Design of Microstrip Patch Antenna for Wireless Communication Devices

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Abstract: ***As per Microstrip Patch antenna (MPA) provide low profile and low volume, so it is use in a now a days communication devices. It is studied that MPA is targeted on planning compact sized microstrip antenna. A printed monopole antenna can be used in wireless communication devices in different operating frequency ranges. In this speedy dynamical world in wireless communication dual or multiband antenna has been playing a key role for wireless service needs applications. In this paper, a microstrip patch antenna with clockwise rotated E-shape radiating patch with I-cut on middle slot is proposed using at 3.5 GHz. The size of microstrip antenna is 19.99×26.08 (L×W) mm^2. The performance parameter of MPA such as Return loss, VSWR, elevation polar plot and 3D view of radiation pattern are simulated by using Zeland Program Manager (IE3D).***

Keywords: Microstrip patch antenna, Ultra Wide band, Operating frequency, feeding techniques.

1. Introduction

An antenna both transmitting and receiving the information so it is the essential part of the microwave communication. It is a device that is made to efficiently radiate and receive the radiated electromagnetic waves. Antenna is a transducer which converts the voltage and current on a transmission line into an electromagnetic field in a space, consisting of an electric and magnetic field travelling right angles at each other [1,2,3].

Generally, to detect the cancerous tissue, the microwave imaging system is made by a circular cylindrical array antenna microwave imaging systems need little antennas with Omni-directional radiation patterns and enormous information measure. Thus, in microwave imaging systems, over the full operative band one of key issues is that the style of compact antenna where as providing wideband characteristics. It is a well known incontrovertible fact that compact monopole antennas physical options, like easy structure, little size and low price presents very appealing [2-4]. Consequently, variety of planner monopoles with totally different geometrics are through an automatic style strategies and experiment characterized have been developed to attain the optimum compact form [5].With the event of band wireless communication systems, ultra wide band (UWB) systems have been increasing quickly. The Federal communications

Commission allotted the wave band 3.1~10.6 GHz for the UWB services. These UWB systems have been used for radiolocation applications, localizations, information communications etc. The antennas of UWB systems area unit embedded into these transmission devices, the house networking system is wide utilized in transmission devices like HDTV's, DVD's, cameras and private computers through the UWB service channels [6].

The most commonly employed microstrip patch antenna is a rectangular patch. The rectangular patch antenna is approximately a one wavelength long section of rectangular microstrip transmission line. The antenna is loaded with a dielectric as its substrate, the length of the antenna decreases as the relative dielectric constant of the substrate increases . When the air is the antenna substrate the length of the rectangular microstrip antenna is approximately one half of a free space wavelength. The proper miniaturized antenna will improve the transmission and reception.

Microstrip resonators will be classified into 2 sorts counting on the length and width of antennas. Resonators with a slim conductor known as microstrip dipole and resonators with a large conductor are referred to as microstrip patch. Resonance happens once the dipole or patch dimensions are of a half guided wavelength. Longitudinal current distribution here for their pattern and gain are similar, however the alternative properties (e.g. input electrical phenomenon and polarization) will vary.

When the signal frequency is within the section of a resonance, a microstrip resonator radiate comparatively broad beam, broadside to the plane of the substrate. A serious a part of the sign participates in radiation and so the resonator acts as an antenna. Since patch dimensions should be should be of the order of a radio-controlled wavelength, its directivity is extremely low as an example, a half-wavelength dipole generally features a gain of regarding 5-6 db and beam width between 70 and 80 degrees.

The design of a microstrip antenna begins by deciding used for the antenna so the size of the patch. due to the fringing fields on the radiating edges of the antenna there's a line extension related to the patch. The basic structure of the microstrip patch antenna design is shown in fig.1.

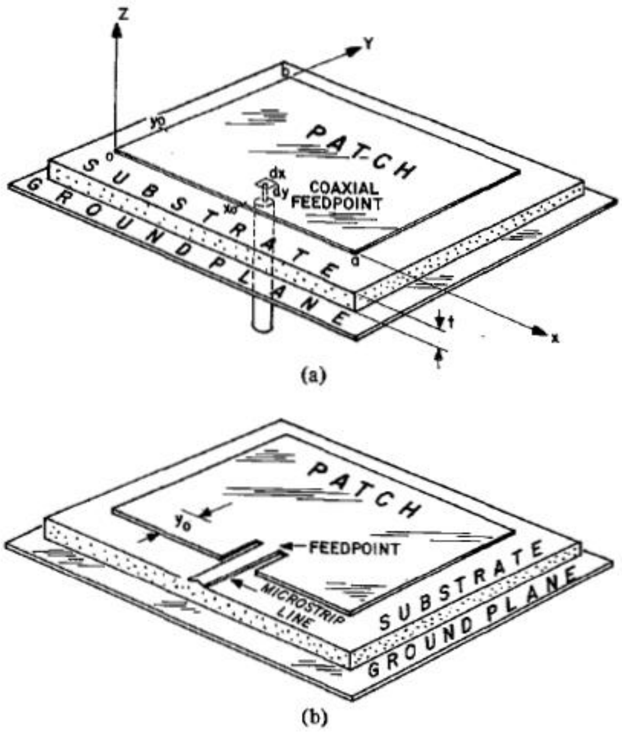

Figure 1: The structure of microstrip antenna

2. Study of Antenna Designing Parameters

There are three essential parameters for design of a rectangular microstrip Patch Antenna. Firstly, the resonant frequency (f_0) of the antenna must be selected appropriately. The frequency range for ultra wide band applications is 3.1 to 10.6 GHz and the design antenna must be able to operate within this frequency range.

The second important parameter of antenna is substrate thickness. The height of dielectric substrate (h) of the microstrip patch antenna with coaxial feed is to be used in S-band range frequencies. Hence, the height of dielectric substrate employed in this design of antenna is h = 1.6 mm.

The third important parameter of good antenna design is dielectric substrate (ε_r). A thick dielectric substrate having low dielectric constant is desirable. This provides better efficiency, larger bandwidth and better radiation. The low value of dielectric constant increases the fringing field at the patch periphery and thus increases the radiated power lower quality factor Q. FR-4 Epoxy which has a dielectric constant of 4.4 and loss tangent equal to 0.02 can be used for new antenna design.

The look of patch are going to be fed by a microstrip transmission line. Patch is act as a conductor. This structure of the antenna having length of patch L, width W, height of dielectric substrate h and Loss tangent. The dielectric constant of the substrate material is an important design parameter. These are placed on infinite ground plane.

The length is formed around $L_g/2$ that the patch starts to radiate, that typically incorporates 50Ω impedance. The antenna is typically fed at the diverging edge on the dimension W because it offers sensible Polarization, but the disadvantages area unit the spurious radiation and want for electric impedance matching this is often as a result of 150 to 300 typical edge resistance of a microstrip antenna ranges. The antenna is typically fed at diverging edge on the dimension W because it offers sensible polarization, but the spurious radiation and want for electric impedance matching this is often as a result of 150 to 300 typical edge resistance of a microstrip antenna ranges. The antenna parameters antenna can be calculated by the transmission line method [17] as exemplified below:

Width of the Patch (mm)

$$W = \frac{c}{2f0\sqrt{\frac{(\varepsilon r+1)}{2}}}$$

where, c = speed of light in free-space (3×10^8 m/s)

Resonant Frequency (in GHz):

$$f_0 = \frac{c}{2Le\sqrt{\varepsilon r}}$$

and length Le (Effective Length) is chosen as

$$L_e = L + 2\Delta L$$

Formula for the extended length due to fringing effect is given as,

$$\frac{\Delta L}{h} = 0.412\left(\frac{(\varepsilon reff+0.3)(\frac{w}{h}+0.264)}{(\varepsilon reff-0.258)(\frac{w}{h}+0.8)}\right)$$

$$\varepsilon_{eff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left(1+\frac{12h}{w}\right)^{\frac{-1}{2}}$$

Where,
h = Height of dielectric substrate
W = Width of the patch

Ground Dimension

For practical considerations, it is essential to have a finite ground plane if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, the ground plane dimensions would be given as:

$L_g = 6h+L$
$W_g = 6h+W$

By using these formulas we can calculate L×W the dimension of the main patch and $L_g \times W_g$ the dimension of the ground plane of the main patch.

Feed Location Design

To radiate the antenna a feed is used to excite by direct or indirect contact. The feed of microstrip antenna can have many configurations like microstrip line, coaxial, aperture coupling and proximity coupling. But for fabricate easily microstrip line and the coaxial feeds are relatively used . Coaxial probe feed is used because it is easy to use and the input impedance of the coaxial cable in general is 50 ohm. There are several points on the patch which have 50 ohm impedance. We have to find out those points and match them with the input impedance. Feed point is chosen so that where at the point of radiating patch maximum area of patch is covered. By changing feeding points antenna is radiate at different radiating frequency. We will use coaxial probe feeding technique.

3. Antenna Design and Structure

After study and calculation of the parametric analysis of antenna design fig. 2, shows the proposed microstrip patch antenna design, it consists of the clockwise rotated E-shaped radiating patch, I-shaped cut on it, ground plane and a feed line. For signal transmission a 50Ω - SMA connector is connected to the proposed antenna. The dimension of the patch of the substrate, is Lp×Wp = 19.99×26.08 mm^2 operated at the 3.5 GHz (resonance frequency). In choosing the width of the radiating patch there is a lot of flexibility.

To accomplish a compact size design, the minimum size of the ground plane is desirable. The parameter to study is the length of the ground plane. Hence, a small portion of ground length is taken. The proposed antenna is simulated using Zeland Program Manager (IE3D) software. In the presented structure, taking a some portion of ground and feed-line provide an additional current path. Moreover, these structures change the inductance and capacitance of the input impedance, which in turn leads to change the bandwidth. Based on defected structures (DS), for bandwidth enhancement we use an I-shaped slot on the feed-line of the radiating patch. The Defected Structure applied to middle of a microstrip line causes a resonant character of the structure transmission with a resonant frequency controllable by changing the shape and size of the slot.

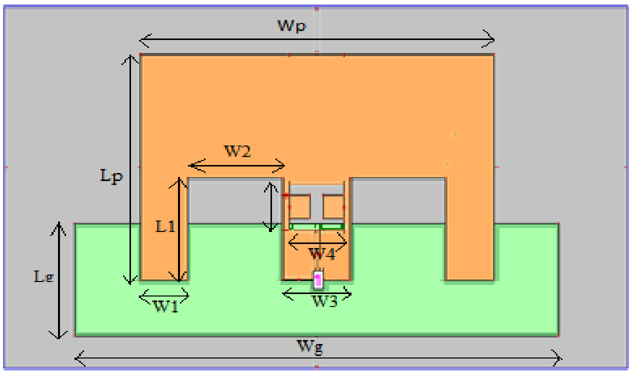

Figure 2: Geometry of the proposed antenna

Dimensions of the Proposed antenna structure is shown in table No.1.

Width	mm	Length	mm
W_P (Main patch)	26.08	L_P	19.99
W_G (Ground plane)	35.68	L_G	9.7
W_1 (Main patch)	3.54	L_1	8.9
W_2 (Main patch)	7	L_2(I-cut)	4.5
W_3 (Main patch)	5	L_3(I-cut)	1
W_4, W_5 (Inner I-cut slot)	4, 1.5	L_4(I-cut)	2
W_f (Feed point)	9.9	L_f	0

4. Simulation and Results

A different design of microstrip patch antennas in measured dimensions with same basic parameter is simulated using IE3D simulating software. Various characteristics of antenna such as VSWR, Return Loss, 3D view of polar plot and 3D view of radiation pattern are given in following figures.

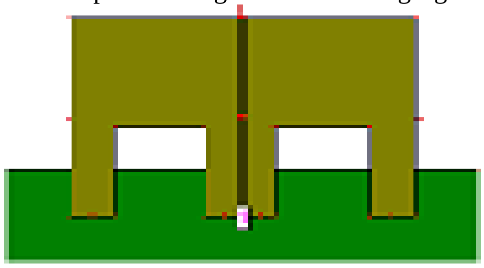

Figure 3: (a) Ordinary Clockwise Rotated E-shaped Antenna Design with Ground plane

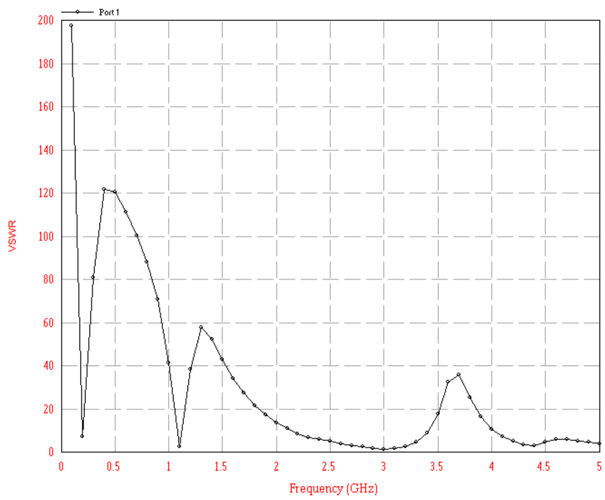

Figure 3: (b) VSWR Vs Frequency plot

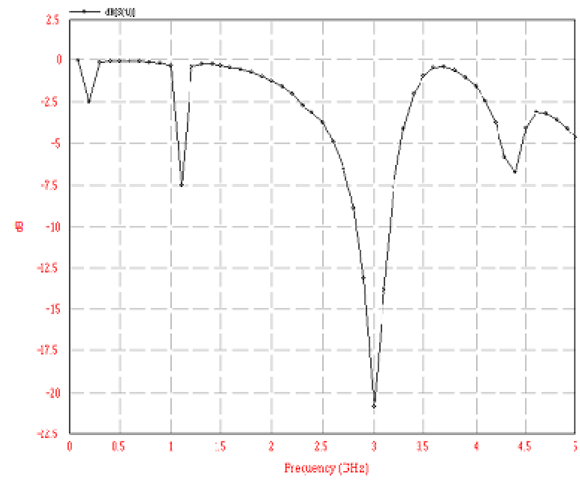

Figure 3: (c) Return Loss vs Frequency plot

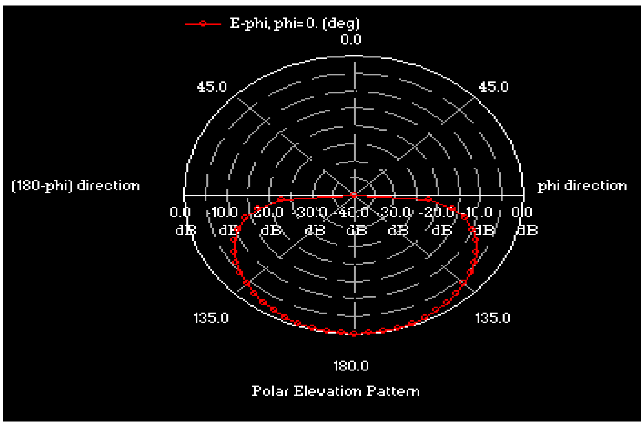

Figure 3: (d) 2D view of Polar Elevation pattern

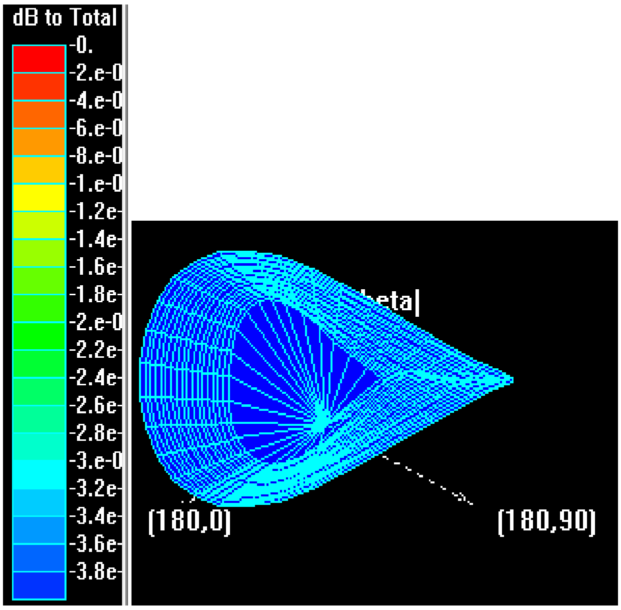

Figure 3: (e) 3D view of Radiation Pattern

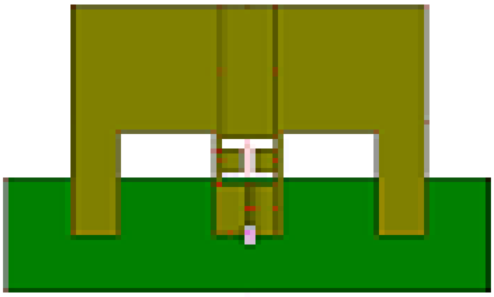

Figure 4: (a) Proposed clockwise Rotated E-shaped Antenna Design with I-cut slot on radiated plan

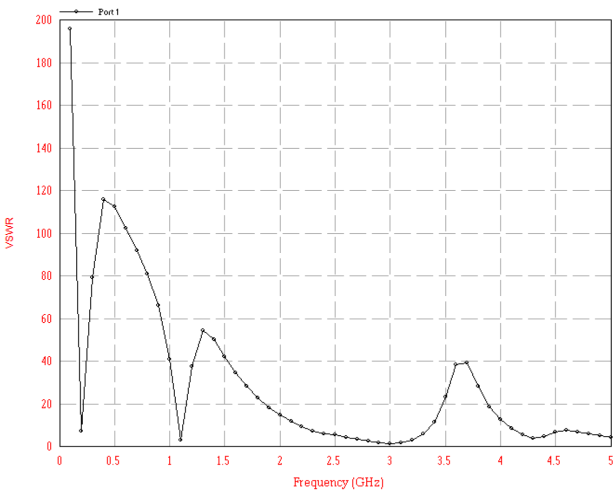

Figure 4: (b) VSWR vs Frequency plot

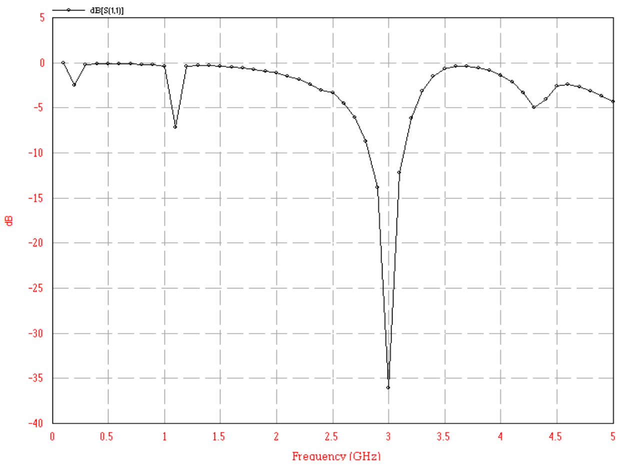

Figure 4: (c) Return Loss vs Frequency plot

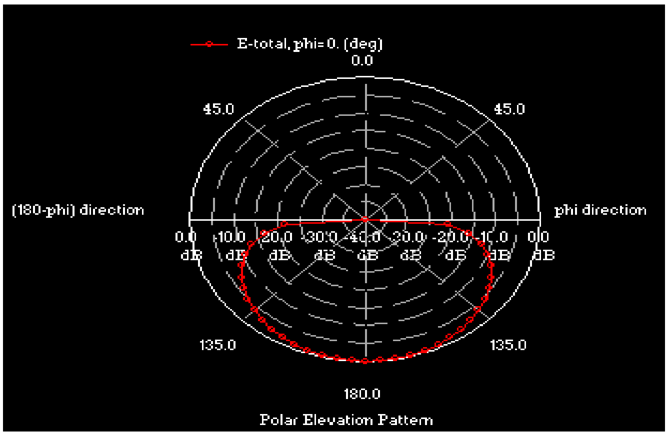

Figure 4: (d) 2D view of Polar Elevation pattern

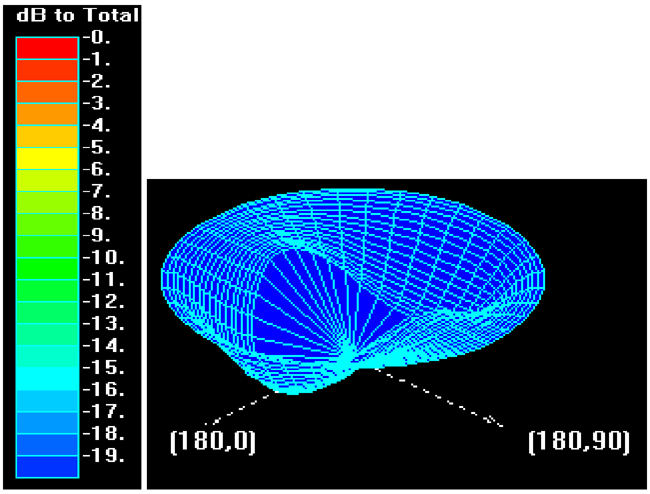

Figure 4: (e) 3D view of Radiation Pattern

Performance comparison of different antenna structures shown in Fig.3(a),(b),(c),(d),(e) and Fig.4(a),(b),(c),(d),(e) are given in a table no.2

Performance Table no.2

Different Antenna Designs	*B.W. at VSWR < 2 (GHz)*	*B.W. (%)*	*Return Loss (dB)*
Clockwise Rotated E-shaped antenna with Ground	2.9-3.1	66.6	-20.83
Proposed Clockwise Rotated E-shaped antenna with I-cut Slot and ground	2.9-3.1	66.6	-36.12

Fig. 3(a) and Fig. 4(a) show the dimensional view of ordinary antenna and proposed microstrip patch antenna respectively. Here, we are discussing the performance of both antenna.

Fig.3(b) and Fig.4(b) show the VSWR Vs frequency graphs, at 3.5 GHz frequency range at 3GHz. VSWR is used to describe the performance of an antenna when attached to transmission line. It is the measure of how well the antenna terminal impedance is matched to the characteristic impedance of transmission line. Ideal value of SWR is unity indicating that there is no standing wave on the line .SWR values of up to 2.0 is acceptable in patch antenna design. Bandwidth of the MPA is usually specified as the frequency range over which VSWR is less than 2. From both figure it is cleared that this antenna give the result at acceptable range.

Fig.3(c) and Fig.4(c) show the return loss Vs frequency plots also known as Reflection coefficient plot which determines the return loss of antenna. Return loss is a logarithmic ratio measured in dB that compares the power reflected by the antenna to the power that is fed into the antenna from the transmission line. The centre frequency or resonant frequency is selected as the one at which the return loss is minimum. From the performance table, fig. 3(c) and fig 4(c) it is cleared that the simulated antenna design of Clockwise Rotated E-shaped antenna with I-cut Slot has given return loss -36.12 dB at 3 GHz having a bandwidth 66.6 % while ordinary patch antenna has given return loss -20.83 dB at the same operating range. Hence, the proposed antenna is more radiated than the ordinary patch antenna.

Fig.3(d) and Fig.4(d) elevation polar plots, the elevation pattern for $\varphi = 0$ and $\varphi = 90$ degrees would be important. So the elevation radiation pattern for $\varphi = 0$ and $\varphi = 90$ degrees are presented here. These plots show that a proposed Microstrip patch antenna radiates normal to its patch surface. The basic patch covered now is linearly polarized, since the electric field only varies in the one direction. Polarization can be either vertical or horizontal depending on the orientation of the patch. Here both plot shows the vertical polarization. Fig.3(e) and Fig.4(e) show the 3D view plot of radiation patterns in a specified bandwidth are almost identical in shape and there is no any back lobes or side lobes means that the proposed antenna uniformly radiate in only one direction. Hence it shows the omni-directional radiation pattern.

As discuss above and from performance comparison table it is cleared that the proposed antenna has given better performance than the ordinary patch antenna.

Conclusion

A Microstrip Patch Antenna of design Clockwise rotated E-shaped antenna with I-cut slot on the radiating plane of size 19.99×26.08 (L×W) mm^2 has been proposed using IE3D Zeland Program Manager. As discussed in the simulation and results proposed antenna satisfies the VSWR < 2 requirement from 2.9 to 3.1 GHz and Return loss -36.12 dB having a bandwidth 66.6%. Elevation polar plot and 3D view of antenna shows the omni-directional radiation pattern. From the results and discussion it is concluded that the performance of antenna further can be improved by using different feeding techniques, by cutting or slightly changing the structure of the ground plane and defected structures. Hence it is concluded that the proposed antenna would be a good choice in many wireless communication systems at 2.9-3.1 GHz operating range.

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