Antenna with Defected Ground Structure for future mobile and Wireless communication 5G

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Abstract. The scope of this study is to design and develop a miniature antenna for future mobile and wireless communication 5G.On this paper is designed a new type DGS antenna for future mobile. The size of this antenna is 5.33mm width and 6.67mm long, with dielectric constant ε_r=2. 2 and thickness H=0. 8mm. The new patch antenna has T&U slotted and notches.50 ohm single microstrip line feeding with radiation patch, which is resonant with the dual band frequencies. The design and simulation results are analyzed the return loss, VSWR, surface current distribution, Fairfield radiation pattern and Fairfield gain. This antenna obtained the return loss -20.16576dB and -28.7672dB which cover the27.58443GHz to 27.652 GHz and 29.284GHz to 29.318 GHz band. The Fairfield gain have a 7.35dB and 5.11dB.This antenna operates dual band frequency 27.626Gz and 29.303 GHz for 5G communication is presented..

Keywords: DGS antenna theory, filter DGS.T&U Slotted,notches,5G communication,mmwave

1 Introduction

Utilization of the millimeter wave (mmWave) band is a key technology for the development of the heterogeneous networks (HetNets) that will be used for 5th generation wireless cellular networks (5G) [1].

The beams generated in mmwave (band ka) are much more directive than in lower frequency bands. This why it's reserve for the communications satellite. Its frequency band between 26.5 GHz and 40 GHz, The big problem when used mmwave absorption and attenuation with environment , For example, the oxygen molecule (O2) normally absorb electromagnetic energy at 60Ghz to a much higher degree than in the regions 30-160Ghz . The rain attenuation and atmospheric absorption characteristics of mmwave propagation. The solution proposed for this type of frequency band it is of added by small base station with Distance less than 1Km. Moreover used (MIMO)multiple antennas at the transmitter and /or receive improve the global performance of wireless systems .

For working the huge of frequency band size of antenna change smaller and become a many defiance for fabrication**.** This paper, design a new antenna by depends on merging three ideas in [1] [2] [3] which works the dual band of f1=27. 632 GHz, f2=29.3032 GHz frequency use for future 5G wireless and mobile communication is presented**.** In [3] is created a novel topology of antenna patch with mesh-grille, and also is proposed a position for the antenna to be installed that avoids the problem of attenuation of the wave with the user. In [4] is developed a new concept of antenna patch with a slot with shape 'T' and 'L' to be used in band frequency 28Ghs. In [5] is proposed a circular patch with DGS that improves the performance of other antennas.

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In [6] is proposed an antenna with a 'U' slot bi-band in 28Ghz and 38Ghz, and added an array of an antenna to improve their performance.

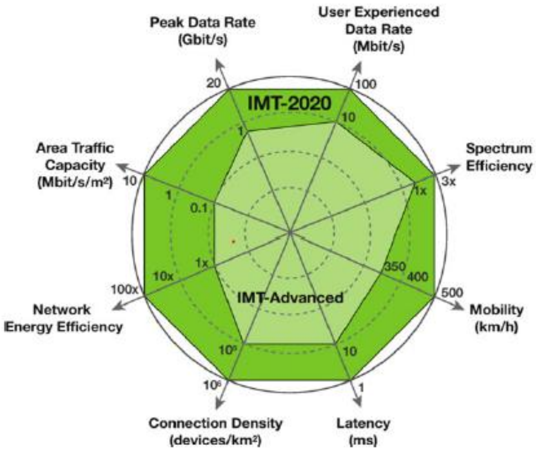

Fig. 1. Enhancement of key capabilities from IMT-Advanced to IMT-2020[13]

2 Geomrtry of new type

The geometry of the new antenna is presented in fig (1). The size of this antenna is 5mm width and 6.33mm long, with dielectric constant ε_r=2. 2 with thickness H=0. 8mm. The new patch antenna has T&U slotted and notches.50 ohm single microstrip line feeding with radiation patch, which is resonant with the dual band frequencies.

Before calculating the length of the patch it is necessary to calculate the effective dielectric constant, effective with and length extension of the resulting length by using the equation:

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}[1 + 12\frac{h}{W}]^{-\frac{1}{2}} \qquad 1.1$$

$$L_{eff} = L + 2\Delta L \qquad 2.2$$

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}} \qquad 1.3$$

All the dimensions presented in table.1, table.2, table.3.

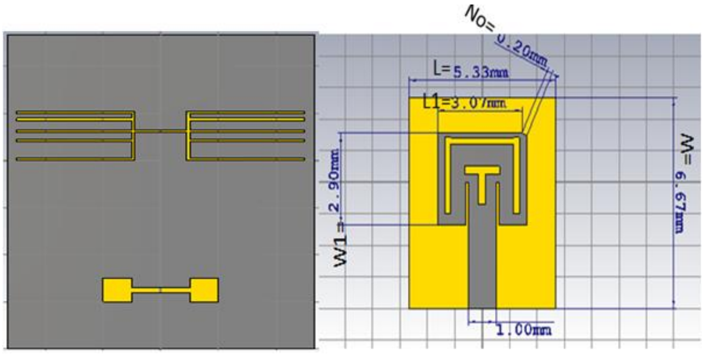

Fig. 2. Geometry of proposed antenna with DSG unit cell and DGS filter

Table 1: dimensions of patch antenna

Parameters	**Dimensions (mm)**
L	5.33
W	6.67
L1	3.07
W1	2.9
NO	0.2

Fig.3 and table.2 present the geometry and dimensions of the filter DGS .

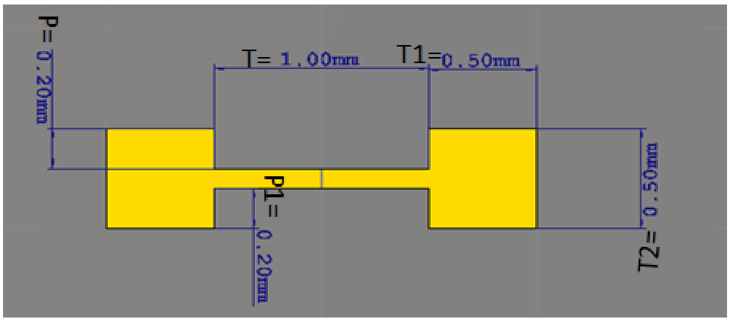

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Fig.3. Geometry of proposed DGS filter

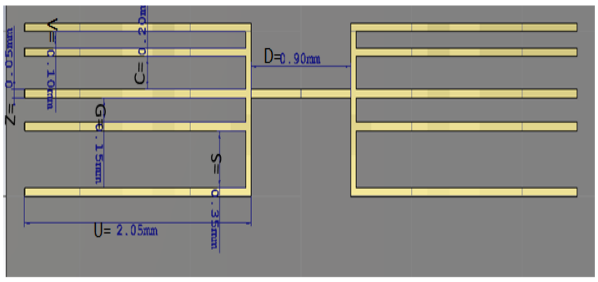

Fig.4. Geometry of proposed DGS unit cell

Table 2: dimensions of DGS filter.

Parameters	**Dimensions (mm)**
P	0.2
T	1
T1	0.5
T2	0.5
P1	0.2

And the sconde table.3. present the geometry of unit cell

Table 3: dimensions of DGS filter

Parameters	**Dimensions (mm)**
D	0.9
C	0.3
G	0.15
V	0.1
Z	0.05
U	2.05
S	0.35

3 DGS antenna theory

In general, circuit equivalent of this structure DGS to consist of a circuit LC parallel and series with the transmission line:
Fig.5 represent DGS equivalent .

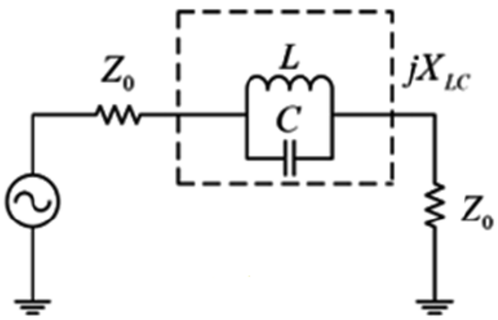

Fig.5. Equivalent circuit LC

The next calcul we take into consideration the lossless we insert resistance in parallel like illustrated in fig (2)

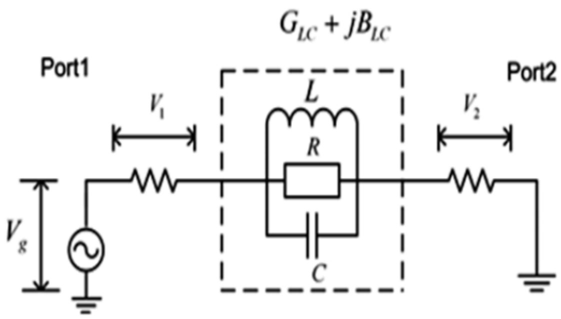

Fig.6. Equivalent circuit LRC

So the equivalent circuit is given by:

$$Y = \frac{1}{R} + j2\pi(Cf - \frac{1}{4\pi^2 Lf})$$

Because:

$$Z = \frac{1}{Y}$$

$$Z = \frac{1}{\frac{1}{R} + j2\pi(Cf - \frac{1}{4\pi^2 Lf})}$$

And we know:

$$S_{21} = \frac{1}{1 + \frac{1}{2} Z Z_0^{-1}}$$

At -3db we find:

$$\mid S_{21} \mid = \frac{2Z_0}{\sqrt{4Z_0^2 + (\frac{w_c}{w_0^2 - w_c^2})^2}} = \frac{1}{\sqrt{2}}$$

- wc is the angular cutoff frequency.

- w0 is the angular resonance frequency

At the resonance frequency we calculate the resistance R replacing Ze = R and we find:

$$S_{21}\mid_{w=w_0}=\mid \frac{2Z_0}{2Z_0+Z_e}\mid=\frac{2Z_0}{2Z_0+R}$$

This gives:

$$R=\frac{2Z_0(1-S_{21}\mid_{w=w_0})}{S_{21}\mid_{w=w_0}}$$

The current distribution through the patch, by increasing the length electric current Which leads to increased capacitance and the inductor and consequently the antenna has characteristics slow wave.
The slow wave factor (SWF) shows the relationship between the number in free space, k0 and the propagation constant of the line of transmission.SWF is determined by:

$$SWF=\sqrt{\varepsilon_e}$$

With :

$$\varepsilon_e=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}[1+12\frac{h}{w}]^{-\frac{1}{2}}$$

In addition, the propagation constant is given by:

$$\beta=\sqrt{\varepsilon}_e.k_0$$

Which gives therefore:

$$SWF=\frac{\beta}{k_0}$$

4 Simulated results

The DGS filtre and unit cell MMW frequency antenna for 5G networks is presented in Fig.5.

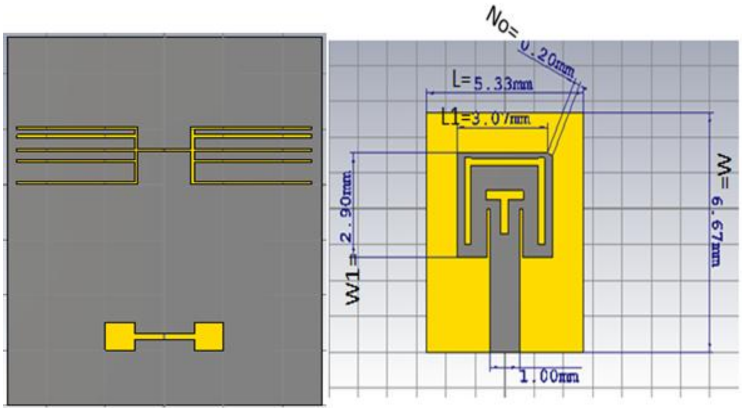

Fig.5. Geometry of proposed antenna

At first we begin with the introduction of a unit cell fig 6 and in one Second time we introduce the filter DGS fig.11.

4.1 Patch antenna with unit cell :

Fig.6 illustrates the patch scheme with the DGS cell unit engraved in the ground plane.

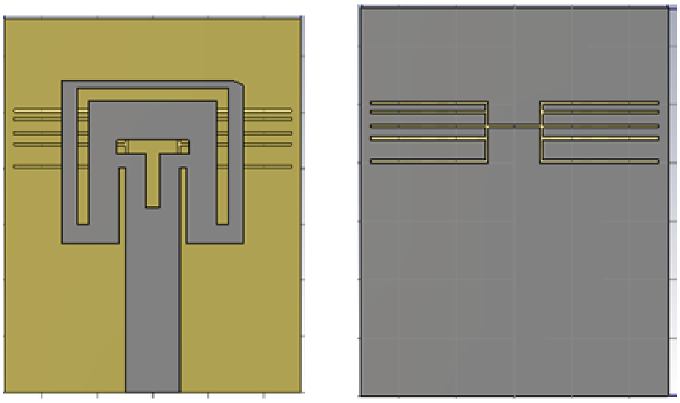

Fig.6. the DGS cell unit engraved in the ground plane.

The engraving of the slots and notches on the patch we note an improvement at the level of adaptation by keeping the resonant frequency Intact.

On the pretext that we want to further improve the adaptation of the antenna, we add breaks on the patch as shown in the fig6.

Fig.7. is present the simulated Sparameter of designed antenna with DGS unit cell and Fig.8 is present the simulated VSWR. Its result obtained at f1 for good matching impedance of dual band antenna. Notice that the resonance frequency of the antenna, with coefficient of reflection which is equal to $S11_{f1}$=-25.119848dB $S11_{f2}$=-16.4987dB and $VSWR_{f1}$=1.35 and $VSWR_{f2}$=1.2345. the gain of the proposed antenna is equal G_{f1}=7.16dB, G_{f1}=4.18dB Fig.9.

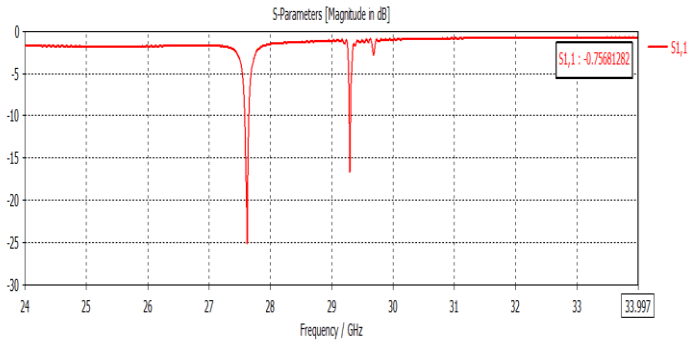

Fig.7: Simulated S-parameter of designed DGS unit cell

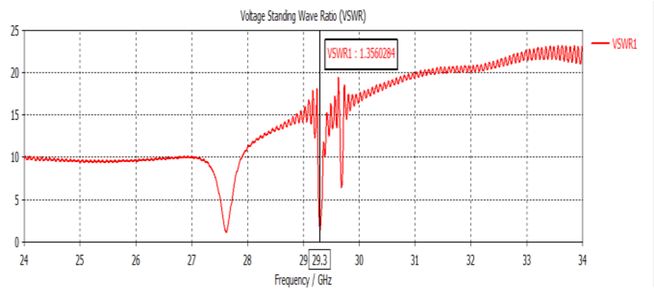

Fig.8: Simulated VSWR result of designed DGS unit cell

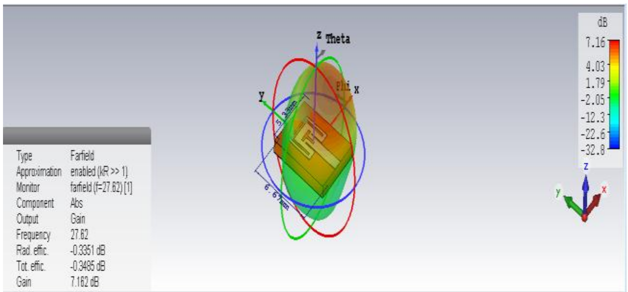

Fig. 11: Simulated 3D radiation pattern of DGS unit cell f1.

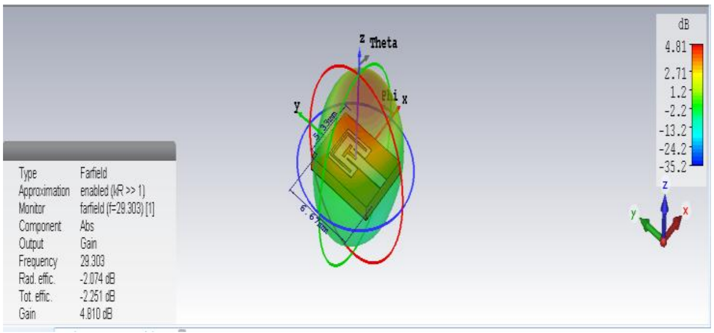

Fig. 12: Simulated 3D radiation pattern of DGS unit cell f2.

4.2 Patch antenna with DGS filter and unit cell :

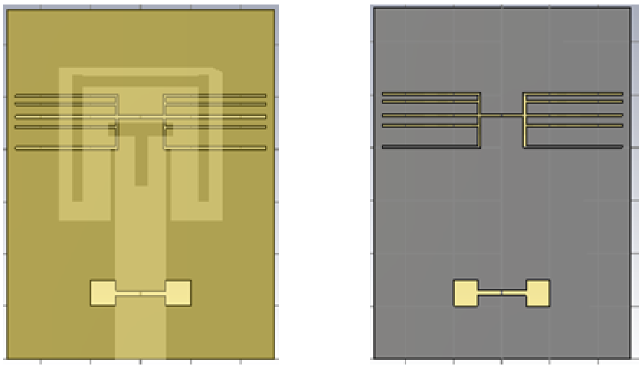

Fig.13: Geometry of proposed designed Unit cell and DGS filter

To understand the effect of introducing the DGS structure to the antenna patch we did a study same structure .but this time we engraved it on the ground plane of a transmission line the geometry of the filter is shown in fig.13.

Fig.(14,15,16,17) are present the simulated S parameter of designed microstrip patch antenna and VSWR and gain .This simulated result obtained the F1=27.636GHz and F2=29.323 GHz of resonant frequency have a return loss $S11_{f1}$=-20.119848dB $S11_{f2}$=-28.7672dB and $VSWR_{f1}$=1.2862and $VSWR_{f2}$=1.07.the gain of the proposed Antenna is equal $Gf1$=7.35dB,$Gf2$=5.11dB.

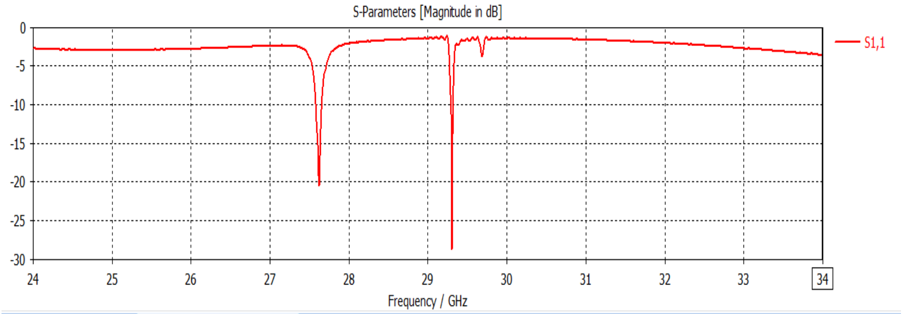

Fig. 14: Simulated S-parameter of designed DGS unit cell and DGS filter

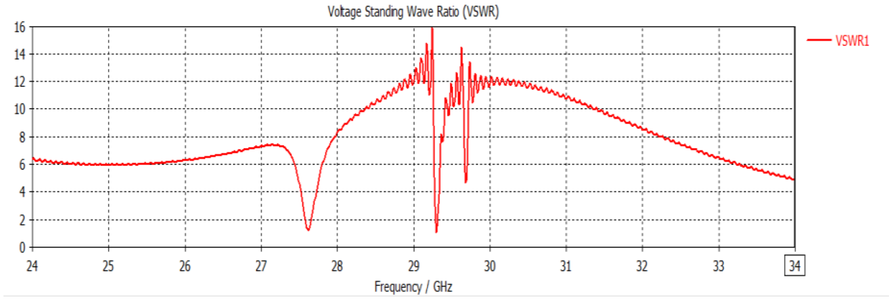

Fig.15: Simulated VSWR result of designed DGS unit cell and DGS filter

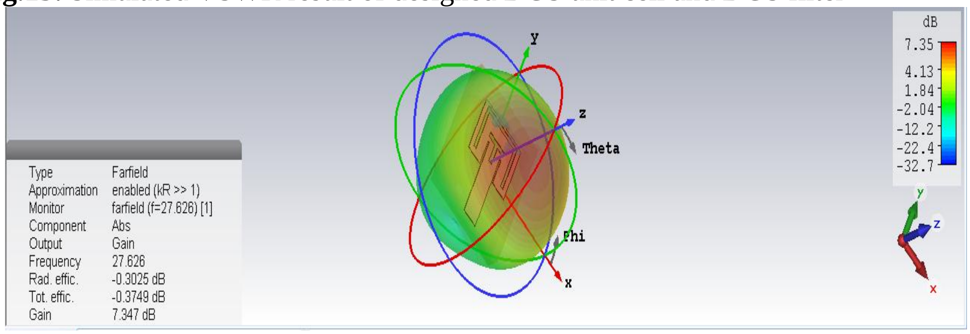

Fig. 11: Simulated 3D radiation pattern of DGS unit cell and DGS filter f1.

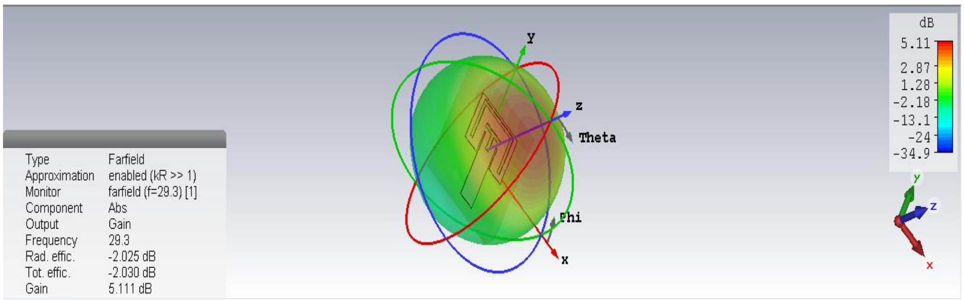

Fig. 11: Simulated 3D radiation pattern of DGS unit cell and DGS filter f2

Note that the gain of the antenna with DGS cells for the frequency f1 = 27.626 equal to 7.16dB and for a frequency f2 = 29.303 GHZ, Gain equal to 4.17dB.when adding DGS filter the gain increases from 7.16dB for f1 and 5.11dB for f2 in table (4) we have a comparison between antenna with unit cell and we adding the filter DGS .

Table 4: Comparison of designed antenna DGS unit cell with antenna DGS unit cell & DGS filter

	F(Ghz)	G(dB)	VSWR	S11(dB)
Unit cell DGS	F1=27.63 F2=29.323	G_{f1}=7.16 G_{f2}=4.18	$VSWR_{f1}$=1.35 $VSWR_{f2}$=1.2345	$S11_{f1}$=-25.11984 $S11_{f2}$=-16.4987
Add filter DGS	F1=27.63 F2=29.323	G_{f1}=7.35 G_{f2}=5.11	$VSWR_{f1}$=1.2862 $VSWR_{f2}$=1.07	$S11_{f1}$=-20.119848 $S11_{f2}$=-28.7672

Table 5: Comparison of designed antenna with other reference antenna

	[2]	[1]	[3]	Antenna proposed
Gain db	7.77	5.54, 6.4	15.6-10	5.35-7.11
S11(dB)	-31.24	-35.73,-47.53	-50,-40	-20.119848, -28.7672
Resonant Frequency(Ghz)	30	28,28	28-39.95	27.63, 29.323
size mm×mm	10×10	10×10	16×16	5.33×6.67

4 CONCLUSION

I n this paper,the DGS structure has been presented and we analysed different parameters by CST simulator.The detail of the design approach presented in the article may beprone to modification amid evolution of wireless devices in the future.

Nonethelss ,the authors predic the methodologies able to help to increases gaon of this antenna, we can also add array antenna for the same reason.

The antenna obtained is characterized by a better adaptation, more bandwidth and greater gain and directivity which make it suitable to respond to the majority of constraints imposed by the modern telecommunication systems.

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