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DESIGNING OF HEXAGON SLOTTED MIMO ANTENNA FOR WIRELESS APPLICATION

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Abstract:
The wireless system capacity can be increased by the use of multiple antennas at transmitting and receiving side. The technology which uses multiple antennas called multiple inputs multiple outputs used to fulfils the demand of higher bit rate. In this paper two element antennas has designed using MIMO technique for dual band application and produced better isolation characteristics. In the proposed structure the high isolation was achieved using triangular and hexagonal cut structure. The presented simulated result produced low value of ECC and optimum value of VSWR in the given frequency band. The value of S12 is found less than -18 dB. The value of ECC is obtained 0.015 at 5.3 GHz. The proposed antenna operates in two frequency applications which are 3.59 GHz and 5.3 GHz.

Keywords: *MIMO; ECC; MEG; VSWR; WLAN; Microstrip Patch Antenna (MPA).*

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1. Introduction

In the MIMO antenna system various techniques are available for size reduction as well as the improvement in isolation among ports. The use of defected ground plane, neutralization lines, and use of active components in MIMO antenna reported previously for the mutual coupling reduction. Some of mutual coupling techniques focused on antenna ground part where as some techniques included the isolation structure between the radiators. Some MIMO design reported for L-slot MPA [1-3] for WLAN applications. A compact MIMO antenna with omnidirectional radiation characteristics proposed has peak gain of 3 dBi at the resonating 3.5 GHz. A MPA [4] for multiband application was presented using some unique structure, and printed on top of the substrate for WLAN systems, and achieved a good frequency response with the maximum value of gain. A slot antenna [5] fed by a microstrip line for WLAN and satellite application applications have been presented.

Some broadband MPA developed [6] for WiMAX and WLAN, exhibits wideband characteristics using two PIN diode and achieved the good isolation among the radiators. This antenna shows 36.2% impedance bandwidth with more than 90% antenna efficiency and is suitable for 2.3/2.5

GHz WI-MAX and 2.4 GHz WLAN application. Few more MIMO antenna has investigated for different frequency ranges and mutual coupling enhancement techniques [7-14].

In this paper a triangular slotted and hexagon cut based MIMO antenna proposed which works at 3.59 GHz and 5.3 GHz frequency. The designed MIMO antenna system includes a hexagonal slot to improve the overall performance of the MIMO antenna. The design parameter was calculated for single patch which further extend for two elements.

2. Antenna Design Parameter

The various design parameters for patch antenna are as follows:

Calculation of Width (W)
The width of Simple MPA can be calculated by the equation (1). The main consideration is proposed resonant frequency, and the permittivity of the material.

$$w = \frac{c}{2fo\sqrt{\frac{(\varepsilon r+1)}{2}}} \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where, c is light velocity
fo is Frequency of resonance
Ɛr is Dielectric Constant
Calculation of length (L) and calculation of effective dielectric constant (Ɛreff)
To calculate the length of Simple MPA, first we have to calculate the effective dielectric constant which is given by equation (2). The effective length can be calculated by equation (3).

$$\varepsilon_{reff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left(1 + 12\frac{h}{w}\right)^{\frac{1}{2}} \ldots\ldots \quad (2)$$

Effective length (Leff)

$$L_{eff} = \frac{c}{2fo\sqrt{\varepsilon_{reff}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Calculation of length extension (ΔL)

The MPA parameter length extension can be calculated by equation (4)

$$\Delta L = 0.412h\,\frac{(\varepsilon_{reff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{w}{h}+0.8\right)} \ldots\ldots \quad (4)$$

Calculation of actual length of patch (L)
The actual length of patch antenna is given by equation (5)

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$$L = L_{eff} - 2\Delta L \ldots\ldots\ldots\ldots\ldots \quad (5)$$

3. Antenna Design Specification

The proposed dual band MIMO antenna system composed of 2 radiating elements of uniform geometry has size of 39 × 29 mm^2. The dielectric constant of the substrate is 4.3. A rectangular patch is chosen as the radiating element and each of the radiators is fed separately by a 50Ω microstrip line.

Dimensions of antenna Array
Substrate ($L_s \times W_s \times h$) = 43 mm×42 mm×1.524 mm
Patch ($L_p \times W_p \times t$) =29 mm×39 mm×.07 mm
Ground plane ($L_g \times W_g \times t$) = 37.5 mm×42 mm×.07 mm

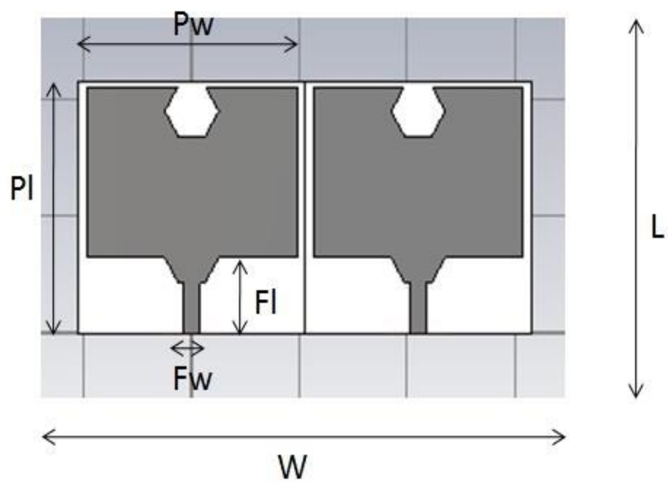

Figure 1: Proposed MIMO antenna

In the first step a plane rectangular patch antenna was designed with simple feed structure, than the hexagon cut has created while the feeding side one hexagon has added. The 50 ohm SMA connector was used for energized the port.

4. Simulation Results

The two elements MIMO antenna is desiged analysed and simulated by CST MWS tool. The simulated results of S-parameters are obtained and analyzed at the resonant frequency 3.59 and 5.3 GHz. Simulated results of S-parameters are shown in figure 2 and 3 S_{12} and S_{21} was obtained less than -10 dB at frequency 3.5 GHz and less than -19 dB at the frequency 5.3 GHz. The return loss parameters S_{11} and S_{22} were less than -18 dB and -19 dB at frequency 3.5 and 5.3 GHz respectively. The obtained results satisfied the isolation requirement in MIMO antenna system.

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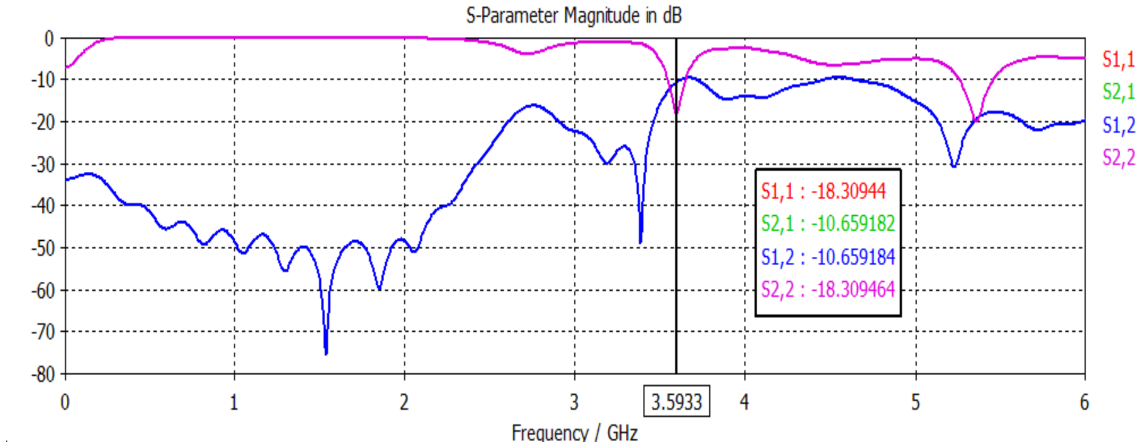

Figure 2: Simulated s-parameters of two element antenna system at 3.5 GHz.

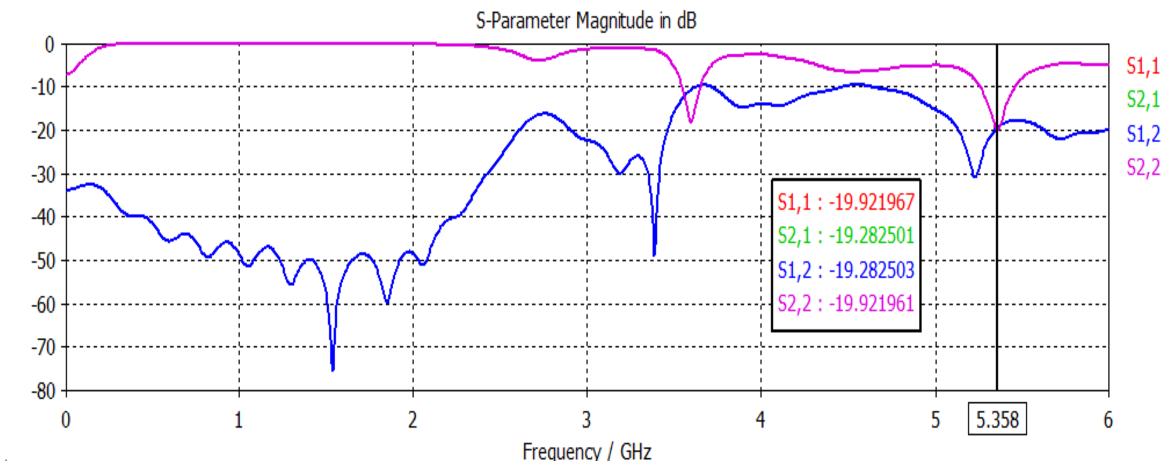

Figure 3: Simulated S-parameters of two element antenna system at 5.3 GHz

4.1. Bandwidth Calculation

BW=f_u- f_l= (3.54-3.64) GHz
=.1047 GHz or 104.7MHz
The bandwidth of MIMO antenna was obtained 104.7 MHz and 198 MHz at frequency 3.5 GHz and 5.3 GHz.

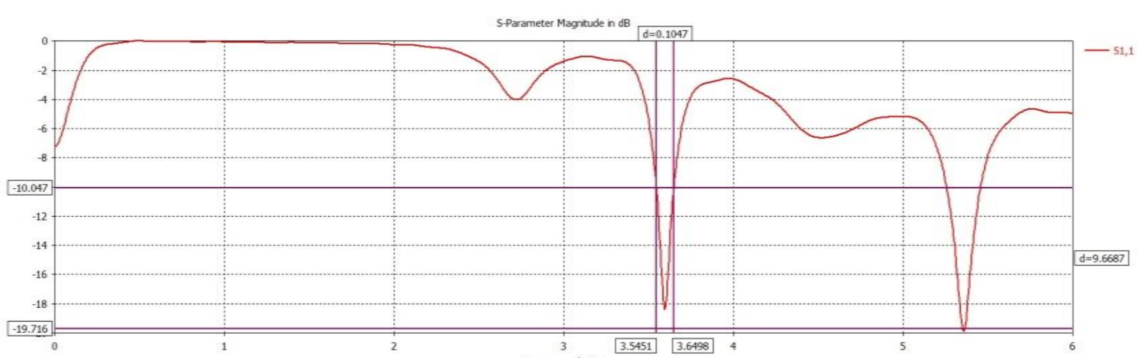

Figure 4: Bandwidth of two element antenna system at 3.5 GHz

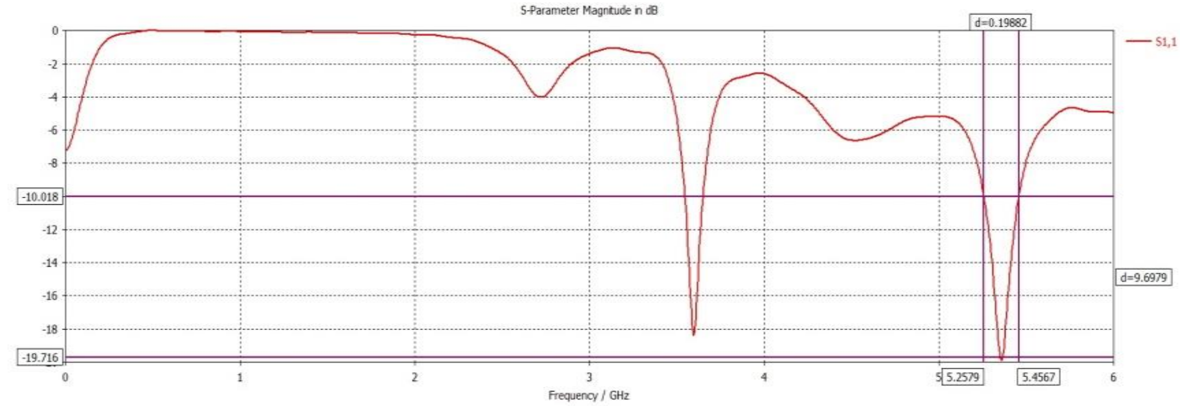

Figure 5: Bandwidth of two element antenna system at 5.3 GHz

4.2. Radiation Pattern

Radiation pattern is the graphical representation or a mathematical function of the radiation properties. The radiation pattern of MIMO antenna system is calculated in terms of directivity. The E and H-plane patterns of the proposed antenna are obtained when one of the antenna ports is energized, while the other antenna port is ended with a 50 ohm load line. The simulated radiation patterns are shown in Figure 6 and 7, for the resonant frequency 3.5 GHz. The directivity of 5.46 dBi and 5.08 dBi was obtained at frequency 3.5 GHz and 5.3 GHz.

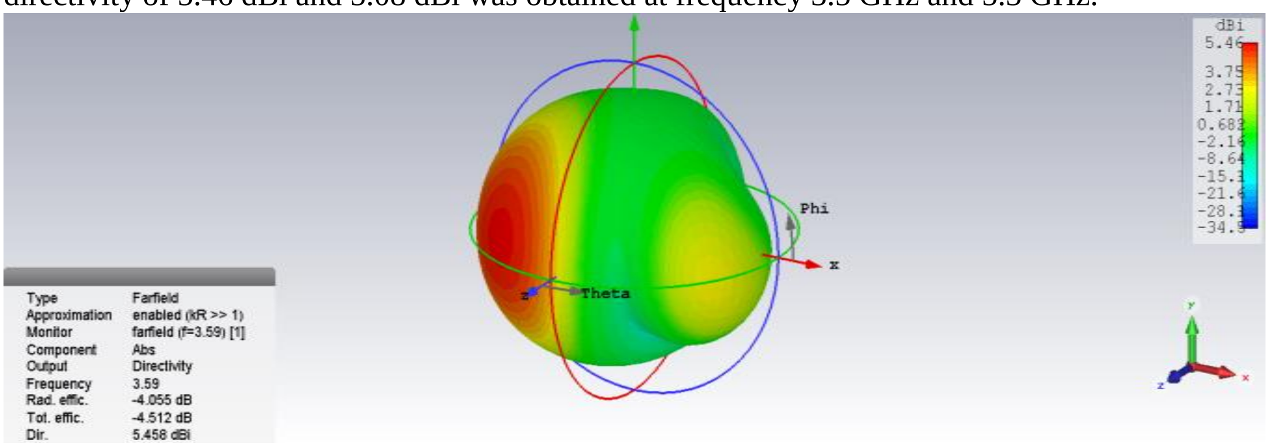

Figure 6: Directivity of MIMO antenna at 3.5 GHz

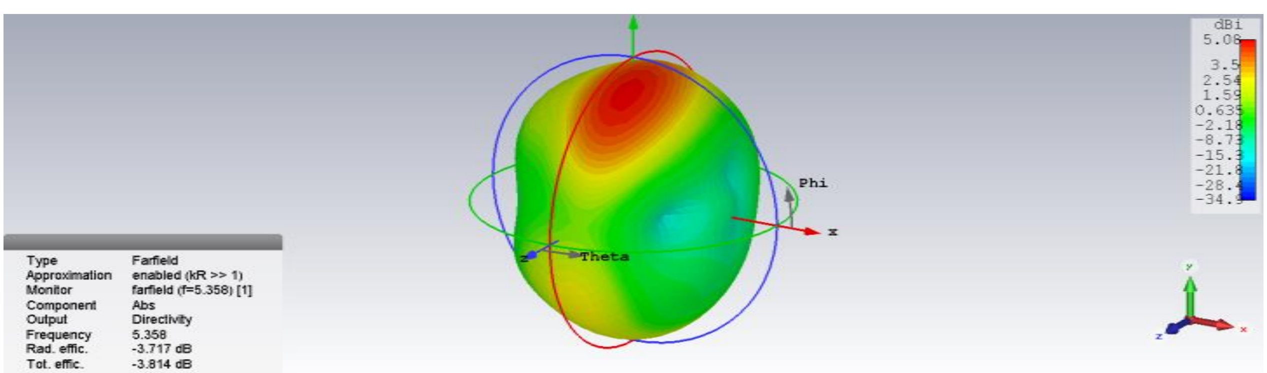

Figure 7: Directivity of MIMO antenna at 5.3 GHz

4.3. Envelop Correlation Coefficient (ECC)

In an MIMO antenna system ECC evaluated the correlations among the radiators/ports. In proposed antenna design, the ECC of .015 was obtained at the resonant frequency 5.3 GHz.

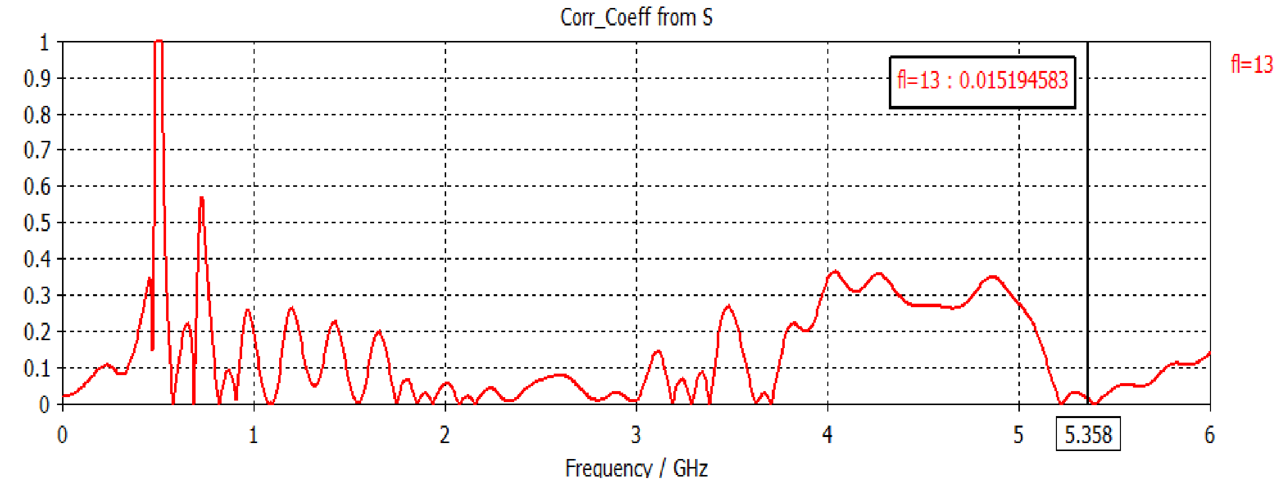

Figure 8: ECC of proposed MIMO antenna

4.4. Surface Current

In figure 9 and figure 10 we can see one antenna is excited through port, and due to correlation some current also appears at another antenna. This causes mutual coupling and overall performance of antenna may affect. These mutual coupling effects must be as small as possible. The designed proposed structure reduced the current to flow from one antenna to other antenna and improves the isolation. The port 1 of proposed antenna is excited; the surface current from the first element to the second element was blocked by the proposed structure. The same current distribution was obtained when the other port alone is excited.

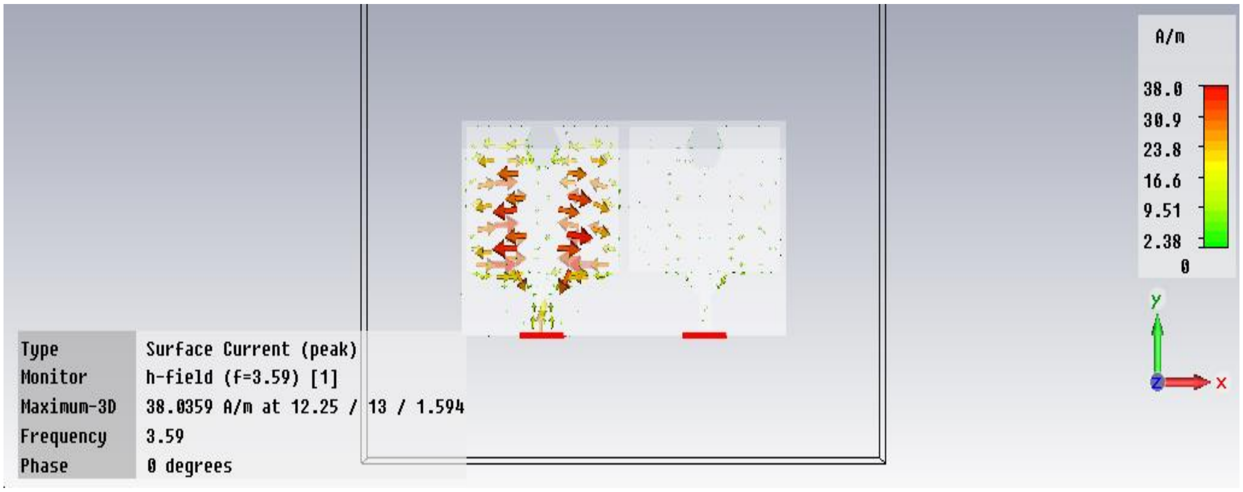

Figure 9: Surface current distributions at 3.59 GHz port 1

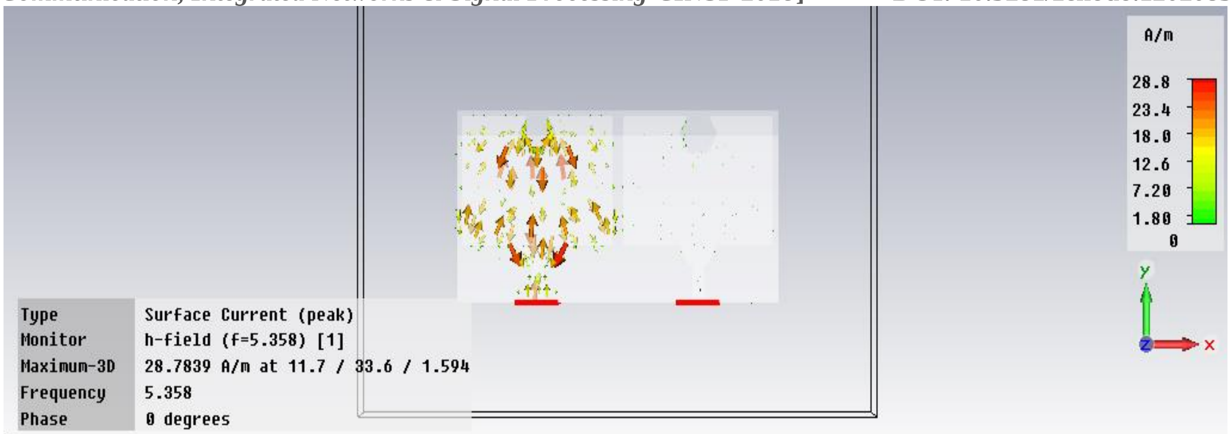

Figure 10: Surface current distributions at 5.35 GHz port 1

5. Conclusion

A rectangular micro strip MIMO antenna is designed with hexagonal cut and simulated and optimized using the CST Studio Suite software. The designed antenna resonate at frequency 3.59 GHz and 5.25 GHz with FR-4 substrate (ε_r =4.3), h=1.524mm. A structure of hexagonal cut and feed improve the value of ECC, VSWR and Isolation. The proposed structure did not allow the large amount of surface current to pass into nearby patch antenna. This structure also improves the return loss.

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