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MUTUAL COUPLING REDUCTION IN MICROSTRIP MIMO ANTENNA USING ROGERS 5880 FOR 5G BAND

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Abstract: The demand for high-speed wireless communication requires improved Bit Error Rate (BER) and better signal reception, which cannot be achieved using single patch antennas. MIMO technology offers an effective solution, though mutual coupling remains a key challenge. In this work, Rogers 5880 is used as the substrate, and a simple decoupling structure is implemented to reduce mutual coupling by 12 dB. The proposed antenna operates at 68.9 GHz with good performance, making it suitable for 5G applications.

Index Term: Microstrip MIMO antenna, SISO, MIMO, Decoupling element, Resonator, Microstrip patch antenna, Rogers 5880.

I. INTRODUCTION:

Modern communication systems demand improvements in bandwidth, gain, channel capacity, and reliability. Multiple-Input Multiple-Output (MIMO) technology enhances system performance by

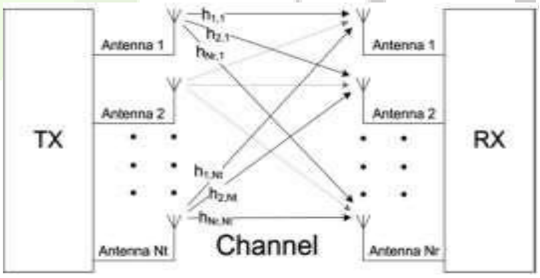


Fig. 1 MIMO system

increasing data rates, improving channel capacity, and utilizing multipath propagation, making it widely used in applications such as Wi-Fi, Bluetooth, and 5G.

However, MIMO systems employ multiple transmitting and receiving antennas arranged in array form. However, they face challenges such as increased complexity, cost, and power consumption. The major issue is mutual coupling between antenna elements, which degrades performance. Techniques like Defected Ground Structure (DGS), Electromagnetic Band Gap (EBG), and resonators are used to mitigate this problem.

In this work, both SISO and MIMO antenna configurations are analyzed. A slotted resonator is introduced as a decoupling element to reduce mutual coupling. Simulations are performed using CST Studio Suite at 2.3 GHz, and the results are discussed in subsequent sections.

II. ANTENNA DESIGN AND RESULTS:

As discussed in the previous section, both SISO and MIMO antenna configurations are designed in this paper. The dimensions of the microstrip patch antenna are calculated using standard design equations. The width of the patch (w) is given by

$$w = \frac{C}{2f_o\sqrt{\frac{\epsilon_r+1}{2}}}$$

Here C is the velocity of light which is $3 \times 10^8\ m/s$, f_o is the frequency and ϵ_r is the dielectric constant. In this paper we use Rogers 5880 substrate and hence the value of ϵ_r is 2.2.

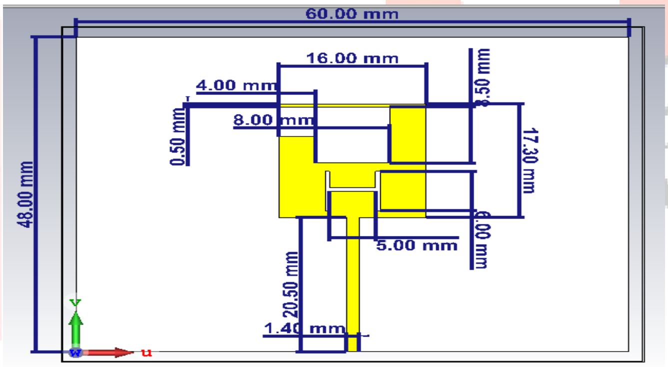
The reason behind choosing the Rogers 5880 is that as we increase permittivity of the substrate, the size of the antenna reduces. But, reduces gain and bandwidth of the antenna as we increase permittivity value. Therefore, a low permittivity substrate is preferred and hence instead of using traditional FR-4 (permittivity = 4.4) we have used Rogers 5880 (permittivity = 2.2). Also, Rogers 5880 has low loss tangent dielectric medium.

Loss tangent of Rogers 5880 = 0.0004 while the loss tangent of FR-4 = 0.013-0.025

After determining the patch dimensions, a feeding technique is applied for signal transmission and reception. Among various methods, the microstrip line feed is chosen for its simplicity and ease of fabrication.

A. SISO Antenna

The SISO (SINGLE INPUT SINGLE OUTPUT) antenna is the simplest form of MIMO antenna. The proposed antenna design, dimensions, hardware photograph along with graph of S-parameter is shown. The proposed works at 66.534 GHz and have return loss around -22 dB (-21.63 dB). The VSWR of the antenna is 1.18, directivity is 10.84 dBi and gain of the antenna is 10.05 dB (Fig.2).



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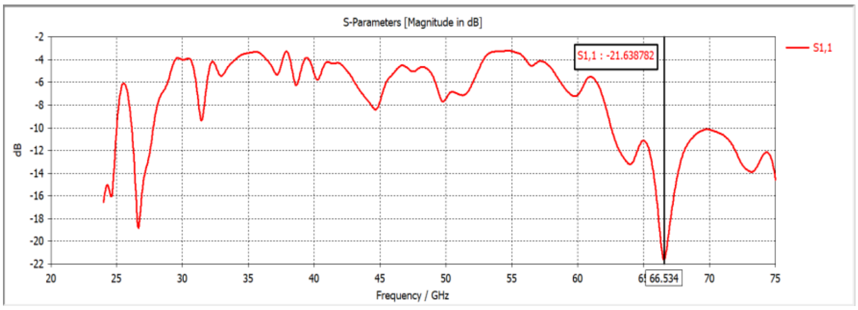

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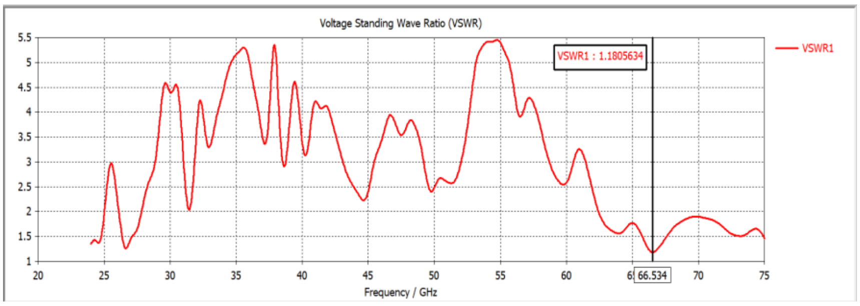

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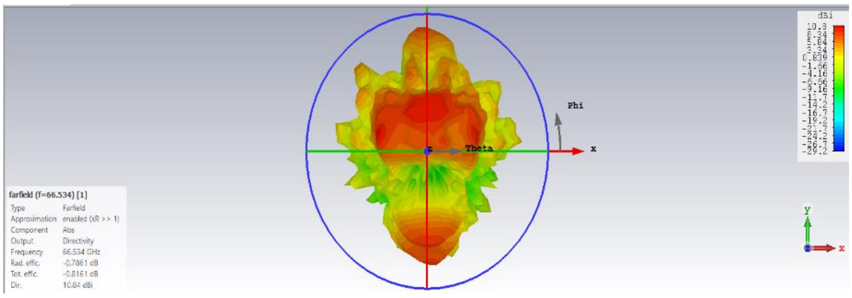

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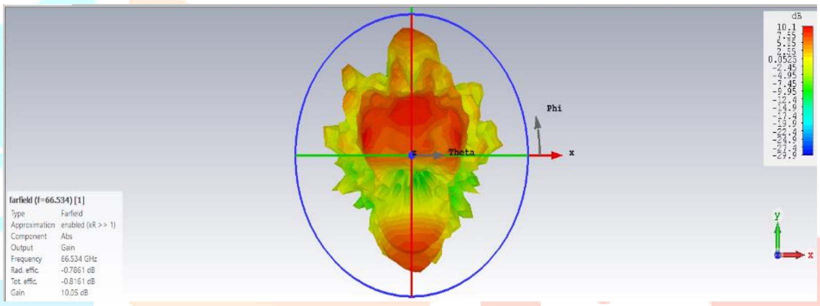

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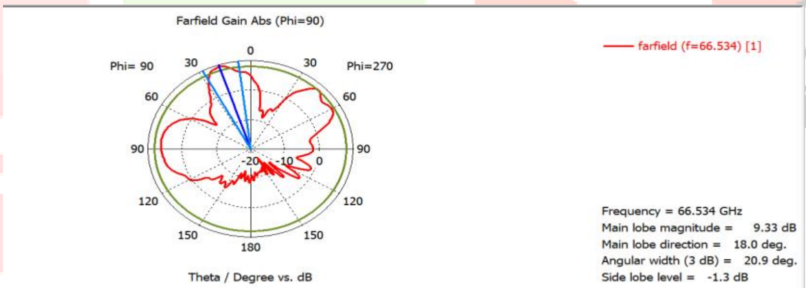

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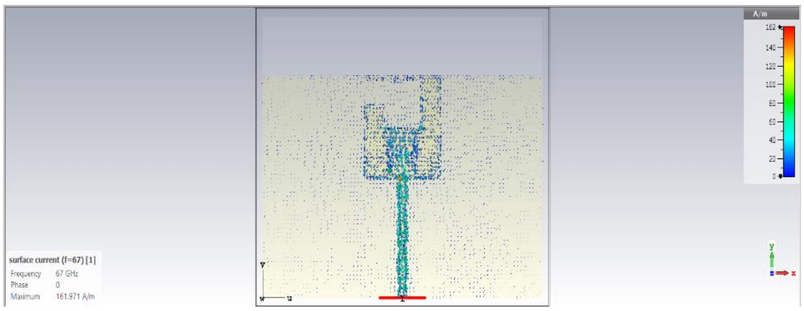


(g)

Fig. 2 antenna 1

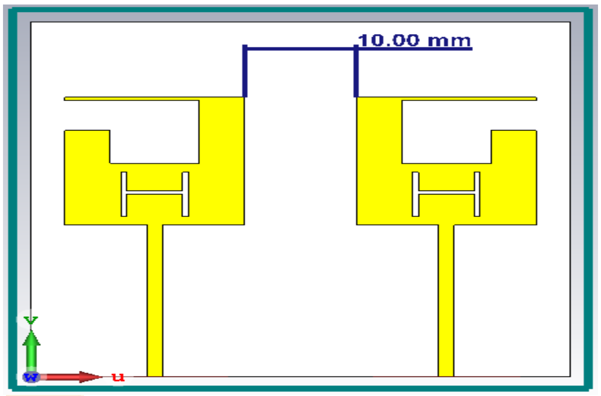
(a) Design dimensions of proposed SISO antenna, (b) Result (graph of S-parameter), (c) VSWR, (d) Directivity, (e) Gain, (f) Radiation pattern and (g) Surface current distribution

The SISO antennas are commonly used in radio, GSM, and CDMA systems; however, they are inadequate in meeting the increasing demand for higher data rates and improved Bit Error Rate (BER) performance.

B. MIMO Antenna

MIMO antennas use multiple transmitting and receiving channels to achieve higher data rates and lower BER than SISO systems, making them suitable for next-generation communication. However, mutual coupling and increased complexity affect performance. In this work, an I-shaped slotted resonator is used as a decoupling element to reduce mutual coupling effectively without degrading antenna performance.

In this paper, we proposed a type of antenna which is a two channel two ports MIMO antenna. The proposed MIMO antenna design without decoupling element (I slotted resonator). The VSWR of the antenna 2 is 1.06, directivity is 11.28 dBi and the gain of the antenna is 10.63 dB (Fig. 3).



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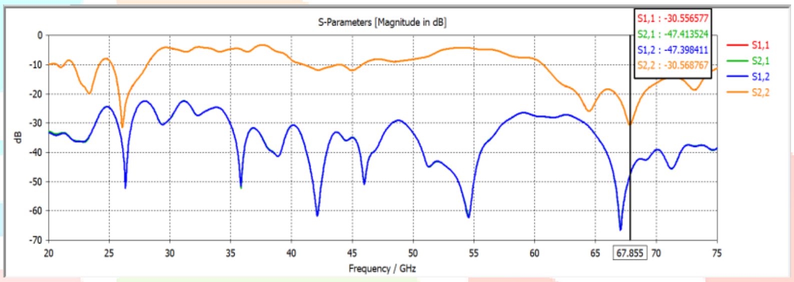

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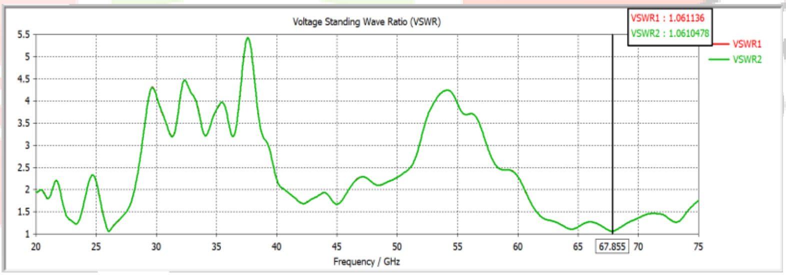

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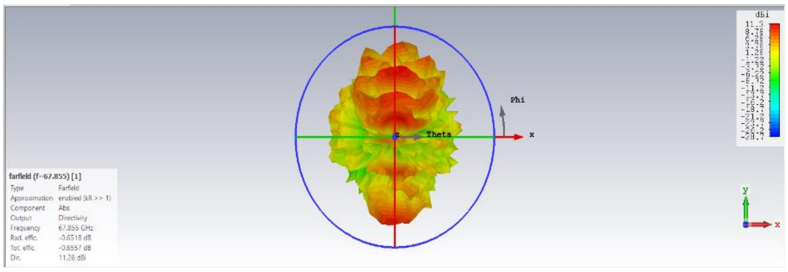

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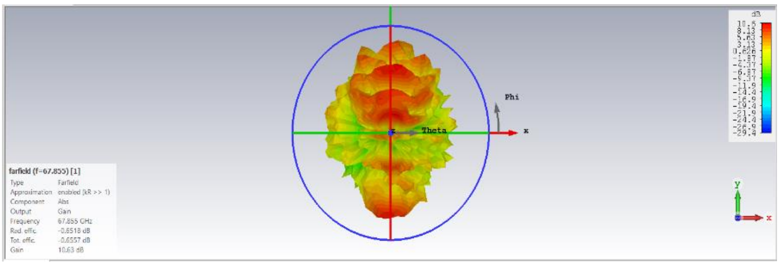

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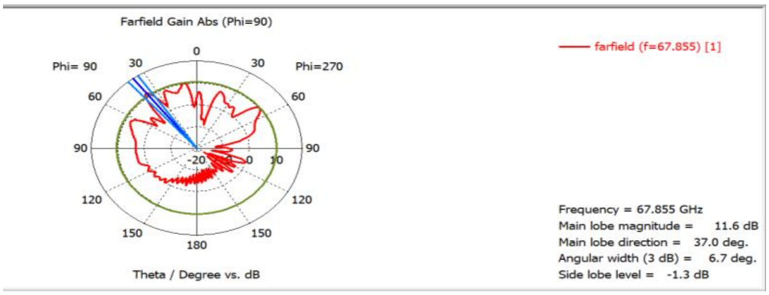

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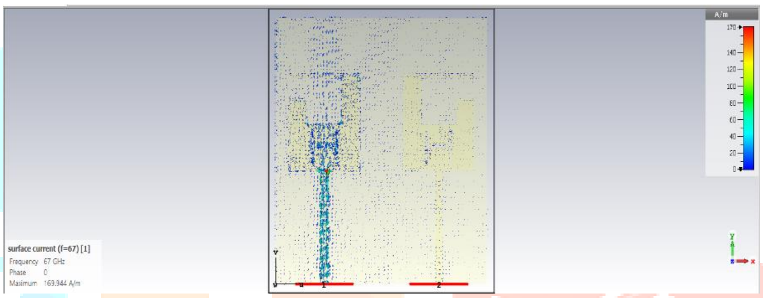

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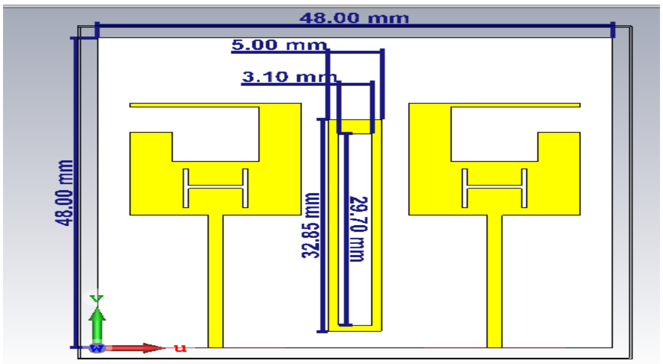
Fig. 3 antenna 2

(a) Design dimensions of proposed MIMO antenna (without resonator), (b) Result (graph of S-parameter), (c) VSWR, (d) Directivity, (e) Gain, (f) Radiation pattern and (g) Surface current distribution

But fig. 4 is the proposed MIMO antenna with decoupling element (I slotted resonator). From fig. 3's S-parameter graph it is clearly seen that due to the problem of mutual coupling only one port is working properly but at the same time the other port is not working and hence to reduce this mutual coupling problem a decoupling element named as I slotted resonator is proposed in this paper which is placed between closely spaced antenna channels (fig. 4). After the use of decoupling element the mutual coupling reduced by 12 dB. The VSWR of the antenna is 1.18, directivity is 11.34 dBi and the gain of the antenna is 10.61 dB (Fig.4).



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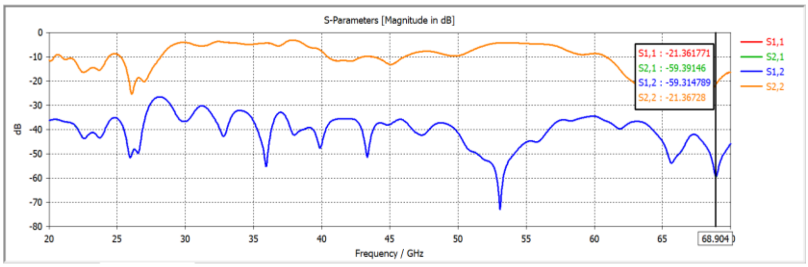

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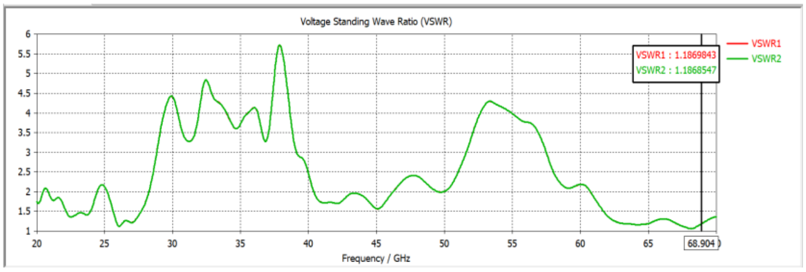

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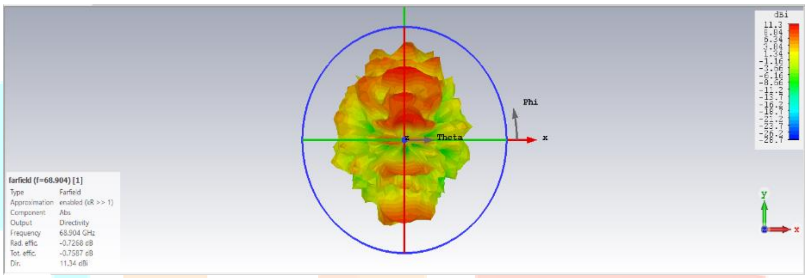

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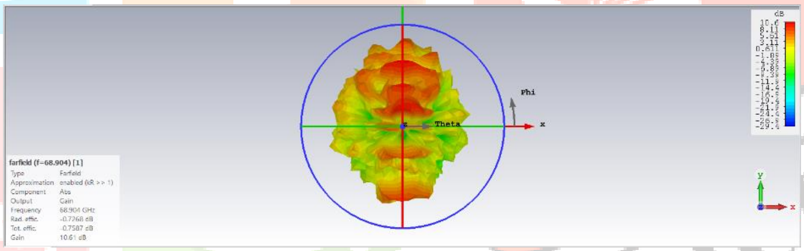

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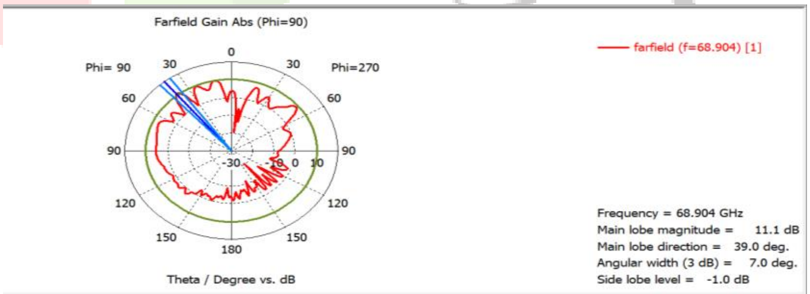

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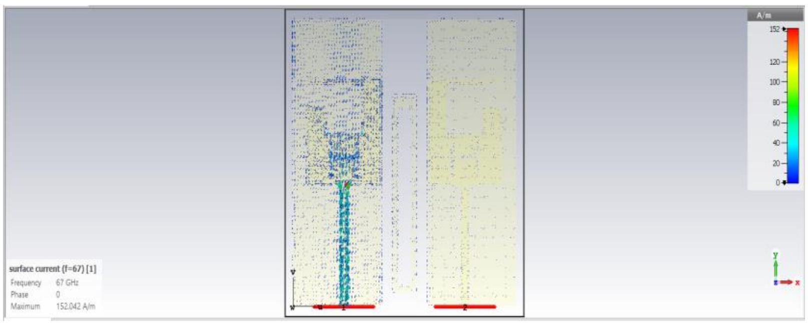

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Fig. 4antenna 3

(a) Design dimensions of proposed MIMO antenna (with resonator), (b) Result (graph of S-parameter), (c) VSWR, (d) Directivity, (e) Gain, (f) Radiation pattern and (g) Surface current distribution

III. CONCLUSION:

As discussed in the previous section, mutual coupling reduction is achieved using a decoupling element. The proposed design reduces mutual coupling by 12 dB in Antenna 3. Additionally, key parameters such as VSWR, directivity, and gain are also improved. The results are summarized in this section.

S. No.	Parameters	Antenna 1	Antenna 2	Antenna 3
1	Center frequency	66.53 GHz	67.85 GHz	68.9 GHz
2	S-Parameter	-21.638 dB	$S_{1,1} = -30.556$ $S_{1,2} = -47.398$	$S_{1,1} = -21.361$ $S_{1,2} = -59.314$
3	VSWR	1.18	1.06	1.18
4	Directivity	10.84 dBi	11.28 dBi	11.34 dBi
5	Gain	10.05 dB	10.63 dB	10.61 dB

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