Transparent Patch Antenna Development for Solar Cell Hybridisation

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ABSTRACT

Straightforward fix antennas are microstrip fix antennas that have a specific dimension of optical straightforwardness. Exceptionally straightforward fix antennas are possibly reasonable for incorporation with solar boards of little satellites, which are winding up progressively critical in space investigation. Conventional fix antennas utilized on little satellites rival solar cells for surface territory. Be that as it may, a straightforward fix antenna can be set legitimately over solar cells and resolve the issue of going after restricted surface land. For such coordination, a high optical straightforwardness of the fix antenna is required from the solar cells' perspective. Then again, the antenna ought to have at any rate adequate radiation properties in the meantime. Dynamic coordinated antenna structure strategy is reached out to coincided fix applications trying to improve the general power efficiency of the front end correspondence subsystem.

I. INTRODUCTION

There is a few probability of putting solar cells straightforwardly on the patches. Different mixes like putting solar cells behind reflect cluster antennas have likewise been contemplated. On account of fix antennas, the cells can't be near the patches' transmitting edges because of damaging collaborations. As innovation has been progressing quickly, a thought rose to incorporate the antenna and solar cell into (solid) building square units. These units may then be duplicated as wanted to make a structure whose transmitting gap is additionally utilized as the light – gathering territory. A tale half and half innovation where formless silicon solar cells are either coordinated or physically joined with printed space antennas is exhibited.

This fundamental thought is shown with the assistance of two inventive structures where the solar cells are legitimately developed on a hardened steel ground – plane or stuck onto a standard copper layer imprinted on a dielectric substrate. execution when contrasted and a straightforward juxtaposition of antennas and solar cells.

Straightforward fix antennas, as an uncommon kind of microstrip fix antennas have been considered for over two decades. Their normal structure comprises of a best layer conductive fix, base layer ground, and dielectric substrate in the middle. In this investigation, the best layer conveyor and the dielectric substrate of the fix antenna are should have been optically straightforward.

The conductor's straightforwardness can be accomplished by applying straightforward conductive

oxides films as strong strip and work structure where the conductive oxide, for example, indium tin oxides (ITO), by using coincided sheets on standard and hexagonal conductors sheet for the substrate, models incorporate ordinary glass, spread glass of solar boards, and so on.

An essential use of straightforward fix antennas is their joining with the solar boards for little satellites, where constrained surface zone is an issue for mounting antennas, solar cells, and space instruments. This is of incredible importance for little satellites. Other conceivable applications incorporate reconciliation of antennas with window glass or vehicle windshield or unpleasant best antenna, electrical vehicle following antenna.
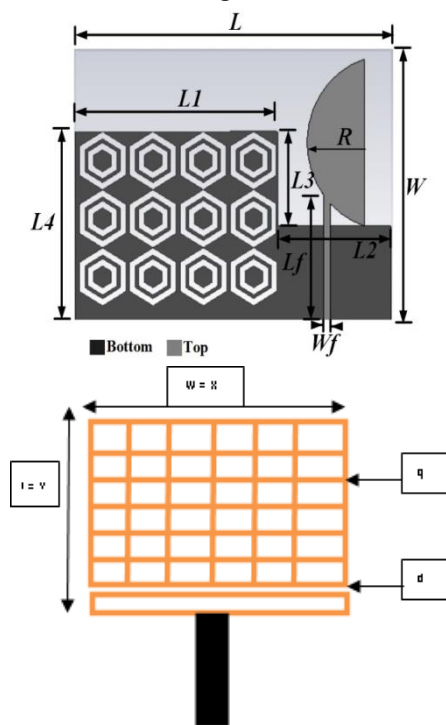
Figure 1 : Antenna design for ITO Glass in Hexagonal and rectangular pattern Mesh Deposition

Table 1: Antenna dimensional parameter

L	45	L3	12
W	35	L4	13
Lf	17	L5	32
Wf	1.2	L6	28
L1	30	a	8
L2	15	g	0.8

These antennas are electrically like customary fix antennas and have similar points of interest. Moreover, they give high optical straightforwardness, which is basic for the solar cells. In this manner, they can be set straightforwardly over the solar board without influencing the solar cells' usefulness. Huge space make expected to agree to the expanding interest for media transmission, interactive media and expanding logical goals. The need to actualize a few complex instruments on one single space make prompts an expansion in the number and size of antennas and solar generators.

For the above issue there is the choice to spare "land" by joining two capacities keeping up execution square with or to expand ability (e.g., to offer correspondence in a non-ostensible circumstance). SONTENNA could even be a mission empowering arrangement.

The physical antenna is organized with the length, width and thickness based arrangement with the assortment in the permittivity and vulnerability. The length and the width of a fix can be found by a mix of informative examination and accurate procedures. Fix width minorly influences the booming repeat and radiation case of the antenna. A greater fix width extends information transmission, and radiation efficiency. With genuine excitation one may pick a fix width W more noticeable than the fix length L without stimulating undesired modes. It might be seen that the width can be resolved from conditions as frail:

$$W = \frac{c}{2fr}\sqrt{\left(\frac{(\varepsilon r+1)}{2}\right)} \qquad (1)$$

Additionally, the fix length decides the resounding recurrence, and is a basic parameter in structure on account of the inalienable restricted transmission capacity of the fix. The length is found by ascertaining the half-wavelength esteem and afterward subtracting a little length to display the bordering fields impact.

$$l = \frac{c}{2fr\sqrt{\varepsilon eff}} - 2\Delta l \qquad (2)$$

$$\Delta l = 0.412h\frac{(\varepsilon eff+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon eff-0.258)\left(\frac{W}{h}+0.813\right)} \qquad (3)$$

$$\varepsilon eff = \frac{\varepsilon r+1}{2} - \frac{\varepsilon r-1}{2}\sqrt{\left(1+\frac{12t}{W}\right)} \qquad (4)$$

$$Zo = \frac{120\pi}{\sqrt{\varepsilon reff}\left(1.393+\left(\frac{W}{h}\right)+\frac{2}{3}\ln\left(\frac{w}{h}+1.444\right)\right)} \qquad (5)$$

Straightforward fix antennas can be coordinated with surface-mounted solar boards of little satellites [3] or window glass of structures or autos [4]. These applications require high optical straightforwardness just as great radiation properties of the antenna. Fix antennas produced using straightforward conductive film, for example, silver covered polyester and indium tin oxides (ITO) films, were accounted for [1, 5]. Be that as it may, the straightforwardness of these antennas isn't sufficiently high for viable applications. Reports on coincided fix antennas recommended an unpredictable exchange off between the antenna's properties: the transfer speed and cross-polarization level can be improved by sacrificing the increase [2]; a low radar cross segment (RCS) can be accomplished if the addition and transmission capacity are undermined [6].

Figure 2: transparent mesh design with solar cell and patch antenna

The polyimide substrate is secured by an aluminum layer (back contact) and by a ZnO layer, which forestalls aluminum dispersion. The layers referenced above additionally structure a mirror for the occurrence solar light so as to expand assimilation and therefore, produce increasingly current. The genuine solar cell is made of three silicon layers: a slight high conductivity phosphor doped n-layer, a natural (un doped) layer with a low imperfection thickness and an extremely meager exceptionally conductive p-layer. Most photons are invested in the natural layer, while the doped layers are in charge of the development of an electric field inside the solar cell itself. The gatherer layer over the cell must be straightforward and conductive and thus it is made of straightforward conductive oxides(TCOs)- either indium tin oxide or zinc oxide. Since TCOs have a somewhat low conductivity contrasted with metals, a finger design is stored on top made of a Cr grip layer secured by thicker Ag layer .Overall the cell thickness is under 5μm however normally a 50 μm thick polyimide substrate is utilized as a help in independent applications. In spite of the fact that this kind of cell is less proficient than Ga-As solar cells which are right now utilized in space applications, a-Si:H cells demonstrates a superior watt/kilogram proportion because of their light weight.
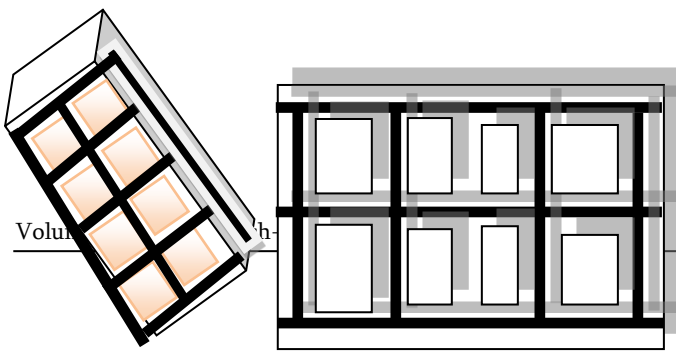
Figure 3 : developed solar cell antenna

Mesh structure

Hypothetically, the geometry of coincided fix antennas can be a self-assertive shape. As referenced before in this segment, nonetheless, the work example ought to be planned dependent on the present ways on the fix that are required for a specific radiation mode. This guarantees unsurprising antenna properties as well as concealment of undesired radiation modes. This paper for the most part centers around rectangular and roundabout fit patches, as delineated in Fig. 3, because of their generally basic work designs. It tends to be seen that a coincided fix antenna comprises of two arrangements of work lines. The first set of lines are in charge of conveying the ideal flows while the second gathering of lines are symmetrical to the present way lines with the end goal that a fix can be shaped.
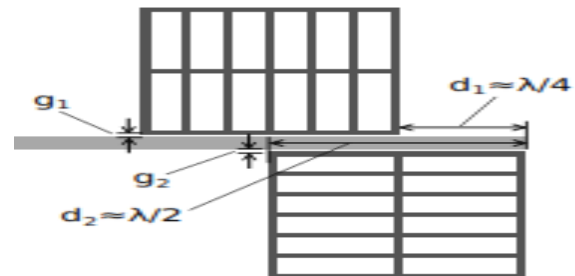
Figure 4: Mesh design for quarter$\lambda/4$ and $\lambda/2$ array antenna design

Table 2: antenna designed with frequency and dielectric basis

| Freq Ghz	W um	L um	effective dielectric Ɛreff	Δ L	Lg um	Wg Um
1.227	97256392	83180172.61	2.160000035	0.841936	83180180	97256401.2
1.575	75767360	64801315.27	2.160000045	0.841936	64801323	75767369.9
1.72	83917190	80971803.68	1.160000022	1.05366	80971811	83917199.8
2.1	56825520	48600986.28	2.16000006	0.841936	48600994	56825529.8
2.4	49722330	42525862.91	2.160000069	0.841936	42525871	49722339.7
2.6	45897536	39254642.64	2.160000074	0.841936	39254650	45897545.1
3	39777864	34020690.2	2.160000086	0.841936	34020698	39777873.7

The optical transparency of such meshed patches is defined as the percentage of the see-through area of the patch. As an example, the formula to calculate the transparency (T) of a rectangular meshed patch which has a dimension of W (width) by L (length) is given as follows:

$$transparacy = \left[1 - \frac{Aconductor}{Apatch}\right] * 100 = \left[1 - \frac{q(NL+MW)-q2NM}{WL}\right] * 100\% \qquad (6)$$

Feed technique

Among the most widely recognized bolstering procedures for microstrip fix antennas are test feed and inset feed. For solar board coordinated coincided patches, these two feed structures can just confound the plan. With the nearness of solar cells, making a

by means of through the solar board is wrong in reasonable structure. In the event that the inset feed line is picked, at that point the geometry of the fit fix must be balanced so as to help a progressively mind boggling current examples because of the abnormality of the fix shape. Because of such focal points, the T-coupling feed structure, was utilized in this investigation.
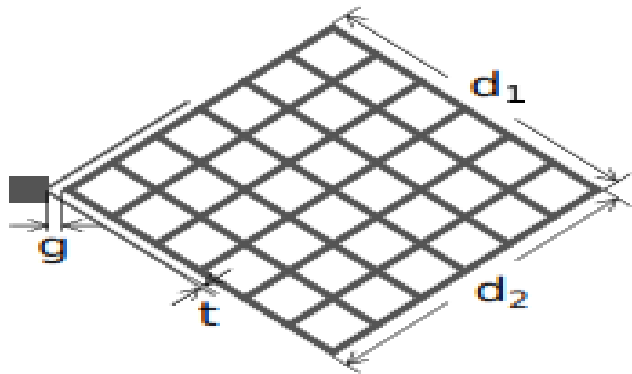
Figure 5 : mesh design with the T-Coupling axial feed point

As an upgraded sort of closeness line coupling, the T-coupling plan can be utilized to couple a ring resonator or to nourish a round or rectangular antenna [9– 11]. This encouraging technique possibly gives two degrees of opportunity to tuning: the branch thickness and the dividing s as set apart for both rectangular and hexagonal coincided fixes in Fig.

Impact of line width

A lot of test encouraged rectangular coincided fix antennas were structured on ITO , Zn and Glass plate

(μ= 2.6, tanδ = 0.0037, h = 2.132 mm) and analyzed so as to think about the impact of line width and on the antenna properties. The substrate (roughly 100 mm × 170 mm) was supported with copper. These antennas have similar measurements (45 mm × 35 mm). To accelerate the recreation, the optical straightforwardness was picked to be 70%. It is conceivable to do a similar report with antennas of 90% straightforwardness and achieve a similar end. Be that as it may, the higher the straightforwardness, the smaller the work line width, and increment the proficiency

Impact of Orthogonal Lines

The flows primarily flow on the matrix lines parallel to the length of the fix (L), while the flows flow on the lines symmetrical to the length of the fix are negligible [13]. This marvel recommends that lessening the symmetrical lines ought not affect antenna properties in a vast sense and that one can accomplish additional optical straightforwardness by such decrease. The accompanying investigation was set up to break down the effect of the symmetrical lines on the antenna execution. The length and width of the fit fix antenna were stayed to be 37 mm and Table 2.1: Simulated feed point embed remove versus linewidth of rectangular fit patches (45 mm × 37 mm). he work geometry comprises of 25 to 50 lines parallel to the present ways, or length, of the fix and the quantity of lines symmetrical to the fix length changed from 20 to 6 with a fixed line width q of 0.3 mm; subsequently, the optical straightforwardness extended from 70% to 79%.

Table 3: transparency basis of the frequency application

Surface material	90% ITO Coated	85% Coated	70% Plastic Coated	72 Polymer doped	**Efficiency**

Surface resistance Ohm/Sqm	4.7	4.7	3.9	5.0	
freq	2.5	3.10	4.5	5.4	6.3
S11 dB	-5.7	-9.3	-13	-20	-18.8
Efficiency	22.1	39.5	65.9	75.6	89.4

As can be observed, decreasing the number of orthogonal lines does not hinder the performance of the meshed patch antenna, and the antenna transparency can be optimized without severely degrading its radiation properties.
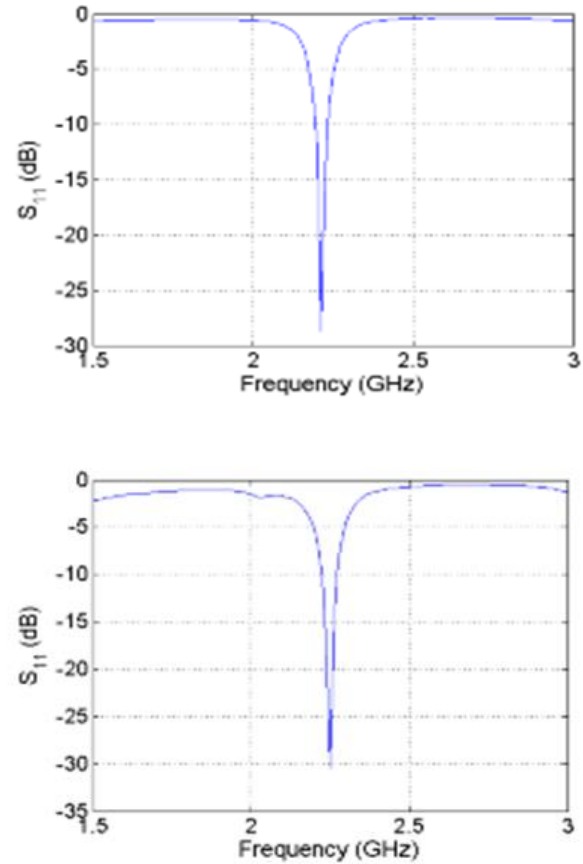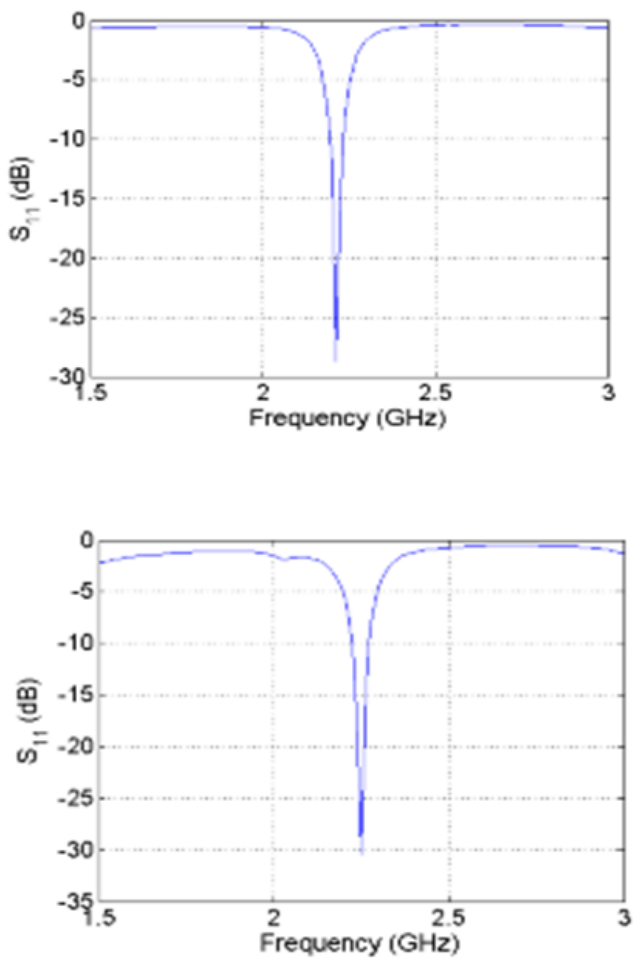
Figure 5 : Effect of feed point a on frequency and feed point
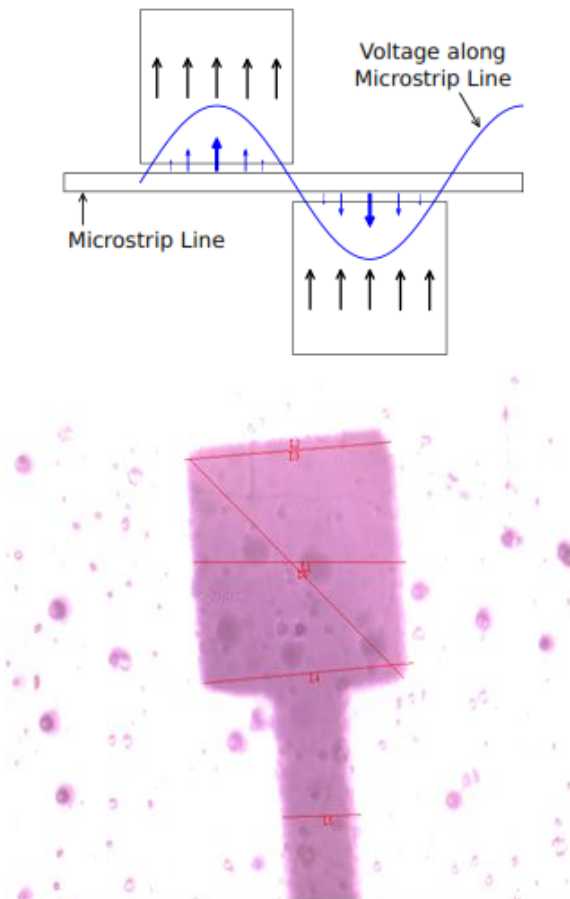
Table 4 : design patch frame

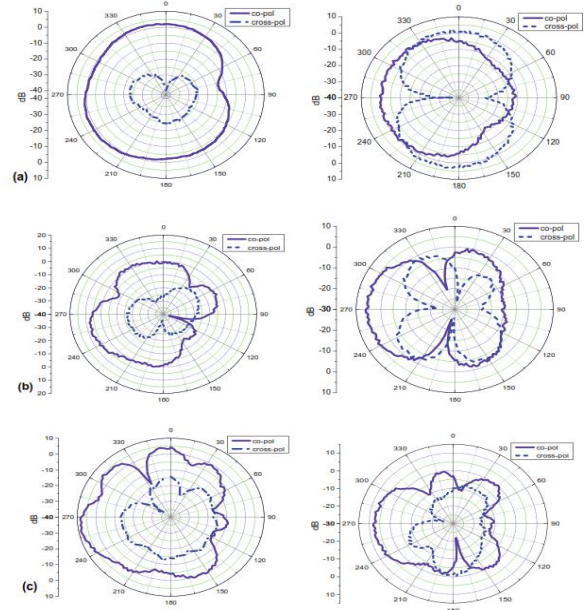| Antenna Parameter	Patch 1	Patch 2
Width	45 mm	45 mm
Length	35.4 mm	35.4 mm
Line Width (q)	1 mm	2 mm
Resonant Frequency	2.417 GHz	2.359 GHz
Input Impedance	226 Ω	262 Ω
Gain	5.471 dB	5.338 dB
Impedance Bandwidth	1.86 %	1.70 %

II. RESULTS AND DISCUSSION

Despite the fact that in the real execution of combination with solar cells, a straightforward

dielectric (for example spread glass) will be the substrate for fit fix antennas, the plan reasoning of the CP fit antennas is the equivalent for straightforward and non-straightforward substrates. Consequently, in the present research center approval, Roger's RO4003C cover (o= 3.55, h = 1.524 mm, tand = 0.0021) was picked to inspect the structure. The two coincided patches are straightforward to lights and the straightforwardness is defined as the proportion of the seethrough zone over the whole fix zone.

Figure 7 : radiation pattern measure with the antenna

Figure 6 : current direction with the developed transparent rectangular mesh structure

The meshed patches can be placed on solar cells whereas the non-transparent feed line can be placed along the gap between solar cells. The transparency of the meshed antenna can be controlled by the width and the number of the mesh lines. The relation between the transparency and antenna properties has been found [15]. The operational frequency is chosen to be in S band, where the size of the meshed patch is realistic to be placed on top of a commercial triple-junction solar cells used in space applications.

Table 6 : antenna design with the frequency

Freq	2.5	3.10	4.5	5.4	6.3
Patch size	13.5x16.7	19.3x20.2	221.0x17.4	21.5x18	7.3x5.5
Line width	0.20	0.16	0.17	0.045	0.13
Loss tangent	0.000256	0.000256	0.000256	0.000256	0.000256

Data transmission Enhancement Mechanism

The proposed strategy to broaden the data transfer capacity in this paper is accomplished by utilizing three fit patches of somewhat different sizes The

three antennas utilize a similar feed line and such a configuration is exceedingly practical to be executed on a multi-U CubeSat (for example joining a few CubeSats together where each CubeSat has an element of 10 cm × 10 cm × 10 cm) for frequencies higher than S band. The holes between the fit patches and the feed line should be tuned all the while so as to accomplish an impedance coordinating.

Furthermore, it is fundamental for all the three patches to create surface flows in stage, bringing about including bordering fields. Something else, the radiation would be extraordinarily diminished because of sources wavering in inverse ways. This can be acknowledged when the two nearby fixes are set on different sides of the feed line.

Table 7 : antenna dimension with the solar cell efficiency

	Antenna designe	Line width mm	No of Line in mesh x mm	No of Line in mesh y mm	S11 dB	Inner distance D mm	Feed line position	Efficiency %
47x36	Rectangular A	0.45	25	27	-23.0	13.2	20	78.2
45x35	Rectangular B	0.53	30	32	-22.4	13.5	22	78.9
40x30	Rectangular C	0.80	34	32	20.3	13.9	12	73.4
47x36	Hexagon A	0.60	22	42	21.3	14.5	12	73.5
45x35	Hexagon B	0.80	28	40	22.6	13.5	12	73.7
40x30	Hexagon C	1.10	30	45	21.3	13.2	12	76.1

III.CONCLUSION

In the moment the expanding voltage size, as theoretically is framed along the open-finished feed line, diminishing surface flows are incited, by means of capacitive coupling, flowing in a similar heading on both the patches. The purpose behind this is the positive voltage on the feed line drives "positive charges" on the upper fix far from the hole side while the negative voltage pulls "positive charges" on the fit antennas is the equivalent for straightforward and non-straightforward substrates. In this way, in the present research center approval,. As a source of perspective antenna, a solitary component square fix with 30 mm side length and 1 mm work line thickness, was intended to reverberate at about 2.48 GHz and manufactured utilizing a circuit board processing machine. The coupling hole and the situation of the fix regarding the tip of the feed line were tuned to get a decent impedance coordinate.

Figure demonstrates the model of the antenna intended for impedance transmission capacity improvement. The transparencies of these patches, defined as the proportion of the region of the openings inside the fix to that of the whole fix, are around 70%. This straightforwardness isn't sufficiently high for the genuine applications from the solar cells' point of view, in any case, these parameters were picked for the simplicity of creation utilizing the processing machine and an extremely high straightforwardness can be accomplished by refining the work lines of the fix with an increasingly exact assembling office.

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