 S parameters

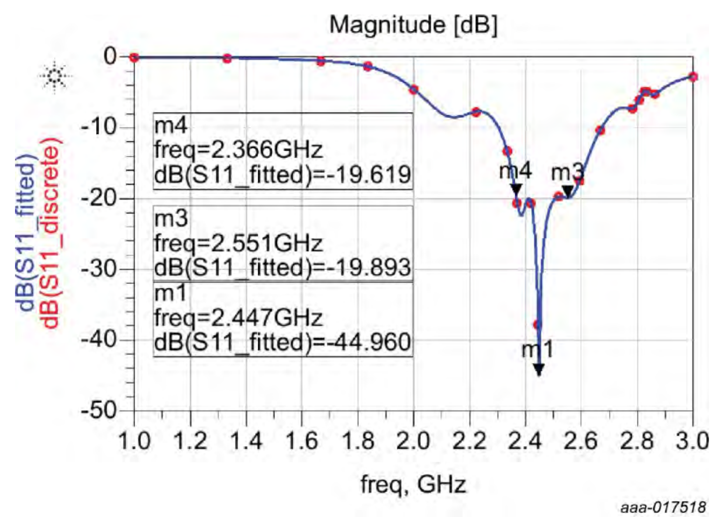


Fig 12. S11 parameter

3.2.2 S11 results

S11[2.366 GHz] = –19.6 dB.

S11[2.447 GHz] = –19.8 dB.

S11[2.551 GHz] = –44.9 dB.

3.2.3 S11 Smith chart

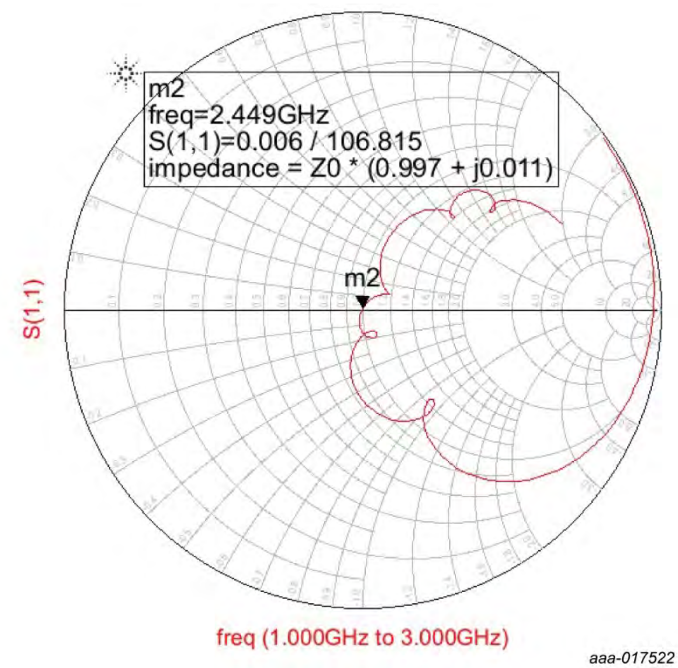


Fig 13. S11 Smith chart

3.2.4 3D radiation

The maximum gain is in the theta direction.

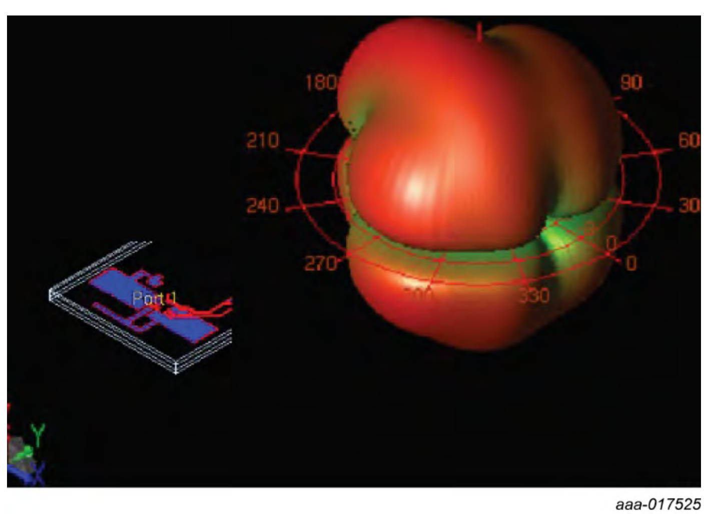


Fig 14. Total gain for all directions

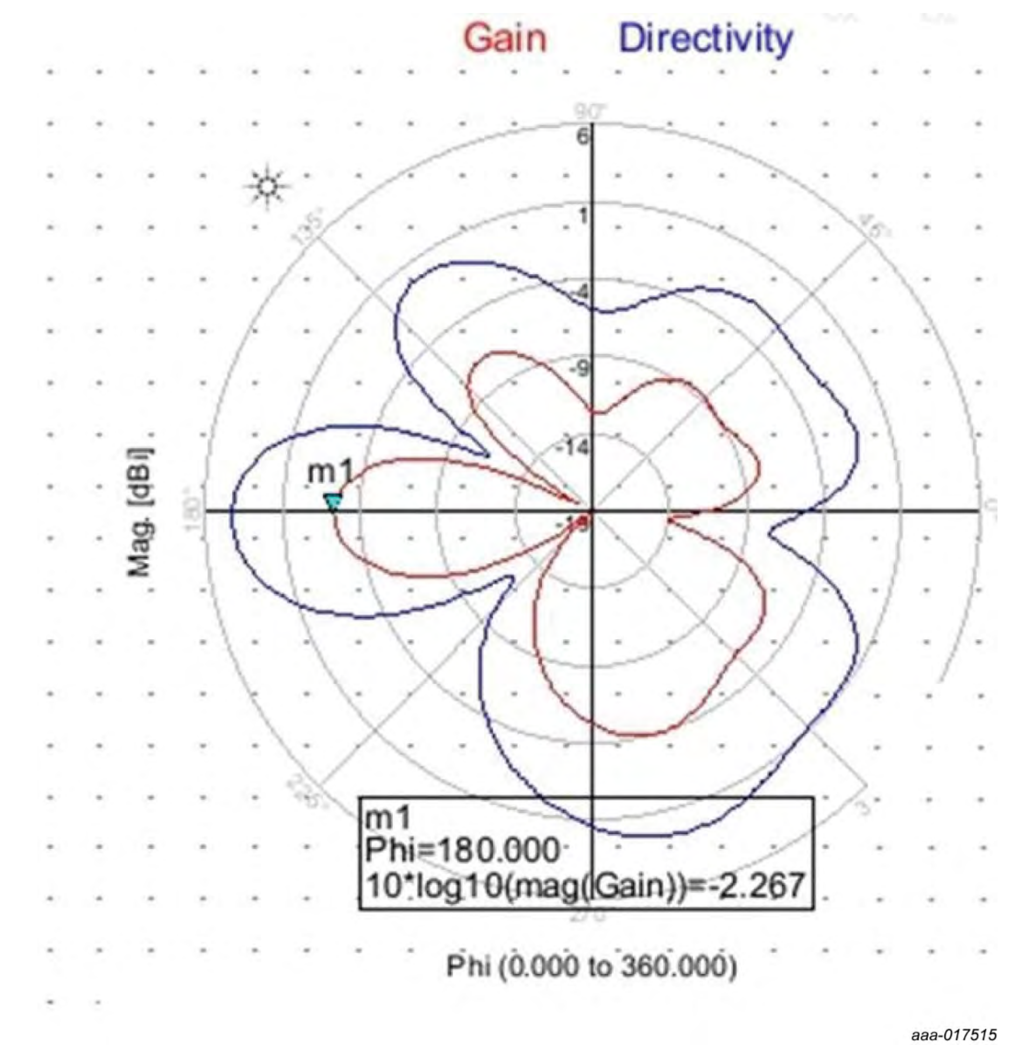


Fig 15. Gain in theta direction

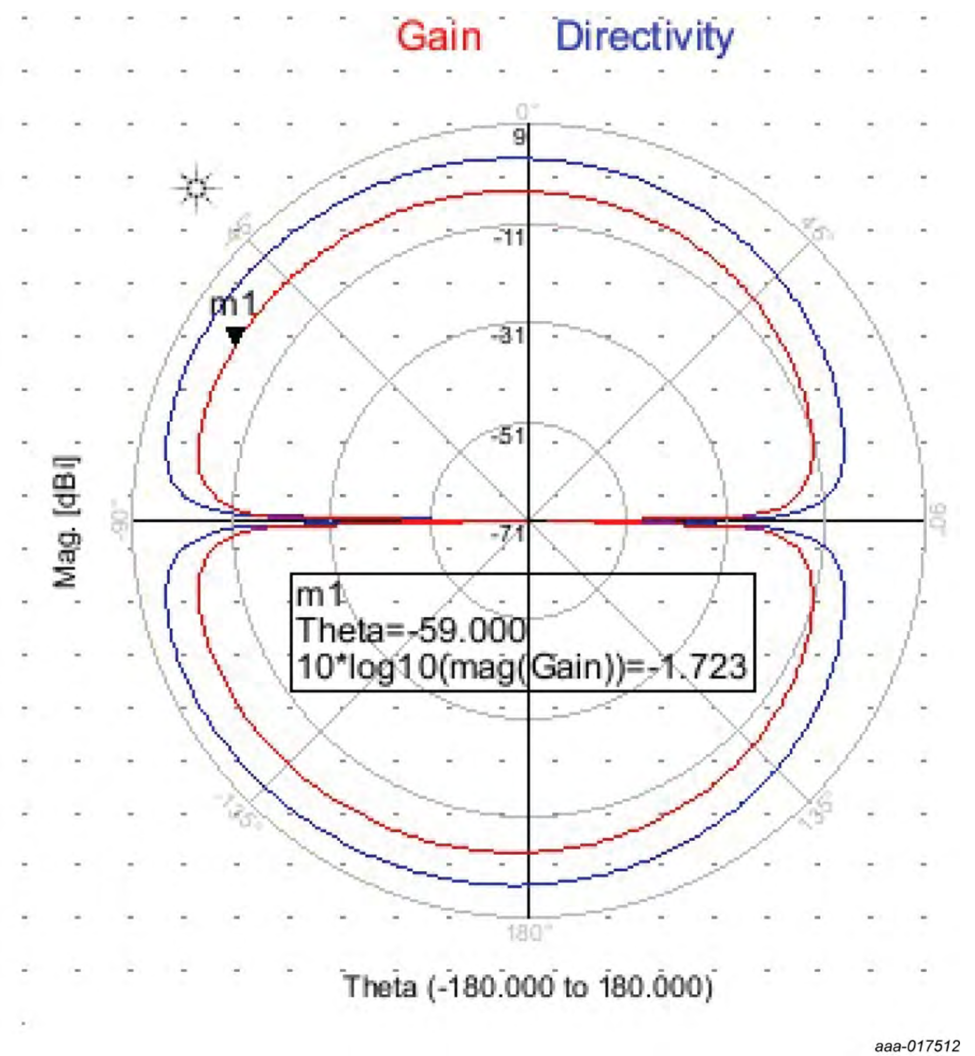


Fig 16. Gain in phi direction

3.2.5 Radiation efficiency

Table 5. Radiation efficiency at 1 GHz, 2.4 GHz and 3 GHz

Frequency	Efficiency
1 GHz	18%
2.4 GHz	25%
3 GHz	20.1%

4. Dipole antenna

The dipole antenna simulations have been done with ADS from Cadence.

4.1 One-layer printed antenna

4.1.1 PCB characteristics

Substrate FR4.

Substrate thickness = 1.6 mm.

Er = 4.6, Er TanD = 0.01.

Copper thickness = 35 µm.

4.1.2 Antenna layout

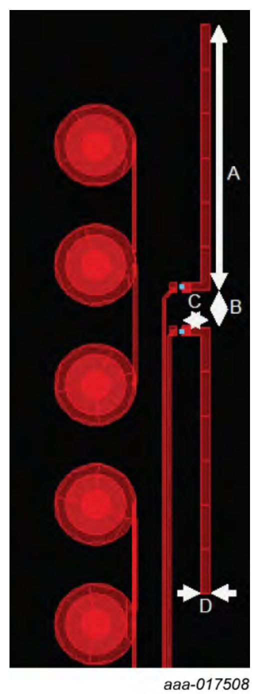


Fig 17. Dipole antenna layout diagram

Table 6. Dipole antenna layout dimensions

Reference (in diagram)	Distance (mm)
A	22.2
B	3
C	2.2
D	0.7

4.2 Simulation results

4.2.1 S parameters

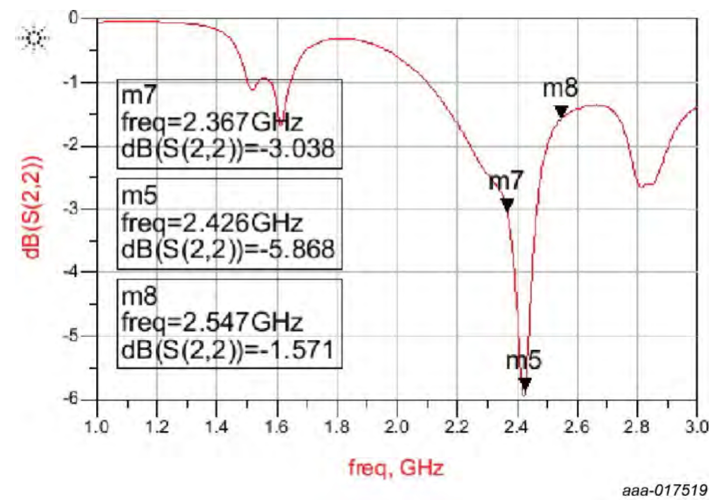


Fig 18. S22 parameter

4.2.2 S22 results

S22[2.367 GHz] = –3 dB.

S22[2.426 GHz] = –5.8 dB.

S22[2.547 GHz] = –1.5 dB.

4.2.3 S22 Smith chart

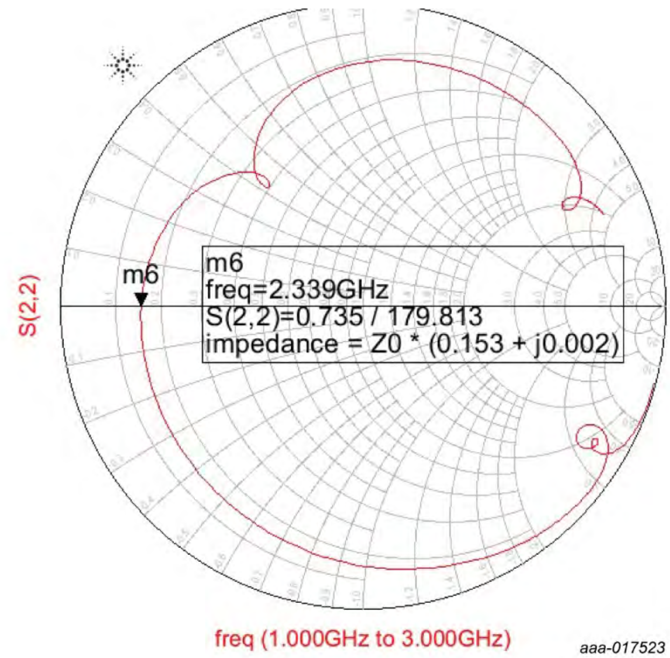


Fig 19. S22 Smith chart

4.2.4 3D radiation

The maximum gain is in the theta direction.

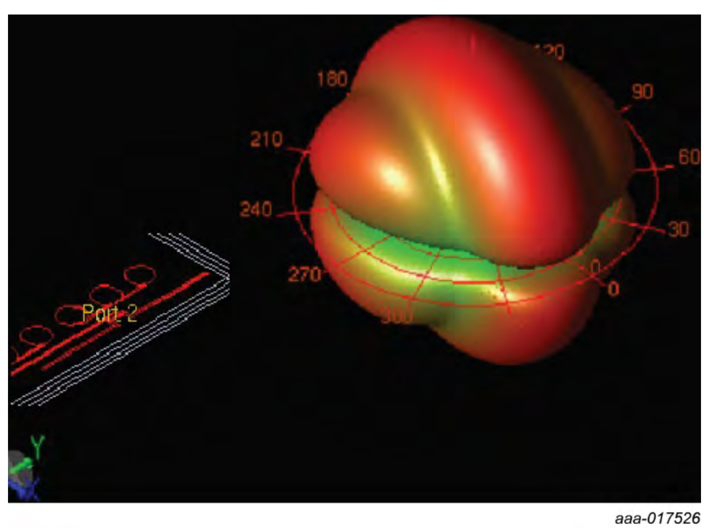


Fig 20. Total gain for all directions

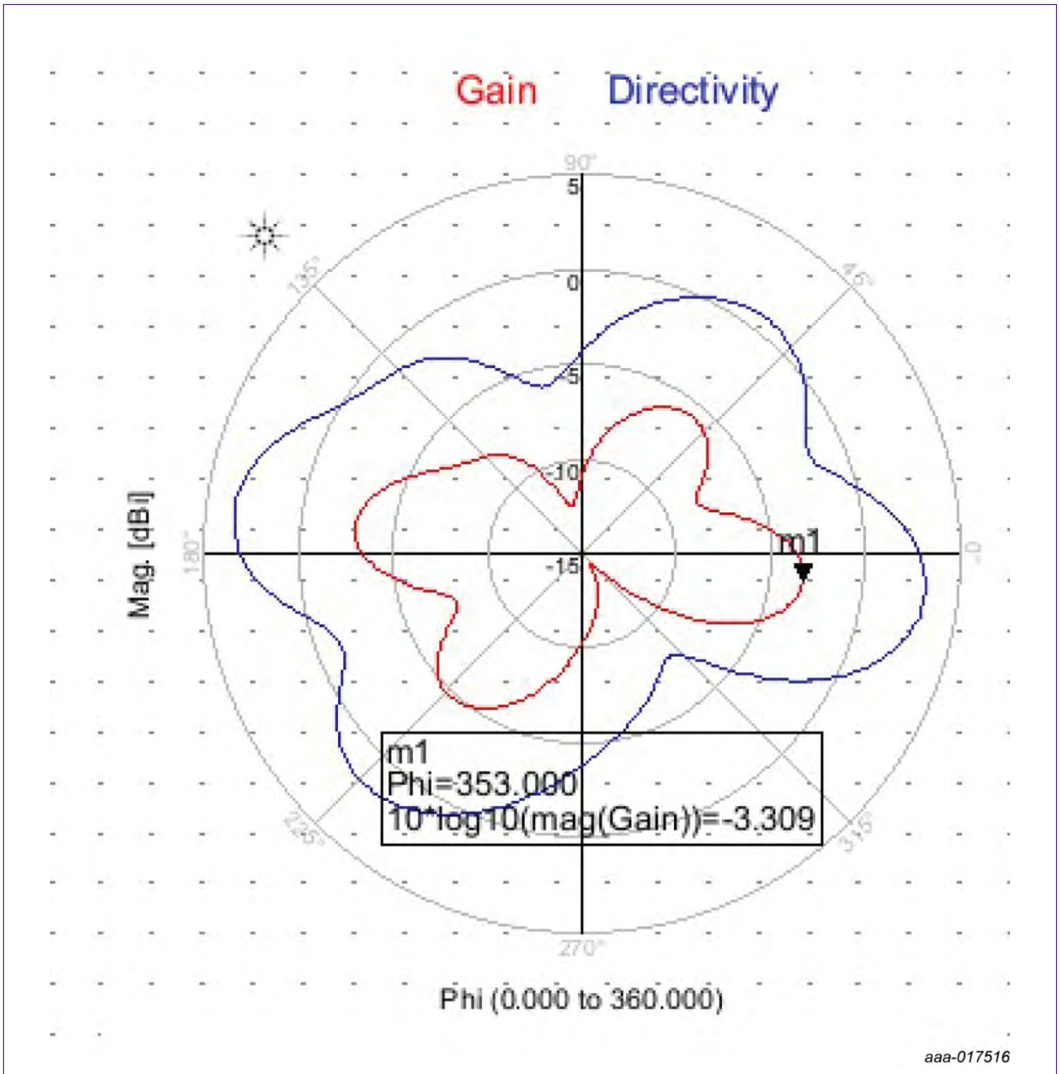


Fig 21. Gain in theta direction

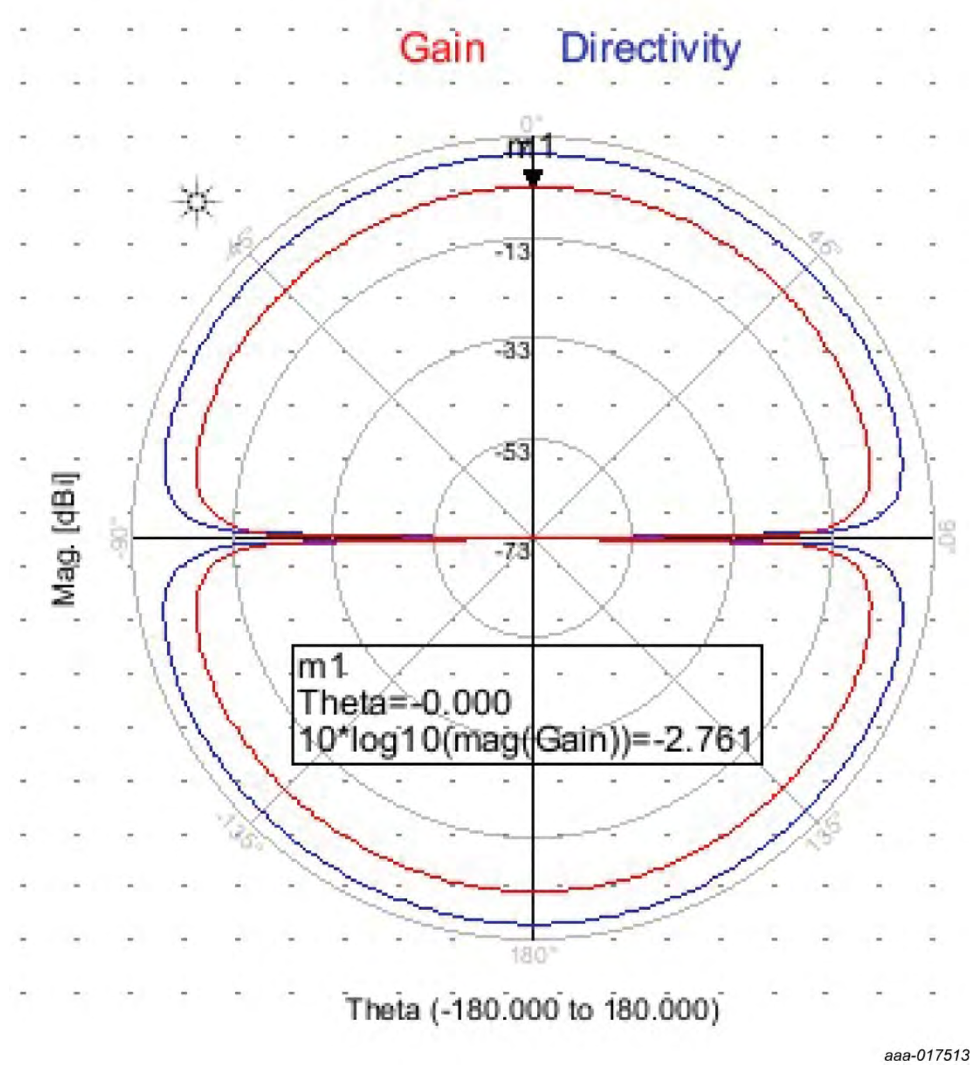


Fig 22. Gain in Phi direction

4.2.5 Radiation efficiency

Table 7. Radiation efficiency at 1 GHz, 2.4 GHz and 3 GHz

Frequency	Efficiency
1 GHz	26%
2.4 GHz	22.54%
3 GHz	41.8%

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6. List of figures

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